International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-6 Issue-6, August 2017

Interfacing of Ammonia Gas Sensors using IoT Technology

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Abstract*: There is high-risk factors involved in industries which use hazardous gases in large quantities for their various processes. People may not identify or monitor the leakage of these gases at a regular basis before it goes out of hand. There is a need for sensors to continuously monitor the leakages and alert the users on the possible hazard. This project gives the solution to reduce the risk factors in isolated areas having large gas installations by detecting and displaying the leakages on a continuous basis. Leakage of gas can occur at multiple points in the same installation. Hence, multiple sensors are interfaced to detect the leakage and transmit the signals to the base station located far away. Using microprocessors, multiple sensor values are received and processed. The processed data is encoded and transmitted to the base (using wired or wireless protocols) where another microprocessor decodes it and shows the respective sensor status. The system also gives an audio and visual warning when leakages are detected and the as the time taken to detect is very low due to high speed processing, the leakage situations are brought under control with minimum or no damage. This project gives an economical and efficient method to reduce leakage risk by using latest IoT technologies and monitoring anywhere in the web.

Index Terms*: Gas leakage, microcontroller, sensors, wireless. IoT (Internet of Things),

I. INTRODUCTION

Ammonia (NH_3) is one of the most commonly used in industry and commerce. At room temperature, ammonia is a colourless, highly irritating gas with a pungent, suffocating odour. The widespread use of ammonia on farms and in industrial and commercial locations also means that exposure can occur from an accidental release or from a deliberate terrorist attack. Anhydrous ammonia gas is lighter than air and will rise, so that generally it dissipates and does not settle in low-lying areas. However, in the presence of moisture (such as high relative humidity), the liquefied anhydrous ammonia gas forms vapours that are heavier than air. These vapours may spread along the ground or into low-lying areas with poor airflow where people may become exposed. Exposure to high concentrations of ammonia in air causes immediate burning of the nose, throat, and respiratory tract. Reaction of ammonia with any reactive element like copper, zinc, aluminium might cause fire. **There is a need for detection of ammonia leakage especially in isolated regions**. **This leakage must be monitored continuously. The ammonia leakage is sensed with the help of a couple of sensors called MQ137.** [1]

II. STUDY OF THE PROBLEM

The industry on which the research was conducted is in an isolated area. The ammonia storage tank is protected by a fence which is of 49x43sq.m area and hence its not a place where frequent monitoring can be done. The tank is 7.5m long and 2.6m wide. The location of the plant is such that the temperature varies from 45 degrees Celsius to -10 degrees Celsius. The area may be too hot, rainy, or windy depending the time of the year. The tank contains anhydrous ammonia which is very reactive and dangerous to humans. The gas is used for electrostatic pollution control. **No materials that are reactive to ammonia should be used**, such as copper, zinc, galvanized iron, bronze. The materials should be **flame proof and weather resistant.**

III. STUDY OF THE SENSOR

The presence of any gas can be found out by two main classes of sensors namely active sensors and passive sensors. There are two kinds of active sensors available in the market the infrared sensors and the ultrasonic sensors. The active sensor need an external source of power for its working which will be dangerous for this application due to the unwanted heat formation. These sensors keep on sending signal to the tank and the scans the reflected signal then analyze it to find the presence of ammonia. Both the infrared and the ultrasonic waves will start heating and this increases the risks of catching fire. The only advantage of these sensor is that it has a fast response but the it has a lot more disadvantage in this application. The waves form the active sensors will heat up the pipes and the storage tank, there is high chances of noise as it will be installed in the open air. Active sensors consume lot of power and hence ruled out from the list. Unlike the active sensors, the passive sensors simply detect and responds only to some type of input from the environment. Even though the response of these sensors is slow, it is apt for this application as it does not have any components reactive to ammonia. These sensors have variable resistance which changes its value when subjected to the gas that it must sense. The change in the resistance depends on the concentration of the gas that encounters it.

