IOT DEVICE FOR DETECTION OF AMMONIA GAS LEAKAGE

Report submitted to the SASTRA Deemed to be University
as the requirement for the course

BECCEC608: MINI PROJECT-I

Submitted by

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Bonafide Certificate

This is to certify that the report titled "**IOT device for detection of ammonia leakage**" submitted as a requirement for the course, **BECCEC608: MINI PROJECT** for B.Tech. ECE programme, is a bonafide record of the work done by **Malavika Venkatanarayanan** during the academic year 2019-20, in the School of Electrical & Electronics Engineering, under my supervision.

Signature of Project Supervisor :

Name with Affiliation: Dr. R. John Bosco Balaguru

Date : 05.07.2020

Project viva-voce held on _________________

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DECLARATION

I declare that the thesis titled "**IOT Device for detection of ammonia gas leakage**" submitted by me is an original work done by me under the guidance of **Dr. R. John Bosco Balaguru, Dean Sponsored Research, School of Electrical & Electronics Engineering,** SASTRA Deemed to be University during the final semester of the academic year 2019-20, in the **School of Electrical & Electronics Engineering**. The work is original and wherever I have used materials from other sources, I have given due credit and cited them in the text of the thesis. This thesis has not formed the basis for the award of any degree, diploma, associate-ship, fellowship or other similar title to any candidate of any University.

Signature of the candidate(s) **:**

Name of the candidate(s) **: Malavika Venkatanarayanan**

Date **: 05.07.2020**

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ABSTRACT

KEYWORDS: *IOT, ammonia leakage, ESP32, MQ137*

By textbook definition, *"The Internet of Things (IoT) is a system of interrelated computing, mechanical, digital devices with the ability to transfer data over a network without requiring human to human interaction"* (Wikipedia). The project in its bare bones is the transmit of real time data using sensory nodes with the help of IoT. We know that the production of toxic, flammable gasses in large scale or usage of them in large quantities is a dangerous task. A small malfunction or perforation in the system could lead to gas leakage and if not found early, it is only a matter of time before another major industrial accident. Ammonia in its gaseous form is particularly toxic. The leakage can happen at multiple points in a factory, hence multiple sensors are installed in and around the site. The continuous sensor data are transferred wirelessly to the cloud using a Wi-Fi module (ESP32). When the said leakage is detected, the concerned party is warned giving them enough reason to take ample measures and reflexes. The project is economical, viable and much more efficient due to the usage of IOT technology.

Specific Contribution:

- The fast and easy detection of toxic gas leakage at low expense

Specific Learning:

- The IoT technology and it's need in the growing world
- Sensors and Wireless transmission

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ABBREVIATIONS

IDE	Integrated Development Environment
IOT	Internet Of Things
LED	Light Emitting Diode

NOTATIONS

English Symbols (in alphabetical order)

°C	Celsius
e^-	Electron
H	Hydrogen
MHz	Mega Hertz
N	Nitrogen
NH_3	Ammonia
ppm	parts per million
SnO_2	Stannic Oxide
V	Volts

CHAPTER 1
INTRODUCTION

Ammonia is usually in a liquid state and once it comes into contact with air it turns into gaseous form. Ammonia gas is toxic, flammable and explosive. It is completely soluble in water. Usually when there is a leakage of ammonia, it can be detected by the human olfactory nerves at 5 ppm. Therefore, we employ several sensors to detect the leakage. The method of IOT is proven useful here Since data is seamlessly and wirelessly transferred.

1.1 Motivation

In a huge industry such as a firm manufacturing large doses of ammonia or using ammonia in a large scale, it is possible that minor accidents might occur due to industrial negligence. But it is within our reach to prevent any major industrial accident from taking place. It was reported the 50 people fainted in a factory due to ammonia leakage in Kurukshetra (*via* THE HINDU). Previously 14 people had been hospitalized in Ratnagiri, a place 330 km from Mumbai (*via* The Economic Times). Various such incidents have been taking place in and around the world. Within a span of 10 years from 2007-2017, 59 such incidents were reported. Thus, the motivation of my project is to at least contribute a small part to make sure that such incidents do not take place in the future. Human response to exposure of varying amounts of ammonia is given in Table 1.1.

