DESIGN OF AN AIR QUALITY MONITORING AND CONTROL SYSTEM USING INTERNET OF THINGS

BY

DWIRE JELLY JOPHIAN
17/A/BEE/0598/G/F

SUPERVISOR: MR ISAAC KITONE

A PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, TECHNOLOGY, APPLIED DESIGN AND FINE ART
DEPARTMENT OF ELECTRICAL ENGINEERING

FEBRUARY, *2022*

DECLARATION.

I GWIRE JELLY JOPHIAN declare that this report is the original copy of my written project report I have written it myself basing on the research and practical work during the design of an AIR QUALITY MONITORING AND CONTROL SYSTEM USING INTERNET OF THINGS project plus knowledge and advice from my supervisor.

Supervisor name: MR KITONE ISAAC

Signature: ....

STUDENTS NAME: BWIRE JELLY JOPHIAN

Signature: .... ~.

Date: 04/02/2022

APPROVAL

This is to certify that this individual project done is my original idea and was carried out under supervision, approved for submission to the department of Electrical Engineering Kabale University in partial fulfillment of the requirement for the award of a Bachelor's degree in Electrical Engineering

SUPERVISOR: MR.KITONE ISAAC

Signature.................................

STUDENT: Mr. BWIRE JELLY JOPHIAN

Signature: ....

Date: 04/02/2022

DEDICATION.

I dedicate this report to all my family members especially MR. OUNDO CHARLES, MS NABANJJA EVA who have been supportive and encouraging throughout my education.

I also dedicate this report to my mom Namusisi TOPISTA **who** has been the core for the success of my Education and all my course.

ABSTRACT

Air pollution is one of the leading global public health risks but its magnitude in many developing countries' though in most cities it is not known. The level of air pollution has increased with times b, lot of f'actors ranging from increase in population, industrialization and urbanization which results in harmful effects on human wellbeing by directly affecting health of population exposed to it. The currently used systems however that are commonly imported in Uganda do not have an automated monitoring mechanism. they are unreliable. expensive. hard to read and their main l(ic11s is on vehicles yet people spend most of their time working indoors in clilTerenl industries hence their health is compromised. In this system, the air quality sensor. temper:lture and humidity sensor are used to detect increase or decrease in the different conditions and taking action by indicating to the responsible personal in the industry at that time

LIST OF ABBREVIATIONS

CSM	Global System for Mobile Co111111unication
WHO	World Health Organization
l ·o	Carbon rnonox 1de
PB	Printed Circuit Bomd
S\llS	Short Message Service
\\'S:'-J	'v\/ireless Sensor Network
Jl\iJ	Particulate Matter
,\AP	J\mbient Air pollution
PPM	Parts Per Million
I.\P	fndoor Air Pollution
NAAQS	National Ambient Air Quality Standard
EMA	National Environment Management Authority
1\C	Air Conditioner

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTfON

This chapter comprises of background. problem statement, objectives of the study. _justilicatiun and the scope.

ln manv cities. c1ir is polluted by emissions from sources such as power plants, manufacturing processes among others. \\'hen gases and par1icles from those activities accumulate in the air in high enough concentrations. they are harmful to human health ~rnd e11vironment /I/. Air pollution is a fast becoming gra, e threat as levels of toxicity in urban centers increase b,·yoncl safe limits [2]. The rapid industrialization. fast urbanization, rapid growth in population and other acti ities of human beings have disturbed the balance of natural atmosphere[3]. Air pollution is one of the most important factors affecting the quality of life and the health of the i11L-reasingly u1·ban population of industrial societies. Health problems commonly Associated with air pollution C'<posure inelude: respiratory diseases such as the chronic obstructive pulmonar) disease, asthma. lung cancer and :1cute respiratory infections in children and cardiovascular diseases such as is,clie111ic heart ciisease and stroke [4].

\crnrcling lo the 20I4 WHO Report, in *2012* about J.7rnillion premature deaths occurrL·d across the globe due to exposure to particulate matter of I0 microns or less in diameter (PM10) 151

On the 25 March 20 l--1. \\'f 10 released new estimates of the Contribution of air pollution to global mortality showing that seven million deaths were attributable to air pollution worldwide in the year 2012. 3.7 million due to ambient air pollution (AAP) and *4.3* million due to indoor air pullurion (IAP).This number represents a doubling from the air pollution mortality rates estimated by WHO in the year 2004 [4]. The United States (US) National Ambient Air Quality Standard (N;\AQS) designates all of the above plus airborne kacl (Pb) ns criteria pollutants. WHO and the US Environmental Protection Agency (USEPA) have defined guideline limits for these pollutants that should not be exceeded in order to maintain and protect public health [-4].

I he \\'110 limits for PM2.5. **PM** I 0, N02. S02, and 03 are 25 g/m3 (24-hour mean). 50 *gm3* 2+-hour mean). *12* **8077** gm3 (one-hour mean). 20 gm3 (24-hour mean). and IO gm3 (eight-hour' mean), respecti\ el) *[--1].*

Existing literature on urban air pollution shows that open Industrialization and urbanization are the key causes of air pollution in Uganda. According to the 20 IO NEMA Report. lower :rncl upper rcspirntory tract infections account for more than 37 percent of the national disease burden in Uganda. The 20 IO NEMA Report also points out that there is continued emission of dioxins particularly from processing factories that are located in big towns such as Kampala. Mukono. . I inja and Tororo among others. Urban growth and development in Uganda have also tended to ignore air pollution as a key issue that need to be investigated and explored with the aim of establishing a more optimal solution and improving air quality in various local towns cine! cities. Public :1wareness or air pollution as a key urban problem in Uganda is still poor clue to Lack of air pollution monitoring equipment and stations [--l]. The existing systems however not in Uganda use hfferent technologies to monitor and store data \\ hich is Resource \vasting since continuous updating of clata at one location is pointless without a solution to the problem and they also have nu control mechanism in an industrial setting about the on the ongoing prevailing conditions of air pollution. Therefore, there is need for a system this system to help in monitoring. and alerting air quality in the Hospital setting.

This chapter summarizes all the related literature about existing and related air pollution monitoring systems, technologies that are in place to improve the air quality within Industries. The l\.'\iC\\' inclucks research work from journals and books cited with the objective of revealing contributions, weakness and gaps within the related systems.

t1

Automation is a technique, method. or system of operating or controlling a process by electronic ,kvices \\ i1h tile aim or reducing human im olvernent to a minimum. An automated device can replace good amount of human working force, moreover humans are more prone to error::. and in intensive conditions the probability or error increases whereas. an automated device can work with dili~ence. \'ersatility and with almost zero error. Replacing humans in tasks done in dangerous environments (i.e. fire. space, volcanoes. nuclear facilities, underwater) performing tasks that are beyond human capabilities of size, weight, speed, endurance, economy irnprovement[6 I.

1\i1· pollution is the presence within the external atmospheres of one or more contaminants, or its combination in quantities or with a temporal duration that can become harmful to hurnan lile. animal or goods [8].

There a1·e two categories of air pollutants which include: Primary and secondary pollutants. Primary pollutants are those in which the substance emitted is itself hazc1rdous. Some primary pollutants c1lso produce other dangerous substances after underg:oing chemical reactions in the :1tmosphcre. :ind these arc known as secondary pollutants [9].

The chemical compounds that lower the air quality are usually referred to as air pollutants These ,,1111pounds may be round in the air in two major forms:

- Ina gaseous form (as gases).
- Ina solid form (as particulate matter suspended in the air)

ppm - 1.145 rng/1113

mg/m3 = 0.873 ppm

Values obtained from above calculations. the threshold value can be set to the requirements dynamic nature of the environment and to monitor the parameters data through sensorsl IO).

The safe level of air quality is 350 PPM and it should not exceed 1000 PPM. When it exceeds the limit of 1000 PPM, then it starts caus1.:' fieadaches, sleepiness and stagnant. stale, stuffy air and if ceeeds 2000 PPM then it causes increased heart rate and many other diseases. [II].

These are traditionally systems which monitors air pollution with stationary monitors. These monitoring stations are highly reliable. acctm=ite and able to 1111:asurc a wide range o!'pullutanls hy using the conventional analytical instruments, such as gas chromatograph-mass spectrom1:ters. a lot of assisting tools including temperature controller(cooler and heater). relative humidity cont ro I ler. air fi It er (for PM), an cl bu i Id-in ca Ii brat or [l 2 1

l '

Through A

1"11is system uses a variety of mobile sensing models to collect data from different scenarios. The s.:ns1ng models measures the concentration of pollutants, tag the pollution data with relevant mnformation, such as time, speed and location. It sends the data over a cellular data link to the cloud TeT Rel\\' pollution data is then processed and aggregated by the server lo make it available as . pollution'map. The rirst sensing model is designed for deployment on Public Transpurlm1un Infrastructure such as buses, which have fixed and reliable routes along high volume corridors. For this model, they use a custom-made Mobile Sensing Box (MSB) which ineludes a microcontroller board with add-on sensors, a peripheral GPS receiver and a cellular modem. Connecting to the bus ball cry \\'Ou ld provide the power supply needed to operate this model. The ~ccoml sensing model relies on air quality-aware drivers who install a Personal Sensing Device PSD) in their cars connected over Bluetooth to their smart phone[13].