Table 1.1. Human response to exposure of varying amounts of ammonia.

RESPONSE	CONCENTRATION (ppm)
Mild irritation	5
Moderate irritation	10-50
Burning of nasal cavity	125-13
Cyclic hyperpnoea	500
Immediate danger to life	700
Pulmonary edema, coughing and Possibly fatal	1500 and above

CHAPTER 2

OBJECTIVES

As a society, we have seen our fair share of industrial accidents. While new and innovative methods are shaping up each year, it is important to maintain and update to the latest technologies so as to prevent any maladies. The sole purpose of my project is detection of toxic gas leakage, in my case ammonia. This is something that will be repeated in the entirety of my report. Having said that the following are the step-wise objectives that I aimed to achieved at the start of my project:

- To detect the leakage of ammonia
- To transfer readings wirelessly using IOT
- The sensor that is subjected to the deliberate leakage should be found out
- If and when the leakage crosses alarming levels reflux actions such as notifications is to be sent

CHAPTER 3
Study of the Components

3.1 Gas Sensor

Ammonia can be detected using a MQ135 gas sensor or a MQ137 sensor. While, MQ135 is a normal gas sensor that can detect a variety of gases, MQ137 is a particular sensor for ammonia (NH3). The type of gas detected is essentially based upon the sensing material.

Fig. 3.1. Top and upside-down view of MQ127 sensor.

MQ137 is a chemiresistor type ammonia sensor. It has 6 terminals out of which 4 are used as input or output and the remaining two are used for heater coils. The pin details are given in the table 3.1 . The digital pin can be used to detect the analyte but the analog pin is used for the proper measurement of it. Here the analog pin is used to detect and measure ammonia.

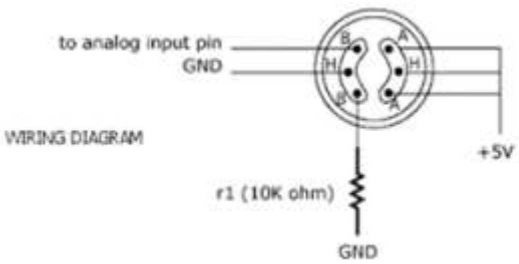


Fig. 3.2. Sensor pin configuration.

Table 3.1 Pin description of the sensor.

PIN NAME	I/O	DETAILS
VCC	Power IN	0-5V
GND	GND	Ground
D0	output	Digital pin
A0	output	Analog pin

The sensor is composed of the following parts:

- Gas sensing layer
- Heater Coil
- Electrode line
- Ceramic Tube
- Electrode

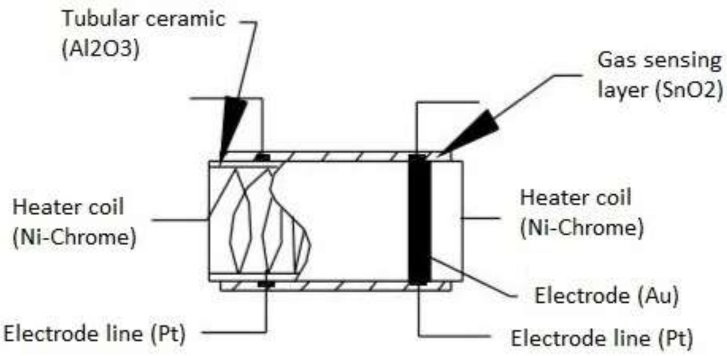


Fig. 3.3 Parts of a gas sensor.

The parts are explained as follows:

Gas Sensing Layer: It is the main component and it is a chemiresisitor that changes the value based on the concentration of the gas. The sensing element used is Tin Dioxide (SnO_2), which is an electron donor and hence it corroborates the flow of electrons causing current to flow through. The type of gas detected is essentially based upon the sensing material.