1

1·1iis system consists of a set of sensor nodes. a gateway and *a* centralize control system provided by the Lab VIEW program. Each sensor node integrates with a Zig Bee communication link. a CO sensor and a battery. And the gateway is consisted of a Global System for Mobile (GSM) communication link and a wind speed and direction sensor. Data from the sensor nodes are uploaded to the gateway and further forwarded to the central system This system was deployed to the main roads in Taipei city and the experiment results illustrated that the systcm can provide rnicro-scalc air pollution information in real-time.[I 0].

Drawbacks of the related systems

- Resource wasting in certain level. The stationary sensor nodes arc in sleep mode most of the time because continuously updating data at one location is pointlessl 7J.
- Inconveniences of calibration and maintenance. The professionals need to visit all stationarv Sensor nodes. which is a time and manpower consuming task, to perform operations.
- 2-Dimensional data acquisition .Only the air quality of urban surface is monitored[7].
- The conventional monitoring instruments involve long-term time-consuming average models. The air pollution situation is updated hourly or even daily. Hence, the air pollution maps built by the conventional air pollution monitoring systems arc with extremely low spatial and temporal resolutions. Such low spatio-temporal resolution is sufficient for ambient background monitoring but extremely inadequate for the public to be aware or their personal exposure lo air pollution and cannot rellect their personal health risks/ l *2* /

Table 1: Showing the gaps between existing systems.

o.	**Eisting system**	**/ Advantngcs**	**Weaknesses**
	I/\'Real - tim~- i\ i r Quality Monitoring / Through Mobile Sensing	- It enables users to view real time pollution data overlaid on map - real-time air quality clatc1 collection due lo increase of cellular bandwidth	- It provides micro-scale air pollution information. 1- Low data acct1rncy reliability
I	vVSNhased urban L\ir C]ll<liity monitoring system	-easy to carry in terms of size and weight -Multiple sensors per node	-limited to only monitoring the air quality of mban surface
	Convecrional air Pollution monitoring svstcm	-highly reliable. -lt is accurate -it **measures a wide range** of pollutants	-large size. heavy weight. -expensiveness **-limited data availability** -high power consumption

Tl1is s_vstern is to be deployed into the industrial working area. after the system being installed. air quality sensor (MQ- l 35). temperature and hurnidi ty sensor (DHT I I) wi I l start to col leer the val ucs lrom the environment and depending on the parameters. it will update according to the delay values, the values are displayed on the screen of the Liquid crystal display. There is particular range for particular sensors and it will aet according to the threshold value by triggering the Red LED to flicker on and off. sending a notification to the industrial staff. The values of sensors are ,ilso stored at the back end saver for analysis purposes.

Accuracies of this system

This system keeps the Industry Management updated about the different parameters detected the sensors and it alerts them when conditions are beyond normal through the Flickering Red Led Indicator and green lighting Led for Normal conditions.

1.3 Problem Statement

With the increasing reports of health problems related to poor air quality such as respiratory diseases like asthma, lung cancer and acute respiratory infections in children and cardiovascular diseases such as ischemic heart disease and stroke resulting from air pollution exposure in industries has greatly claimed many lives and the industries have done less about it. Conventional **air quality monitoring approaches such as gas chromatography (GC) are limited with respect to** time, expense, and installation sites. Therefore, limited data is available for the estimation of ambient air toxins. Further, air quality monitoring systems built into compact, handheld devices have spatial and temporal limitations, since the measurements are conducted manually and this calls for a system that monitors air quality to allowable levels.

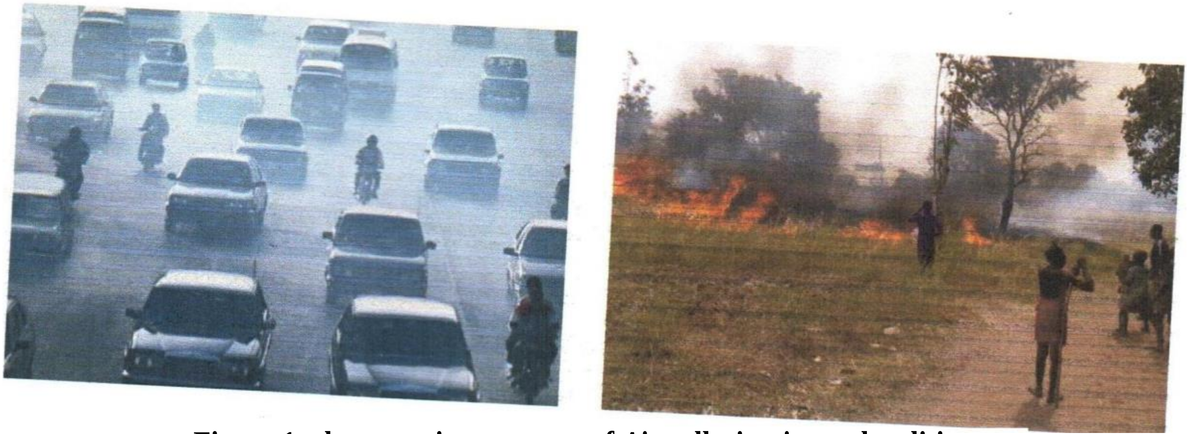


Figure 1: shows various sources of *Air* pollution *in* our localities

CHAPTER TWO: OBJECTIVES AND ESTIMATED OUTCOMES

Io develop an air quality monitoring and control system for industries and industrial setting

i) To study the currently used air quality monitoring systems if any used in industries ii) To design an air quality monitoring system from the study requirements.

iii) To design an air quality monitoring system from the design above.

iv) otest and validate the system developed.

The construction of an air quality monitoring system is a great focus of attention with increasing reports of health problems related to poor air quality. Detecting pollutants in the air and determining polluted areas using an air monitoring system is important as the initial process of common air-quality improvement techniques such as source control, improved ventilation. and air cleaning. Currently. most Industrial workers are always not aware of the presence of toxic air pollutants in their work environment and the Industries has done less in monitoring and then d\11trnl th,: different levels at which these pollutants become harmful. It the system is developed. it will provide data in real time and then remedial action taken to reduct' on amount of air pollutants in the working environment of industries

The prujject focuses on the development of an air quality monitoring. system for a typical Industrial setting. Air quality parameters including, Humidity and temperature are being monitored and alphanumerically displayed on a I *6x2* LCD. The device is based on an 8-bit Atmega328P MCU interfaced with several parameter sensors, when the parameters deviate from normal. the system ,, ill always trigger the red Led indicator to brink continuously clue to occurrence or the above

conditions.

‹)net' the kmperc1tme. air quality or Humidity is detected to be 0111 of normal range for an industrial setting. action is taken to regulate the condition by either switching on funs or Air conditioners for proper ventilation enhancement. This reduces on the toxic gases. reduces the temperatures and improves the humidity of the industrial environment.

. \uto mar ,ca II y connec,; ng and d tScon nccr i ng of fans and air cond,r ionecs when the cond, I ions get UV *ol* range or return to normal is an energy saving strategy in an ind@z

The System has been developed for lhe lndus1ncs lo monitor, air pollution and alert Industries I rim in ,st rn I ,on on the ongoing air pollu Ii on, Temperature and fl um ,di I *y* cond,r ions *in* the Hustr. T*he* device features a Universal Asynchronous Receiver Transmitter (UAR[g,

Development of the system took us about six months.

The de, ,ce ace u racy is d u·ec ti *y* rlependen I on *the* senso,s qua Ii r *y* used.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter explains the procedures and methods that shall be used in project requirement. c1nalysis, diagrammatic frame works, documentation, purposes and relevancies of the methods and the techniques that will be used to meet the above mentioned objectives.

Finding the appropriate research methodologies is very critical in drawing up model systems to identified problems. This chapter therefore is such an important stage in the proposed system development because it acts as the foundation study to determine the rcqt11rcrncnts nccessc1ry !or the proposed system.

;\ number of research mechanisms are expected to be utilized in collecting datc1 needed to c1ccornplish the project through the above stated procedure. The major ones include:

!"his \.\<IS mainly conducied from the people that have technical knowledge about air pollution

Tl1is is the process of defining user expectations for a new product being built or modified taking account of the possibly conflicting requirements of the various stakeholders, analyzing. documenting, validating and managing software or system requiremenb. This describe~ the respective system requirements that are captured by the system. Such requirements are classified into funciional and non-functional requirements

nal Re

l't1nctional requirements captured the intended behavior of the system. This behavior may be expressed as services, tasks or functions the system is required to perform.

on-functional requirements may also be referred to as system qualities for example reliability. They captured required or desirable properties of the system.

3.4 System Design

Before implementation of any system, there was need to have a professional design. In this project, there is software and hardware (physical components) to design all the components of the system.

3.4.1 Hardware

To design the hardware components of the system prototype, the following tools/resources were used.