Heater Coil: It increases the operating temperature of the sensing element (SnO_2) so that the sensitivity of the sensing element rises up. The material used for heater coil is Nickel Chromium alloy due to it's high melting point.

Electrode Line: It helps in moving the low current produced by the sensing element. Platinum is used as electrode line.

Ceramic Tube: It is situated between the heater coil and the sensing layer. It helps maintain the preheating of the sensing layer and prevents any damage.

Electrode: connected between the gas sensing layer and the electrode line it helps in maintain a path for the flow of current. Gold is used as electrode.

3.2 Working of a Gas Sensor

The chemiresistive sensing layer used here is SnO_2 which is an n-type semiconductor. When it is placed in atmosphere, the adsorption of electrons in the conduction band of the sensing element by the oxygen molecules in the atmosphere leads to the increase in the width of space charge region, which results in increased surface resistance. This resistance forms the baseline for the sensing measurement. When the sensor is exposed to the target gas say ammonia, the reducing nature of ammonia leads to decrease in the surface resistance with reference to baseline resistance. The decrease in surface resistance depends on the concentration of the target gas molecules present in the environment. Using the steady state resistance in the presence of target gas and the base line resitace are used to estimate the response of the gas sensor. Finally, when the sensor is exposed again to atmosphere, the desorption process results in the increase in the surface resistance and attains again the baseline resistance. This forms one complete cycle of response and recovery process of a gas sensor.

3.3. Sensor Calibration

Preheating and calibration is essential for most of the sensors. The sensor usually reads arbitrary analog values. But for the purpose of measuring and detecting the gas present we convert the values into ppm.

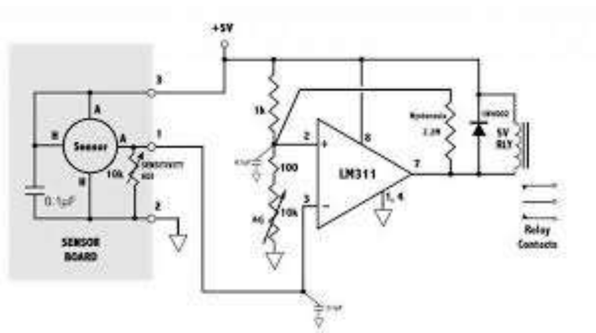


Fig. 3.4 Sensor circuit.

Before, using the sensor, it was preheated and then calibrated to find the value of R_0. Calibration is usually needed as the readings change overtime. The following formulae are used:

$$R_S = [(V_C \text{ x } R_L) / VR_L] - R_L$$

$$R_S/R_0 = 3.6 \textit{ (from the sensitivity curve)}$$

Thus, R_S was calculated and from then on, the value of R_0 at fresh air was also calculated. To convert the values into ppm, few things are to be calculated. The sensitivity graph is taken from the datasheet. Although the graph looks linear, it should be noted that it is in fact actually exponential. Therefore, we use the basic formula,

$$Y = mX+c$$

since it is exponential, the logarithmic values are used as follows:

$$\log(y) = m * \log(x) + c$$

Substituting the points, we get the value of m and c as follows:

$$m=-0.243 \qquad c=0.323$$

The below relation is then used to calculate the values in ppm:

$$ppm= 10 \wedge \{[\log (RS/R0) - c] / m\}$$

Specifications:

R_S= Sensor resistance in various concentration of gases

R_L= Sensor resistance at clean air

R_0 = Sensing resistance

V_C = 5 V

R_L = 47 kilo Ohms (from datasheet)

y = y coordinates

x = x coordinates

m = slope

c = constant

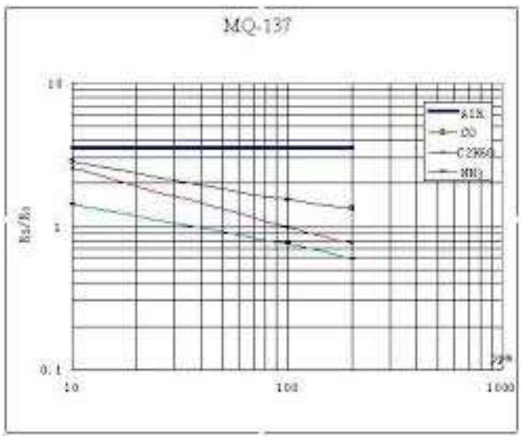


Fig. 3.5 Sensitivity characteristics of MQ-137.

Fig. 3.6 A snippet from the slave sensor code.

3.4. Microcontroller

Both ESP32 and ESP8266 are Wi-Fi modules. ESP32 is a dual core processor whereas the latter is a single one. ESP32 also supports Bluetooth and has touch capacitive pins. The former also has more GPIO pins. Thus, the microcontroller used in my project to read the values is ESP32. It is capable of functioning in temperature ranges from -40°C to +125°C. The board comes with a built-in hall sensor and temperature sensor. The details of the module are given in the Table 3.2 below. It is connected to the PC to power it up.

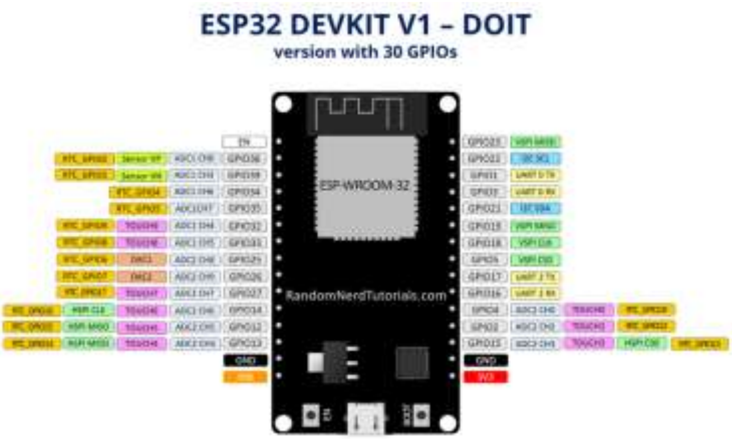


Fig. 3.7 Pin configuration of ESP32.

Figure 3.8 ESP

Table 3.2 ESP 32 specifications.

Board	ESP 32 Dev Kit v1
Processor	Tensilica Xtensa LX6
WIFI	802.11 b/g/n
Bluetooth	Supports BLE and Classic Bluetooth
Clock Frequency	240 MHz
Operating voltage	3.3 V
Flash memory	4 MB
SRAM	520 KB
Total pins	30
GPIO pins	25
Touch pins	9
ADC pins	15
DAC pins	2
UART pins	4

CHAPTER 4
METHODOLOGY AND SYSTEM DESIGN

4.1 Sensor Interfacing

The sensor interfacing is done by connecting it to the microcontroller *via* wire connections and a simple code. Sensor interfacing is basically an analog to digital conversion by the microcontroller. the ADC present in the board takes care of it. Here the connections are quite simple and there exists only three connections as shown in the figure below. To explain it further, the respective V_{CC} and ground pins are connected and the A0 pin of the sensor is connected to one of the ADC pins.

4.2. Working of the Designed System

4 sensors are interfaced with the ESP modules. One ESP module remains as such. The sensor along with the node is called a detector. The detectors are the programmed in the Arduino IDE. The Blynk Bridge is used. The Bridge is the easiest way for two devices to communicate with each other. Therefore, one ESP32 module is used as the master node. A master node is one device that can communicate with all the connected ones. It remains to be the mutual link between the other nodes. All the data collected by the other detectors will pass by the master node. Therefore, Bridge network is established. A two- way communication is established between the master and the slave detectors.