- NODEMCU 8266 WIFI CHIP
- Red and Green LEDS.
- Liquid crystal display HD44780.
- Electronic components (Diodes, capacitors, resistors, and transistors). Different components were used to regulate and direct rightful amounts of current in the system.
- MQ-135 Sensors for Air quality
- DHTI 1 sensor for temperature and humidity.
- PC

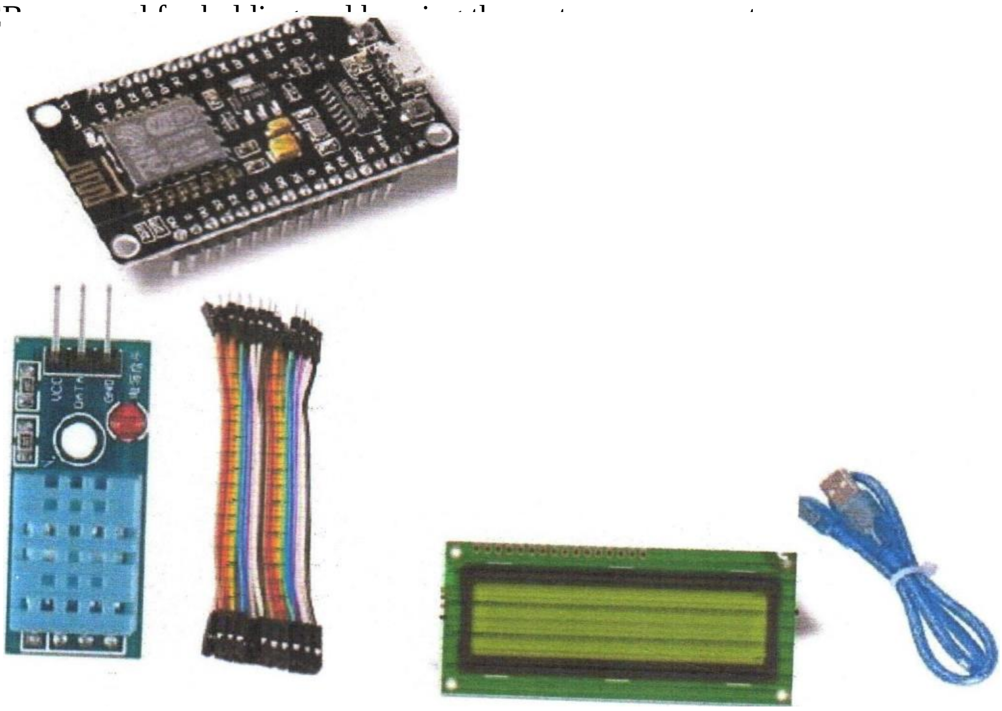


Figure 2: Shows hardware components required for the proto type

To design the software components of the system prototype. the following tools shctll be used. Operating System: Windows

Domain: Internet of Things

IDE Arduino

I ,rnguage: Embeddec! C. HTML

llll' Protocol: HTTP Protocol

pplication: ThingSpeak *Embedded*

C Programming

It is a language extension of *C* Programming which was developed to address the common issues between *C* extensions for different embedclec! systems.

Google firebase

It helps the developers ro build real-time applications for IOT. Which is one of the mobile platform by sending messages and notifications. It is also known as GCM.

I ITl\11. stands for llyper Text mark-up language.

1 **l** lTM L is ;:i structure of web content mistreatment mark-up.

~l lTM Li~ an area of building blocks with mark-up language pages. **. I** lTl\ **l** parts area unit delineate by lags.

CSS

CSS is a language that describes the design of <1ssocic1te hypertext mark-up language document. CSS describes however hypertext mark-up language parts ought to be displayed.

/-frJP

Monitoring the board over ne1. a webpage is meant that uses .JavaScript to urge information frorn the: board mistreatment HTTP POST technique. The web page iclenti fies the board by a tool ID ;1ssocic1ted connects to the Particle's Cloud Service through an access token.

Srn\ing **dcrntnl (S<.'llStffS).** This is c1n air quality sensor that detects gases and sends signals after taking a given measurement to the micro controllei- unit respectively.

Micro-controller. Is a computer on a single chip with all lecltures of *a* computer

Red LED indicator. This is an indicator which flickers on and off corrcsponcling to the signals from the sensing elements when the preset values are exceeded.

Liquid Crystal display. Was used in this system to display the results or the different conditions being detected by the sensor module.

The system consists of both hardware and software. The system implementation was achieved \\ hen sensing devices were connected lo the embedded computing system lo monitor the fluctuation of parameters in air pollution levels from their normal. The program was coded in embedded language in Arduino: it did go through various levels of simulations to ensure the Stem attains the required standard. The program was loaded onto the microcontrollcr. Controlling actions were taken depending upon the conditions. like fixing the threshold value. periodicity or sensing.

The developed system w:1s tested using different techniques and these include:

This method involved testing individual units of source code or development process to determine whether they are fit for use. This included testing all the different modules and classes independently.

The system automatically and continuously reads the input from MO-135 sensor for Air quality. l)Tl 111 for temperature and humidity, whenever the levels or air Qt1ality. temperntun.:- ;incl humidity goes beyond normal. the system triggers the Red Led On when air quality pncentage goes above I5%, temperature goes above 30 degrees and humidity below 50%as per the preset parameters.

Requirements Analysis

Requirement elicitation was done to determine functional requirements and non-functional requirement that fovor or hinder functionality of the system.

These requirements often result into a functional model that includes all the hierarchical breakdown of the major lt111ctional blocks or the system. They serve as the basis for the system testing and validation. The rnain functional requirements for this project include:

- The system's ability to automatically determine the normal and abnormal temperature. percentage of air quality. humidity and compare with threshold \,tlue coded in the microcontrol ler.

- Thl· system's ability to trigger the red led on so that the Industry management is alerted.

While designing the system. some non-functional requirements were achieved therefore rhe system users by using this system will gain the fol lowing results:

- Perf'ormance requirements: the system will have a fast response time in that it responds quickly to a change in the air quality readings humidity and temperature readings.
- Availability: The system will be able to run 24/7.

The system also will be able to perform a lot of computations and still function effectively.

- Efficiency: The system is able to provide real time information without any intervention. thus rw,intaining tile correct outpub ever.
- Rc.'liability: The systern is able to give only right output since it cannot be manipulated like human being.

n **po** '

System design is the process of defining the architecture, components, modules. interfaces and data for a system to satisfy specified requirements. lt can be seen as the application ot systems theory to product development[I6]. This system architectural design gives c1 high level view of the .system with the main components of the system, the services each component provides and how the difle rent components communicate to the system.

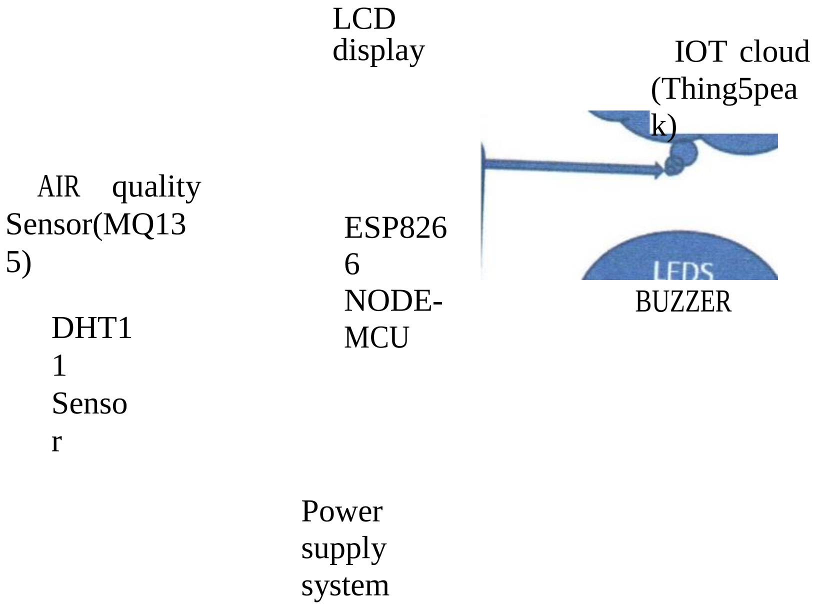


Figure 3: showing system block diagram

3.9.2 The Physical Design;

This describes how the application can be developed/implemented on a physical platform. It represents how the logical design can be implemented on the physical platforms using appropriate technologies.

Sensing elements. These comprise of the air quality sensor, humidity and temperature sensor, their purpose is providing the notification signals in case of increase or decrease in air quality percentage gas levels, temperature and humidity, then the readings are taken to the microcontroller to compare with the logic flow.

3.9.3 MQ-135 Semiconductor Sensor for Air quality

Sensitive material of MQ-135 gas sensor is Sn02, which with lower conductivity in clean air. It makes detection by method of cycle high and low temperature, and detect quality of air when low temperature (heated by 1.5V). The sensor's conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it cleans the other gases adsorbed under low temperature. MQ-135 gas sensor has high sensitivity to air quality. The sensor detect different gases that are harmful to human health, it is with low cost and suitable for different application[l 7].

According to the output voltage to calculate the resistance ratio is as follows:

The sensor in the relatively clean air for more than half an hour, After measuring the output voltage of Aout:

RO_!"_RL V /:
I,

VCC power supply voltage DC5V, RL for the load resistance, VRL = Aout.
When the sensor detects the gas, measured Aout value, It can be calculate the RS value.

$$RS! \frac{MR}{VRL} RL$$

The VRL value at this time is the Aout value after the gas is detected, and the value of the above formula is different from the above formula.

The VCC value and the RL value are the same as above. Get RO and RS value, you can Figure 3 by the RS/ RO value of the gas into the specific concentration value. (0-10V output is 0-5V output through the circuit to enlarge 2 times, so the calculation

method is the same as the VCC is based on the 5/.)

.VIQ 135 Sensor pre hen ting.

The MQ135 is preheated due to the fact that we want stable values when carrying out measurements. Please be clear when you mean the one time only pre-heat and when you mean turning the sensor on to take a measurement, It is an electrochemical sensor and it needs time to burn-in. During those 24 hours, the impedance of the sensor changes a lot. After those 24 hours it can be used in a normal way and it will return constant values.

Ilic pt·c-hear should be done just once. I mec111: just once in the lifespan of the sensor. After buying it, you should run the pre-heat. When the manufacturer writes in the datasheet that the pre-heat time is 24 hours. then you should do 24 hours. I suggest to connect the sensor in a 11or1nal \\ ;1y. with 'A' and 'B' pins connected and with the load resistor, and keep it on for *24* hours. Maybe it is already stable after a few hours. but keep it on for *24* hours to be sure

Tu take a measurement, the sensor needs time to warm up. /\bout 5 minutes might be okay. think that 2 minutes is definitely too short.

When the sensor is always at room temperature, and the time to warm up is always the same. then the measurement is relative accurate and can be compared with other measurements. That means that when the sensor is mostly turned off to save power, only a few minutes to warm up l·,rn be used. l lo\\'evcr, J would start with at least 5 minutes.

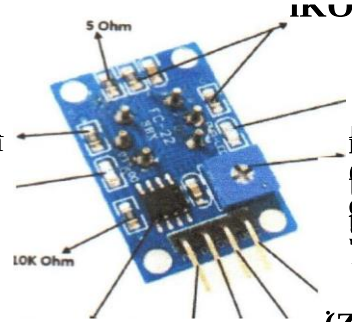


Figure 4: showing the MQ-135 sensor

Sensitive material ofMQ135gas sensor is Sn02, which with lower conductivity in clean air. When target pollution gas exists, the sensor's conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit.

MQ135gas sensor has high sensitivity to ammonia gas, sulfide, and benzene series steam, also can

monitor smoke and other toxic gases well .It can detect kinds of toxic gases and is a kind of low-cost sensor for kinds of applications.

Features

It has good sensitivity to toxic gas in wide range, and has advantages such as long lifespan, low cost and simple drive circuit. It is widely used in domestic gas alarm, industrial gas alarm and portable gas detector. MQ sensors have to be powered up for a pre-heat duration for the sensor to warm up before it can start working. This pre-heat time is normally between 30 seconds to a couple of minutes. When you power up the module the power LED will turn on, leave the module in this state till the pre-heat duration is completed.

Technical Specifications of MQ135 Gas Sensor

- Operating Voltage: 2.SV to 5.0V
- Power consumption: 150mA
- Detect/Measure: NH3, Nox, CO2, Alcohol, Benzene, Smoke
- Typical operating Voltage: *SV*
- Digital Output: 0V to *SV* (TTL Logic) @ *SV* Vee
- Analog Output: *0-5V@ SV* Vee

Table 2: Shows Technical parameters

Model			MQ135
Sensor			Semiconductor
Standard Encapsulation			Bakelite, Metal
Target			ammonia **gas**, sulfide, benzene series steam
Detection range			10-- 1000ppm(ammonia gas, toluene, hydrogen, **smoke)**
Standard Conditi	loop Voltage	v.	<24v DC
	Heater	v.	5.0V+0.1V AC or
	load	R	Adjustable
Sensor under conditions	Heater	R,	29O±3O (room
	Heater	P,,	<950mW
	Sensitivity	s	Rs(in air)/Rs(in
	Output	V	2.0V-4.0V In
	Concentration	a	<s0.6(Roa/Pao
Standard conditions	Tern. Humid		20c±2. 55%±5%R
	Standard test		Vc:5.0V±O.lV V: 5.0V+0.1V
	Preheat time		Over **48** hours

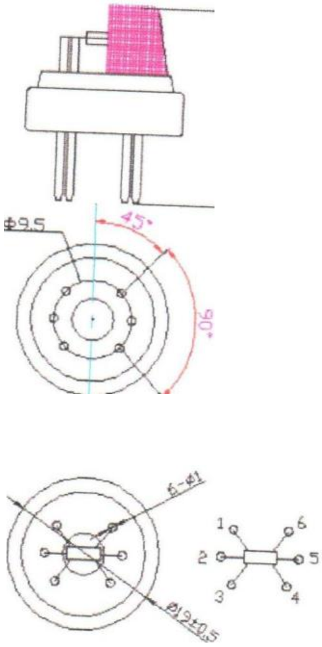


Fig1.Sensor Structure

Cautions

Following conditions must be prohibited

- Exposed to organic silicon steam

Sensing material will lose sensitivity and never recover if the sensor absorbs organic silicon steam. Sensors must avoid exposing to silicon bond, fixature, silicon latex, putty or plastic contain silicon environment.

- High Corrosive gas

If the sensors are exposed to high concentration corrosive gas (such as H2S, SOX, CI2, HCI etc.), it will not only result in corrosion of sensors structure, also it cause sincere sensitivity attenuation. Alkali, Alkali metals salt, halogen pollution. The sensors performance will be changed badly if sensors be sprayed polluted by alkali metals salt especially brine, or be exposed to halogen such as fluorine.

- Touch water

Sensitivity of the sensors will be reduced when spattered or dipped in water.

- Freezing

Do avoid icing on sensor's surface, otherwise sensing material will be broken and lost sensitivity.

- Applied higher voltage

Applied voltage on sensor should not be higher than stipulated value, *even* if the sensor is not physically damaged or broken, it causes down-line or heater damaged, and bring on sensors' sensitivity characteristic changed badly.

Table 2: Shows Technical parameters

Model			MQ135
Sensor			Semiconductor
Standard Encapsulation			Bakelite, Metal
Target			ammonia gas, sulfide, benzene series steam
Detection range			10--1000ppm(ammonia gas, toluene, hydrogen, smoke)
Standard Conditions	loop Voltage	V.	<24v 0C
	Heater	v.	5.0V+0.1V AC or
	load	R	Adjustable
Sensor under conditions	Heater	R,	290±30 (room
	Heater	,	<950mW
	Sensitivity	s	Rs(in air)/Rs(in
	Output	V	2.0V-4.0V In
	Concentration	a	<0.6(Ro/Pus H)
Standard conditions	Tern. Humid		20C±2, 559%6±5%
	Standard test		Vc:5.OV±0.1v V: 5.0V±0.1v
	Preheat time		Over *48* hours

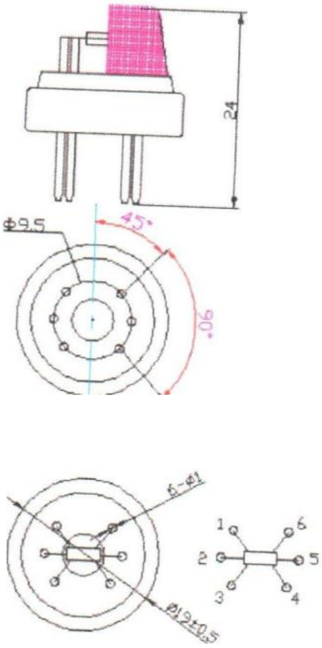


Fig1.Sensor Structure

Cautions

Following conditions must be prohibited

- Exposed to organic silicon steam

Sensing material will lose sensitivity and never recover if the sensor absorbs organic silicon steam. Sensors must avoid exposing to silicon bond, fixature, silicon latex, putty or plastic contain silicon environment.

- High Corrosive gas

If the sensors are exposed to high concentration corrosive gas (such as H2S, **SOX,** Cl2, HCI etc.), it will not only result in corrosion of sensors structure, also it cause sincere sensitivity attenuation. Alkali, Alkali metals salt, halogen pollution. The sensors performance will be changed badly if sensors be sprayed polluted by alkali metals salt especially brine, or be exposed to halogen such as fluorine.

- Touch water

Sensitivity of the sensors will be reduced when spattered or dipped in water.

- Freezing

Do avoid icing on sensor's surface, otherwise sensing material will be broken and lost sensitivity.

- Applied higher voltage

Applied voltage on sensor should not be higher than stipulated value, even if the sensor is not physically damaged or broken, it causes down-line or heater damaged, and bring on sensors' sensitivity characteristic changed badly.

• Voltage on wrong pins

For 6 pins sensor, Pin 2&5 is heating electrodes, Pin (1,3)/(4,6) are testing electrodes (Pin 1 connects with Pin 3, while Pin 4connects with Pin6).lf apply voltage on Pin 1&3 or 4&6, it will make lead broken; and no signal putout if apply onpins2&4.

3.9.4 Node MCU8266

Microcontrollers have small internal memory which is not enough to save sensors generated data for long time, either you have to use some external memory device or can save the data on some cloud using internet.

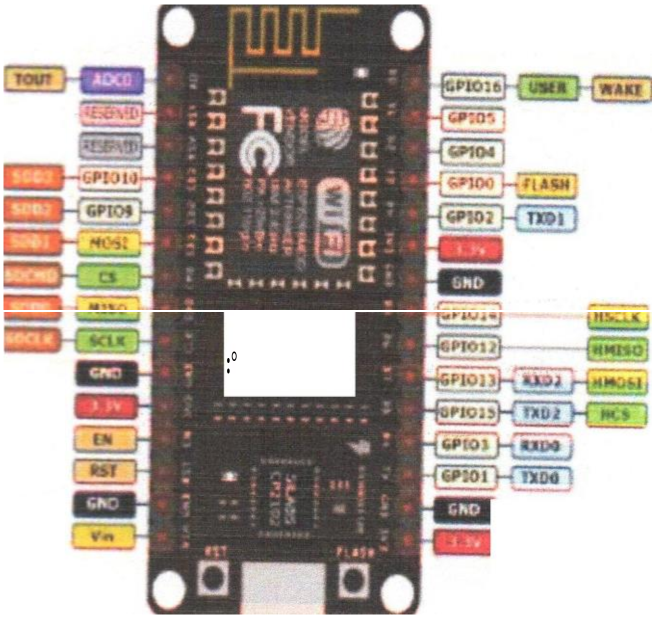


Figure 5: Node MCU8266 Top-view

Internal components.