One of the crucial aims of this project is to find which sensor is being exposed to the toxic gas. Therefore, in the Blynk dashboard aside from the widget showing the ppm value, we also insert an LED for every detector. When an LED glow, it indicates that the particular detector is getting exposed to toxic gas. An LED was also inserted along with each and every detector. It is programmed in the same way as the LEDs in the Blynk dashboard.

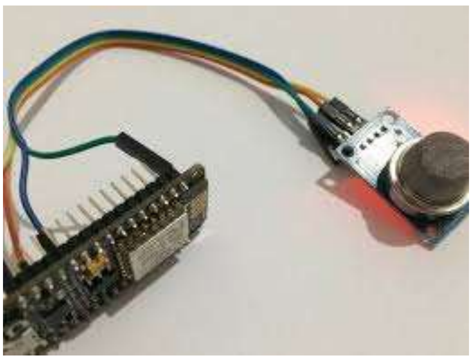


Fig. 4.1 Model circuit of my project.

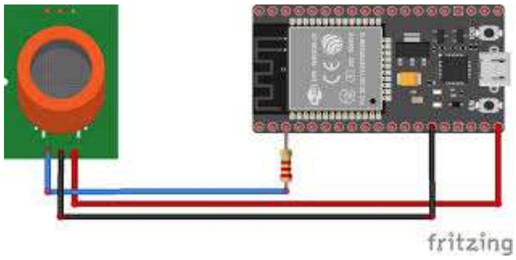
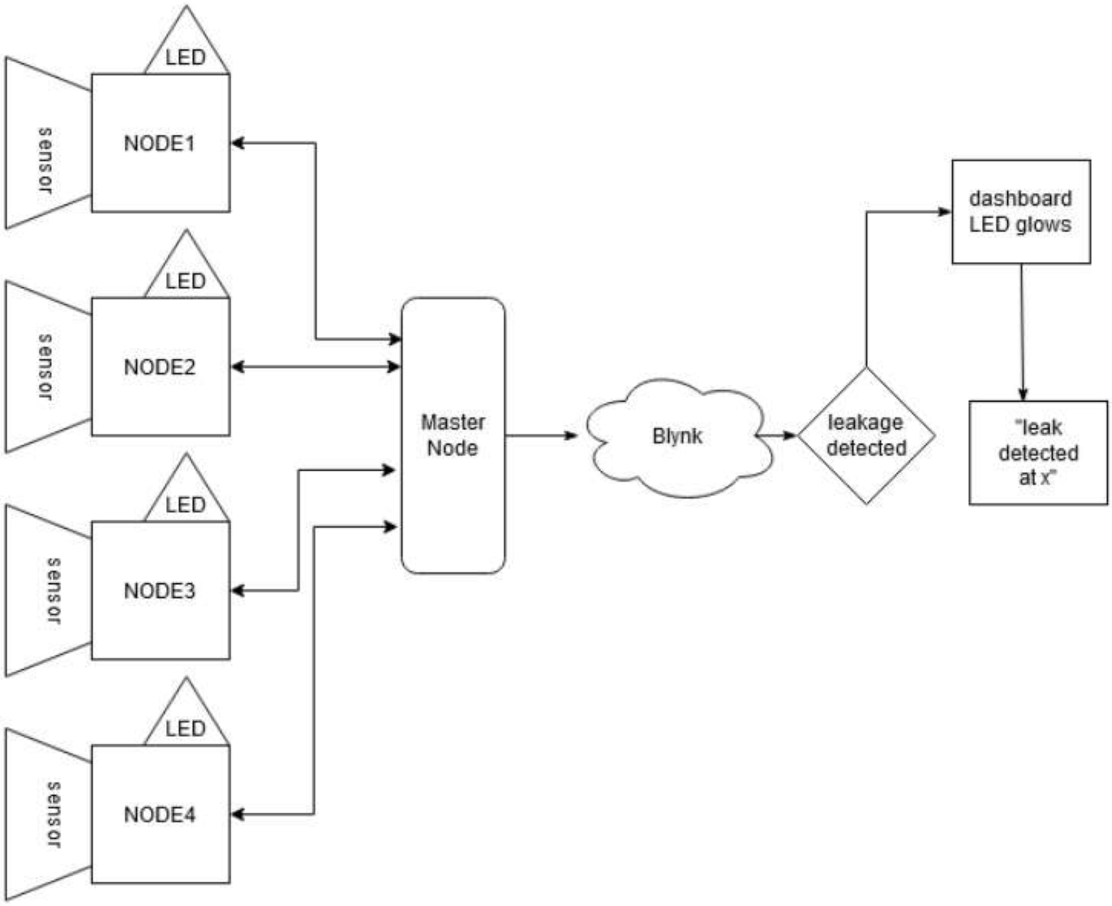