The following are the internal components of ESP8266 Node MCU.

Internal SRAM and ROM

ESP8266EX WI-Fi SoC is embedded with memory controller, including SRAM and ROM. MCU can visit the memory units through iBus, dBus, and AHB interfaces. All memory units can be visited upon request, while a memory arbiter will decide the running sequence according to the time when these requests are received by the processor.

According to our current version of SDK provided, SRAM space that is available to users is assigned as below:

·RAM size < 36kB, that is to say, when ESP8266EX is working under the station mode and is connected to the router, programmable space accessible to user in heap and data section is around 36kB.).

• There is no programmable ROM in the Soc, therefore, user program must be stored in an externalSPlflash.

External SPI Flash

This module is mounted with a 4 MB external SPI flash to store user programs. If larger definable storage space is required, a SPI flash with larger memory size is preferred. Theoretically speaking, up to 16 MB memory capacity can be supported.

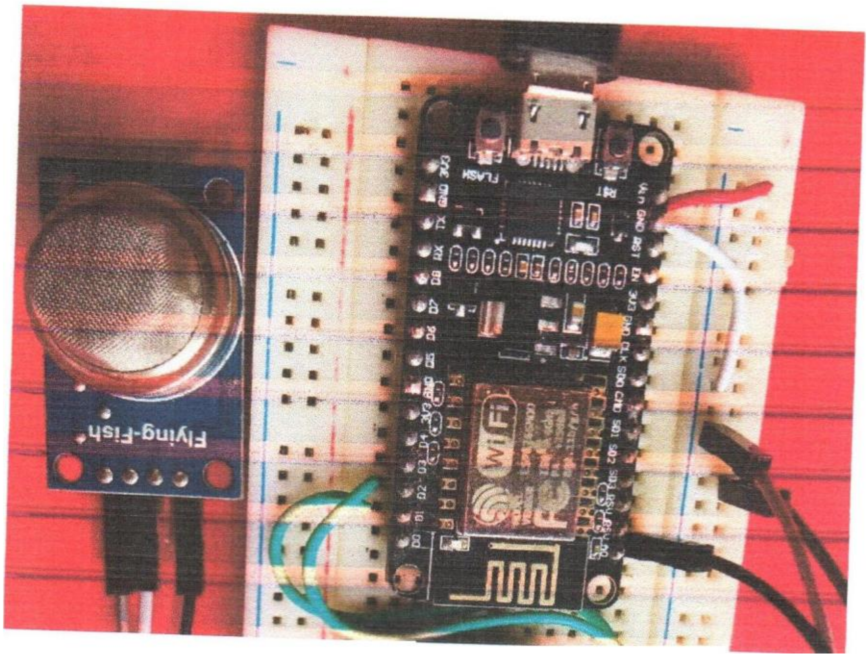


Figure 6: showing NODE

MCU Suggested SPI Flash memory capacity:

•OTA is disabled: the minimum flash memory that can be supported is 512 kB;
·OTA is enabled: the minimum flash memory that can be supported is 1 MB.

Several SPI modes can be supported, including Standard SPI, Dual SPI, and Quad SPI. Packages)

Crystal

Currently, the frequency of crystal oscillators supported include 40MHz, 26MHz and 24MHz. The accuracy of crystal oscillators applied should be ±10PPM, and the operating temperature range should be between -20°C and 85°C.

When using the downloading tools, please remember to select the right crystal oscillator type. In circuit design, capacitors Cl and C2, which are connected to the earth, are added to the input and output terminals of the crystal oscillator respectively. The values of the two capacitors can be flexible. ranging *Crom* 6pF to 22pF. however, the specific capacitive values of CI and C2 depend on further testing and adjustment on the O\'erall performance of the whole circuit. Normally, the cc1pacilive values of CI and C2 are within l0pF if the crystal oscillator frequency is 26MHZ. while the values of Cl and C2 are I0pF<Cl. C2<22pF ii'the crystal oscillator frequency is 10MHz

Programmable Watchdog Timer wirh internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRJ\M. Timer/Counters, USART. 2-wire Serial Interi'c1cc. SP! port. and interrupt system to continue functioning The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip !'unctions until the next interrupt or hardware reset. In Power-save mocle. the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest or the device is sleeping. The ADC Noise Reduction mocle stops the CPU and all I O modules except JS)[1]nchronous timer and *A*DC. tu

minimize switching noise **during ADC** conversions. In Standby mode. the crystaL'resonator Oscillc1tor is running while **the rest of the** device is sleeping. This allows very fast start-up combined with low power consumption.

\ **V R** reset:

The AVR RESET mode is an active **low** module on RESET pin Pulling the RESET pin HIGH disables the unwanted system resets. **Pull-up** resistors on the d(RESET) line must not be smaller than !Ok (datasheet page 256). The pull-up resistor is not required for debug WIRI: functionality. I lowever. connecting the RESET pin Jire.:tl~ tu \'CC will not work in disabling the reset mode.

Clock Sources

The device has the following clock source options, selectable by Flash Fuse bits as shown below. -;-he clock from the selected source is input to the *A* VR clock gcncr,1tor, and routed to the pproprate modules.

Table 3: Device Clocking Option:; Select. Source: device datasheet

Device Clocking Option	CKSEL3...0
LJvv :::,o·:.:,?r CrvsL:il Oscillaior	li 11 - 1000
Full ::;w ng Cr'iSlal OscillItor	0111 - 0110
Low Frequency Crystal Oscillator	0 IO 1 - 0100
Internal 128kHz RC Oscillator	001 1
Calibrated Internal RC Oscillator	
teal lack	20 0
F:eser·1ec1	C00 1

Ne For al fuses I means unprogrammed while O means programme]

The device is shipped with internal RC oscillator at 8.0MHz and with the fuse C'l<DIV8 programmed, resulting in J .OM Hz system clock. The startup time is set to maximum and time-out period enabled. (Cf(SEL = "00 IO", SUT= "IO", CKDTV8 = "O"). The default setting ensures that :ill users can make their desired clock source setting using any available programming interface. f_()w Power Crystal Oscillator

Pins XTALI and XT/\L2 arc input and output, respectively, or an inverting amplifier which can be configured for use as an On-chip Oscillator.

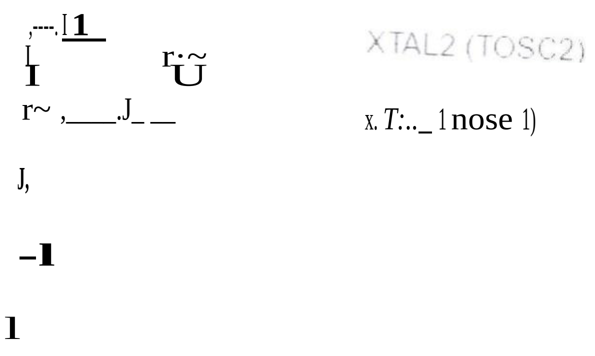


Fig 4. I: **Crystal Oscillator Connections**

J ithcr a qu~rtz crystal or a ceramic resonator may he used. This Crystc1l Oscillator is a low power llscillator, with reduced voltage swing on the XT.!\L:2 output. Jt tlivcs the lu\\cst po11cr consumption. but is not capable of dri\'ing othn clock inputs, and may be more susceptible: to nnise in noisy environments. Cl and C~ should always be equal for both crystals and resonators. he opt i111c1l value of the cc1pacitors depends on the crystal or resonator in use. tlw amount of stray

.:li.mce. and the electrom.ignetic noise or the environment. Some initial guidelines for **osing** capacitors for use with crystals are given below:

able 4: Low Power Crystal Oscillator Operating Modes.

77PHI	Recommended Range for Capacitors C1 and C2 (pF)	CKSEL3..1
0.4 - 0.9		100
0.9 - 3.0	12-22	1O1
3.0 - 8.0		11'.J
8.0 - 16.0	i2 - 22	11

Jl1D162A is a 16x2 LCD module based on the **HD44780 driver from Hitachi.**

fhe JI IDI62A LCD module has 16 pins and can be operated in 4-bit mode or 8-bit mode. I !ere **e** are using the LCD module in 4-bit mode. Before going in to the cletaib or the project. let's ave a look at the .JHD 162A LCD module. The schematic of a JI-TD 162A LCD pin diagram is en below.

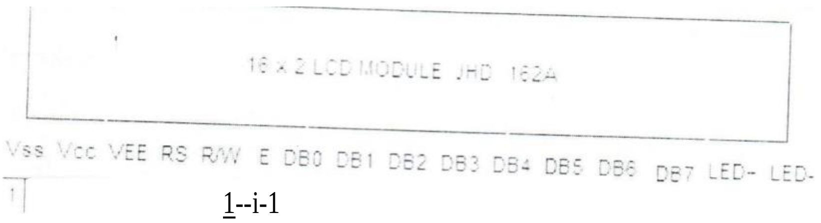


Figure 7: Shows an LCD

The name and functions of each pin of the 162LCD mociule is given below.

- Pin I (Vss): Ground pin of the LCD module.
- Pin2 (Vee): Power to LCD module (+5V suppJy is given *to* this pin)
- Pin3 (VEE): Contrast adjustment pin. This is done by connecting the ends of a I OK potentiometer to +5V and ground and then connecting the slider pin to the VEE pin. The voltage at the VEE pin defines the contrast. The normal setting is between 0.4 and 0.9.
- Pin4 (RS): Register select pin. The JHDI62A has two registers n,rnwly commcmcl register and data register. Logic HIGH at RS pin selects data register anci logic LOW al RS pin seleets command register. If we make the RS pin HIGH and feed an input to the data lines

(DBO to DB7). this input will be treated as data to display on LCD screen. l f we make the RS pin LOW and feed an input to the data lines, then this will be treated as a command (a command to be written to LCD controller like positioning cursor or clear screen or scroll).

- Pin5(R/W): Read/Write modes. This pin is used for selecting between read and write modes. Logic HlGH at this pin i1ctivates read mode and logic LOW at this pin activates write mode.
- Pin6 (E): This pin is meant for enabling the LCD module. A HIGH to LOW signal at this pin will enable the module.
- Pin7 *(0130)* to Pin I4(DB7: These are data pins. The commands and data are led to the LCD module though these pins.
- Pin I5(LED+): Anode of the back light LED. When operated on SY. a 560 ohm resistor should be connected in series to this pin. In Arduino based projects the back light LED c:m be powered from the 3.3V source on the Arduino board.
- Pinl6 (LED-): Cathode of the back light LED.

RS pin of the LCD module is connected to PB L. R W pin of the LCD is grounded. Enable pin of the LCD 111odule is connected to PB2. In this project. the **LCD module and A YR controller are** interfaced in the 4-bit mode. This means only four of the digital input lines (DB4 lo DB7) uftlie I.CD me used. This method is very simple, requires less connections and you can almost utilize the full potential of the LCD module. Digital lines DB4, DB5. DB6 and DB7 are interfaced to digital pins PDS, PD6, PD7. and PB0. The I 0K potentiometer is used for adjusting the contrast of the display.

The DHT22 is the most expensive version which obviously has better specifications. Its temperature measuring range is from -40 to +I25 degrees Celsius with -0.5 degrees accuracy. while the DI-IT! l !cmperature range is from 0 to 50 degrees Celsius with f--2 degrees accurncy . . \!so tl1L: Dlff22 sensor has better humidity measuring range, from Oto *100%* with 2-5% <1ccuracy,
while the DHT humidity range is from 20 to 80% with 5% accuracy.

i.- ....
~-
iii

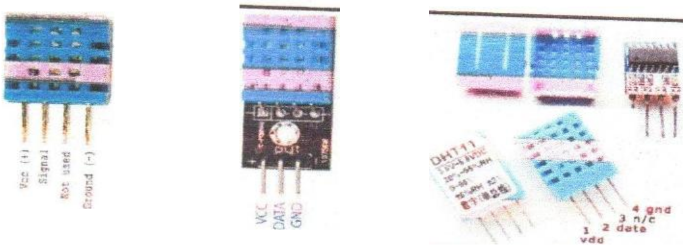


Figure 8: Shows DH11 and its parts

There are two specifications where the DHTI 1 is better than the DHT22. That's the sampling rate which for the DHTI 1 is I Hz or one reading every second, while the DHT22 sampling rate is 0.5Hz or one reading every two seconds and also the DHTH has smaller body size. The operating voltage of both sensors is from 3 to 5 volts, while the max current used when measuring is 2.5mA.

They consist of a humidity *sensing* component, a NTC temperature sensor (or *thermistor)* and an IC on the back side of the sensor.

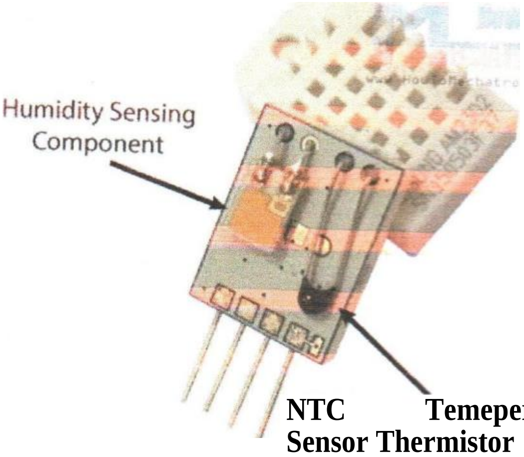


Figure 9: DHT11 sensor: source: https://howtomechatronics.com

For measuring humidity they use the humidity sensing component which has two electrodes with moisture holding substrate between them. So as the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes changes. This change in resistance is measured and processed by the IC which makes it ready to be read by a microcontroller.

The DHTI 1 detects water vapor by measuring the electrical resistance between two electrodes. The humidity sensing component is a moisture holding substrate with electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes.

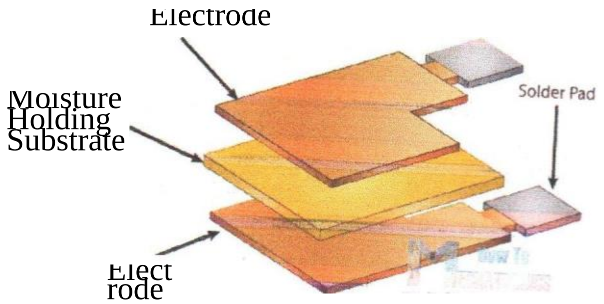


Figure 10: shows internal parts of DHT11

On the other hand, for measuring temperature these sensors use a NTC temperature sensor or a thennistor. A thennistor is actually a variable resistor that changes its resistance with change of the temperature. These sensors are made by sintering of semi conductive materials such as ceramics or polymers in order to provide larger changes in the resistance with just small changes in temperature. The term "NTC" means "Negative Temperature Coefficient", which means that the resistance decreases with increase of the temperature.

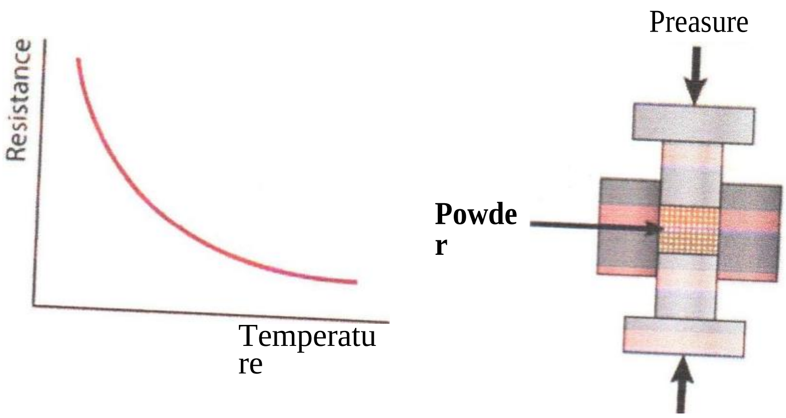


Figure 11: Curve showing relationship between temperature and resistance

The DHT11 measures relative humidity. Relative humidity is the amount of water vapor in air vs. the saturation point of water vapor in air. At the saturation point, water vapor starts to condense and accumulate on surfaces fanning dew.

The saturation point changes with air temperature. Cold air can hold less water vapor before it becomes saturated, and hot air can hold more water vapor before it becomes saturated.

The fonnula to calculate relative humidity is:

$$RH = ()r100' \; p,$$

RH: Rclafiff Humidity p:
Density of water vapor
p: *Density of water vapor at saturation*

Relative humidity is expressed as a percentage. At 100% RH, condensation occurs, and at 0% RH, the air is completely dry.

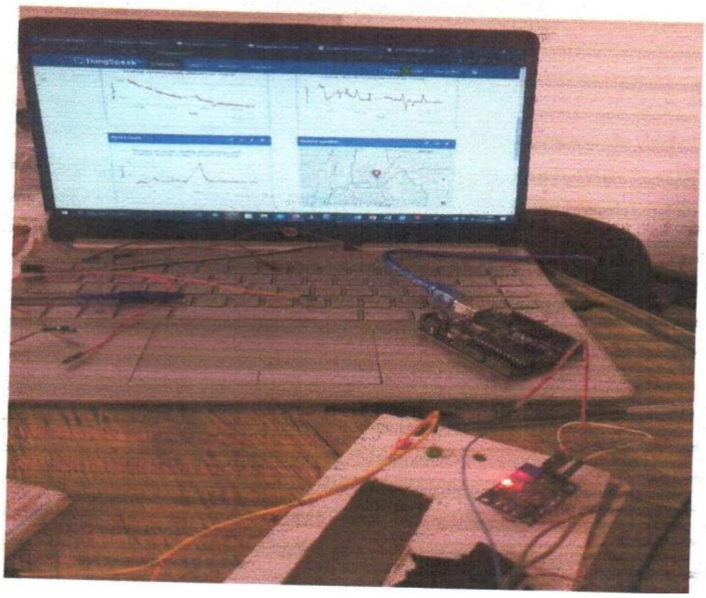
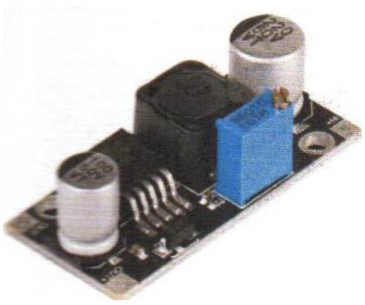


Figure 12: showing assembling of components DC-DC Converter Circuit

A DC Chopper is commonly known as DC-to-DC converter is an electronic device. It converts unidirectional direct current (DC) from one specified voltage level to another desired voltage level. It is an electric power converter. Moreover, the Power levels range from exceptionally low amp batteries to extremely high-voltage power transmission.



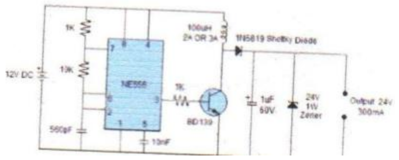


Figure 13: showing back converter 4.8 *7805* Voltage regulator (12 DC power supply).