Fig. 4.2 Model circuit from the internet.

4.3. Flowchart

The flowchart below shows the exact mechanism and the outline of the project:



CHAPTER 5
OUTPUT AND RESULT

5.1. Code and Output

The programming as mentioned before was done in Arduino IDE. The required libraries were downloaded. At first the analog values were read as such before they were converted into ppm. In my project, the values are supposed to fluctuate in the dashboard indicating the sensor's response to the exposure of the NH3.

Fig. 5.1. Output for one node in Blynk platform.

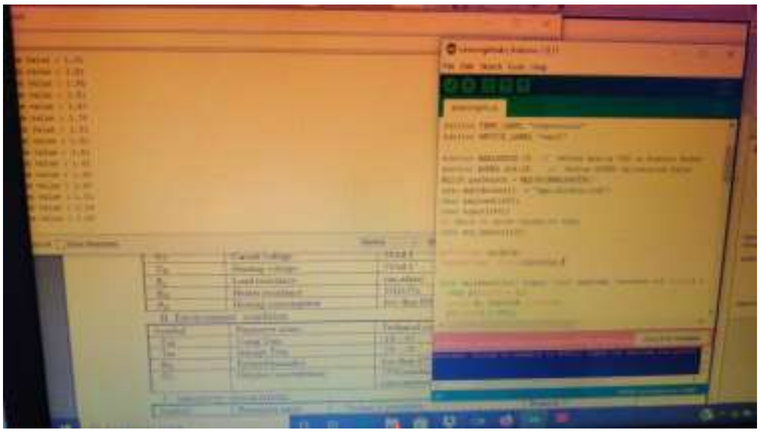


Figure 5.2 Reading of direct analog values before preheating.

As soon as the gas was leaked in a measured manner, the sensors picked up the values and the fluctuations could be seen on the Blynk dashboard for that particular sensor. Besides the glowing of LEDs to indicate a leakage, some reflex actions are also taken.

When the threshold value is crossed, an alert in the form of message is sent to the concerned person via text message from Blynk app. Furthermore, the nearest Fire station can also be alerted if the leakage becomes highly dangerous. Thus, a proper code based on logic and intuition was written and compiled. The said code will be modified when there is chance to test it on a real time basis.

5.2 Future Work

The experiment described above does not involve storing of values on cloud. A further project can be done in which the values are stored in cloud and the data procured with the values can be devised into a regression system. This proposed model will bring together IOT and Machine learning. It will be useful to compare the data with the past data and. The final idea being that we can learn the system's fluctuation, if any, can be mapped and understood.

CHAPTER 6
CONCLUSIONS

Thus, a viable and an economical way to detect the leakage of ammonia has been successfully accomplished. Blynk App is an efficient IoT platform and is easier to work with. In chemiresistive sensor calibration, the higher the change in the value of resistance, the greater the sensitivity of the sensor. ESP32 is far more efficient than ESP8266 because of the dual core. The sensor has to be calibrated once in every six months. Multiple sensors are to be interfaced for a huge area. The real time display of all the sensor values was seen on the Blynk app. The proposed project can be carried out in the future to prevent such hazardous incidents.

CHAPTER 7
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