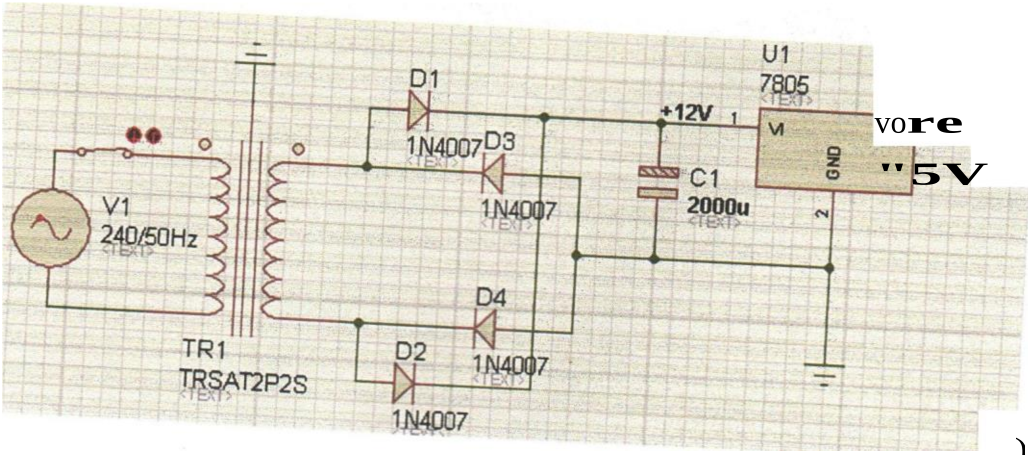
The L7805 series of three-terminal positive regulators is available in TO-220 TO-220FP TO-3 and D2PAK packages and 5V fixed output voltage, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. This regulator type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over lA output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents. The device outputs a stable 5V for any input in range of 7V to 18V DC.

Power Supply Unit

The Power Supply Unit consists of a 240 V, 50 Hz alternating current source that is stepped down to approximately 9.5 V by a step-down transformer. The 9.5 V AC is rectified using a full wave bridge rectifier and smoothened by shunt capacitor filter to 12 V DC. The 12 Vis regulated to *5* V, which is fed to the microcontroller, buzzer and gas sensor.

Figure 14: shows a center tap transformer

r



)

Figure 15: rectification circuit

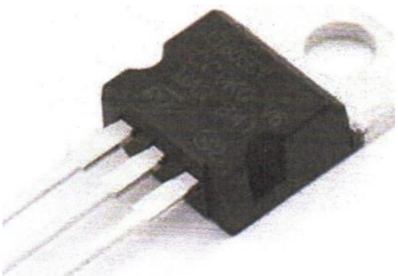


Figure 16: LM78O5 Voltage Regulator

Figure 12 shows a typical example of a step-down transformer, circuit diagram of the proposed power supply and an LM7805 voltage regulator respectively.

Sizing of Power Supply

The turns ratio and the desired output voltage are determined according to the following calculations (Theraja and Theraja, 2005):

$$\frac{1}{151rc}$$

$$C = \frac{1}{4V3fyR,} \quad (3.1)$$

Since a very smooth clc is required, a ripple foctor of 0.0 l was used.

Load Voltage

f-?L ==-----*Load Current*

R, = 52.60 .(1

1

C == --------

43 50 X 0.03 X 52.60

C == 1.88 *mF* = 2 *mF*

Vrp a= 1 'tr, (3.2)

(1)

»=?l'ti-aaaa 1–

bi = 12.60 *v*

Peak ***secondary*** *voltage*= J 2.60 + (2 x *0.7)*

== 14 *V*

Peak ***primary*** *voltage* == 339.40 *V*

El *JZ:* 339.10 24

Turns ratio ==·== ·==--= -

E, *Le* 14 1

Where: *y* ripple factor of the **rectified voltage** r- line frequency

(·=·shunt capacitance

RL =- load resistance

Va= de voltage

Vir-- peak full-wave rectified **voltage at *filter*** input l:1 = peak primc1ry voltage

E~ = peak secondary voltage

L. primary transformer inductance L~--,,. secondary transformer inductance

Table 3 5 shows the obtained values of lhe calculated parnmeters

able 5· Calculated Values

Peak primary oltage	339.41 V
Peak secondary voltage	14 .00 V
Transformer turns ratio	24: I
Voltage...sop _ ,,eachdiocte(Silicon)	0.70 V I
Peak full-wave *re* **tified** voltage at filter input	:2.60 V
Shunt capacitance	2000 pF
Ripple factor	0.03
Unregulaiec! **outp t** \Oliage	12.00 V
Regulated **output voltage**	5.00 V
Load resistance	52.60 2

(**'onnectors** (" **i,·es)**

These are signal **carriers that transfer** signal inform of voltage values from one point to another in the circuit.

z4
ii@ti

figure 17: Connector (For wires)

IMPLEMENTA ON AND **TESTING**

TI Introduction

This chapter dis::::ss,,-. ~ p::;,::::::r,:~3- explaining the different tools used while developing the system, the minimum **hara** requirements needed for the deployment of the system, how the system will ope:- .a '.!::I:: b:,:;;'.-ct ~ ::>e used.

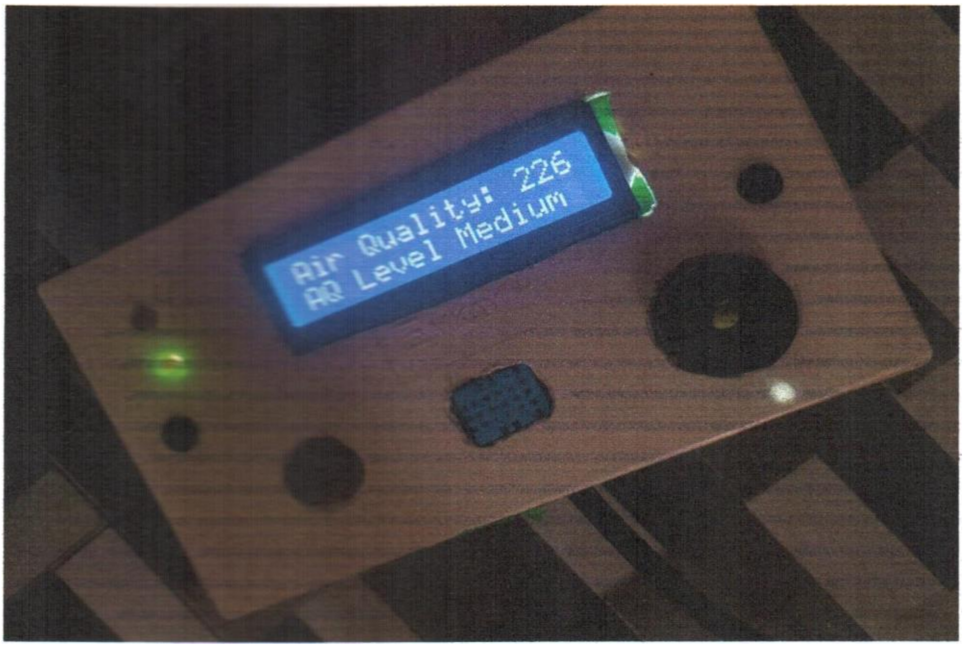


Figure 18: Shows final assembled proto type

Arduino programro~~ ·.....,..:..-!.::::-=' ~ zn implementation of Wiring, a similar physical computing platform, which is **based** on the Processing multimedia programming environment[23].

Air quality, temperature and humidity

When a given level of temperanure, humidity and air quality is detected by the sensor the readings are displayed on the liquid rysal display (LCD), then if the levels set are reached then the green led will be on but **when conditions** set are exceeded then the Red led is triggered on telling him them "POOR AIR QUALITY

System Testing

This was conducted on a complete. integrated system to evaluate the system's compliance with its speci Cied requirements. For module unit testing, the C code (program) was tested first. before it was embedded, and it was running without errors. This included the source codes for implementing the sensor unit, microcontroller operations and control functions. Also, the independent hardware l'()lllponents of the system were tested before connection. As for integrated system testing. after ,·rnbcdding ,11! the *C* source codes onto the microcontroller. c1ncl connecting c11l the other components on the Printed circuit board. the system w;1s tested !'or inter-process communication
and it was a success.

System Verification

This was done to ascertain that the system was meeting its specification and delivering the functionality it was expected to do. The system was checked !or acct1r;;tcy. perforirn1ncc. and completeness.

1\ccuracy: The system was checked to find whether it was working well at different intervals of time and in all the tests carried out correct results were output and this was viewed over thingspeak platform which enabled reading of real time results. This proved that system is :ll.'CUr,lte. Performance: The system was checked to find out the time it takes to react to any abnormal condition, when air quality, temperature and humidity level are exceeded and output the results. the system response was fast. This proves that the system's performance is good

Completeness: The system was checked to find out whether all the functionalities specified durine the design stage were satisfied. The system had all the functionalities and was therefore declared complete.

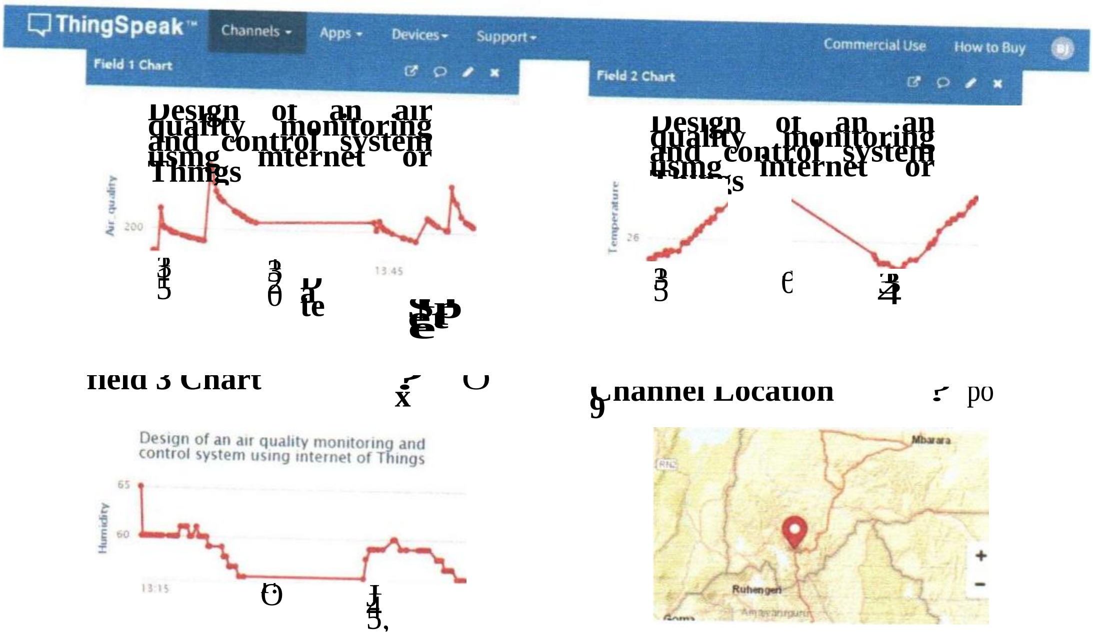


Figure 19: Shows graphical representation of data fed from sensors to Thingspeak platform ***Validation of the system***

During the implementation process, verification of the system was performed by checking that the system was meeting the specified functional and non-functional requirements. This is where I tested the system functionality against the requirements.

This was done by connecting the air quality (MQ-135) sensor, DHTI I sensor for temperature and humidity, LCD, and other components to the microcontroller and establishing the communication between them and the system was running normallySystem evaluation

The developed system once deployed will meet all of the required objectives that is detecting the air quality, temperature and humidity levels from industrial indoor environment, comparing sensed data with the programmed threshold values in the microcontroller, taking an action by triggering the Red LED on, when conditions are abnormal.

Comparing my system with other related ones;

- This system will consider some of the most problems industrial workers and administrators face while carrying on their duties and also help administration know how to preserve both health and environment. When compared to others it is cheaper to deploy hence it will be affordable by majority. The other related system' focus is only put on monitoring, storing data and the source is in automobiles yet industries are also a mayor cause of air pollution in the society. The system monitors, alerts and thus improving health.

- Cost efliciency by this system has been met because the system has been built with minimum cost which is worth the work it is to serve and will be affordable by the target group

CHAPTER FOUR: DISCUSSION AND RECOMMENDATIONS

Summary of Work Done.

The main objective or this project was to design and implement an air qua lity monitoring system that determines the air quality basing on air quality. humidity and temperature conditions using internet of things. The system is able to measure the levels of air quality. tempcrnturc and humidity \\ ith1n the industry. compare with the estimated values in the code according to the test prototype then it indicates in case any of those conditions is met.

Recommendations.

he system has revealed more about air quality and how sensor technology is so crucial in the aspect of life to provide information concerning the prevailing conditions in our environments and more research is needed to improve on the air quality control. l recommend that the following cm be done on the system: -

- The system should also be enhanced with SMS facility to send an SMS to the responsible heads of departments for analysis and being able to control the air quality by turning on and off the fans and Ac's will help the industry save on power consumed by these equipments as they will be on only when conditions are requiring them to be on.

- The system is an automated air quality monitoring for an industrial setting but we recommend that more research should be done> to enable automation in otlwrs areas like hospitals. PSV vehicles. domestic homes and so many others.

\ir Pollution is a major threat to our health as workers and as a society <1nd afkch the environment as well therefore we have designed such a system which automatically monitors the status of air quality levels in an industrial environment and then alerts the responsible persons. Timely and with all data records stored for further analysis for remedial action and decision making.

CHAPTER FI\'E: REFERENCES

I 11 ,\ R. Kasar, D. S. Khemnar. and'\. P. Tembhurnikar, "WSN Based Air Pollution Mo11itoring[1] System." *!111. J Sci. Eng. Appl..* \'Ol. 2, no. 4, pp. 55-59.2013.

I 2 I .J. lkram, A. Tahir. H. Kazmi. Z. Khan, R. Javed, and U. Masood, "View: implementing low cost air quality monitoring ~olullt,n for urban areas," pp. 1-8.2012.

l3J M. N. Rajkumar. :\I. S. Sru1hi. ancl V. V. Kumar, "IOT Based Smart System for Controlling Co 2Emission." vol. 2. no. 2. pp. 284-288, 2017.

/41 13. J. Kirenga *et al..* **"The** state of ambient air quality in two ugandan cities: A pilot cross-scction,1I spatial assessment." ***Int.*** *J Environ. Res. Public Health.* vol. 12. no. 7. pp. 8075-8091. '.2015.

/ .::;·I A. T. Kiggundu. ··capabilities and Gaps Assessments of Urban Air Quality Manage-ment in Uganda," *Indones. J Geogr.* vol. 47. no. I, pp. 1-10.2015.

/(1/ S Anusha. \I. \ladh~ni. ,rnd R. llcmalatha. "HOME AUTOMATION USING 1\Tnieg,1328 M ICROCO'\TROLLER AND ANDROID APPLICATION." *Int. Rn. J. Eng. leech0l.* pp. 865-868. 2015.

I 7] A. R.ajalakshmi. S. Kanhick, and S. Valarmathy. "Vehirnlar Poll11tion cllld Status Monitcning Using RFID." vol. 2. no. 4, pp. 580-586, 2015.

[8] *A.* R. Kasar. WSN Based Air Pollution Monitoring System." vol. 2. no. 4. pp. 55-59_ 2013

f9] *1'\.* Al-dahoud. \I. Fezari, I. .Jannoucl. and T. Al-rawashcleh, "Monitoring Metropolitan City Air-quality Using Wireless Sensor Nodes based on." Ne *Dev. Circuits. Sst. Signal Process Commun.* ***Cumput.*** *Based,* pp. 121-125.

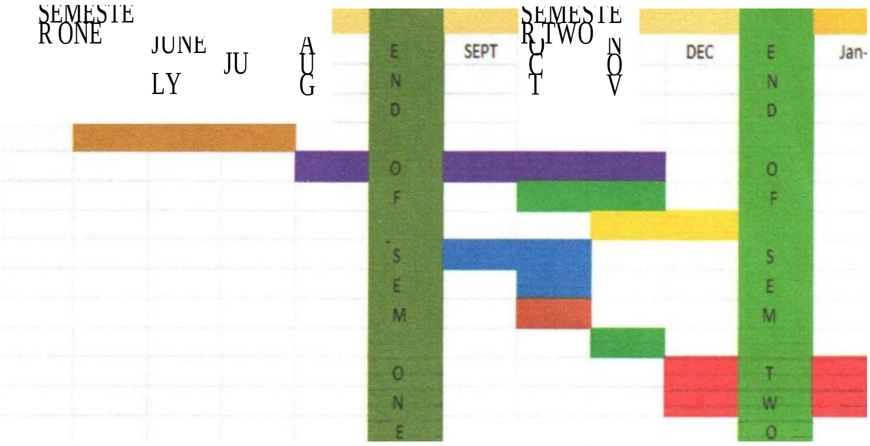
/ IU/ *1\.* Gurhi. --implementation ofan Efficient Noise and Air Pollution Monitoring System l.ising l111L'rnt't of Thing::, (loT)," vol. 5, no. 7, pp. 237-242, 20 I (1.

11 I J P Y. Sai. ··_-\n loT Based Automated Noise and /\ir Pollution Monitoring System," vol. 6, n0.3,pp' 419 423. 2017.

[I2] WY Yi.KM Lo. T Mak. K. S. Leung. Y Leung. and M. L. Meng. *A Surver of Wireless Sensor Network Based Air Pollution Monitoring Systems. 20*15.

[I3] S Devarakonda. P. Sevusu, 1-l. Liu. R. Liu, L. lftode, and B. Nath, '·Real-time air quality monitoring through mobile sensing in metropolitan areas," *Pnw }nd .IC\! SIGKDD /111. 11/'ork Urhun Co111p11t. - L'rhC0111p 'I 3,* p. I. 2013.

CHAPTER SIX: TIME PLAN



,14

SUBMISSION OF PROJECT TITLES SUBMISSION OF FIRST PROJECT PROPOSAL AISING WITH PROJECT SUPERVISOR
MID SEM PRESENTATION
SUBMISSION OF APPROVED PROPOSALS
DATA COLLECTION
DA TA ANALYSIS
DESIGN ANO CONSTRUCTION OF PROJECT SUBMISSION OF PROJECT PROGRESS FINAL PROJECT SUBMISSION
FINAL APPROVED PROJECT TO FACULTY

CHAPTER SEVEN: ESTIMATEDBUDGET

Description		
Supplies		360,000
Research/consultation		100.000
Stationary		80,000
Miscellaneous		100,000
Total		**640,000**