Manuscript published on 30 August 2017.
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A. MQ Sensors

MQ series Semiconductor Gas Sensors are used for Gas leak detection for houses, workshops, industries, commercial building, Fire, Safety detection system. Its features include High sensitivity, fast response, wide detection range,

Stable performance -long life and simple drive circuit The MQ series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gases and are used indoors at room temperature. They can be calibrated (see the section about "Load-resistor" and "Burn-in") but a known concentration of the measured gas or gasses is needed for that. The output is an analogue signal and can be read with an analogue input of the Arduino. MQ 137 is sensitive for Ammonia and the heater uses 5V. Sensitive material of MQ137 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity becomes higher as the concentration of the gas rises. MQ137 gas sensor has high sensitivity to Ammonia, also to other organic amines. The sensor could be used to detect different gas which contains Ammonia, it is with low cost and suitable for different application. A couple of MQ 137 sensors are to be connected in parallel to detect ammonia at various joints. [2]

Table: MQ 137 details

Model No.			MQ137
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite (Black Bakelite)
Detection Gas			Ammonia
Concentration			5-500ppm (Ammonia)
Circuit	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.2V ACorDC
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤900mW
	Sensing Resistance	R_s	2KΩ-15KΩ(in 50ppm NH_3)
	Sensitivity	S	Rs(in air)/Rs(5000ppm CH_4)≥5
	Slope	α	≤0.6 (R_{100ppm}/R_{50ppm} NH_3)
Condition	Tem. Humidity		20℃±2℃；65%±5%RH
	Standard test circuit		Vc: 5.0V±0.1V； V_H: 5.0V±0.1V
	Preheat time		Over 48 hours

Power of Sensitivity body(Ps): $Ps=Vc^2 \times Rs/(Rs+RL)^2$

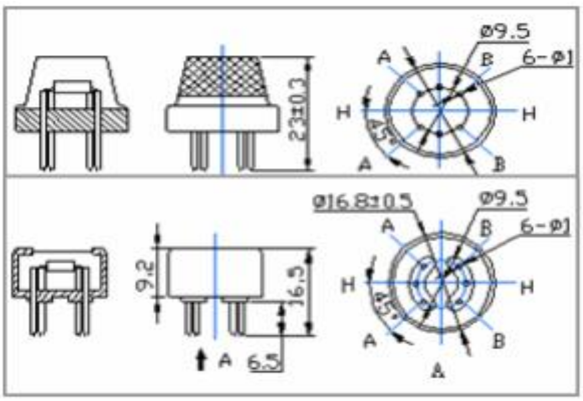

Fig: 1. Configuration MQ 137 [3]

IV. INTERFACING THE SENSORS

There is a need of multiple sensors for detecting the presence of ammonia in the open air and hence these multiple sensor interfacing should be done with the help of a controller that will receive the voltage value from different sensors. Multiple MQ sensors can be connected to the controller which will regularly check the value from each sensor and then analyze status of each sensor. This controller then decodes the sensor number into a four-digit binary number and sends it to the display board unit. The controller after receiving the output from the sensor converts it into two binary digit that shows the sensing status and the working status. This is again sent to the unit at the display board. So totally six wires run to the display unit there is again a micro controller which decodes the signal from the six wires and then shows it with data with thirty-two LEDs. Hard wire had to be used as the display board was very far away and was in an isolated area. Six-bit wireless protocol can also be used in other applications. Arduino Mega was used as the micro controller as it can have sixteen sensors connected to it at the same time and it has a power full processor and a good memory. Again, an Arduino Mega will have to be used at the display board to have a sync with the sensing side and also as it has the option to connect thirty-two output pins and six input pins so a total of thirty-eight pins.

A. ATMEGA

The Arduino Mega is a microcontroller board based on the ATmega1280.It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

V. PROGRAMING THE CONTROLLERS

Encoder Side: The sensors that are connected to the micro controller will be giving analog values which will be read by the controllers' analog pins. These data are then converted and then compared to a sensing value which will give an output status as high or low (Presence of ammonia gives high else gives low).

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There is a conversion of the sensor number to a digital number and then the respective working and sensing status is given.

Decoder Side: The signals from the encoder micro controller comes into the decoder which is the decoded to the sensor number. The respective sensor number with the working and the sensing status is shown to the display board using separate 32 output pins. The decoder will have 16 pins for showing the working status of the 16 LEDs. (LOW for showing the working status to be good). The decoder has another 16 pins to show the sensing status of the respective sensor (HIGH for the presence of ammonia).

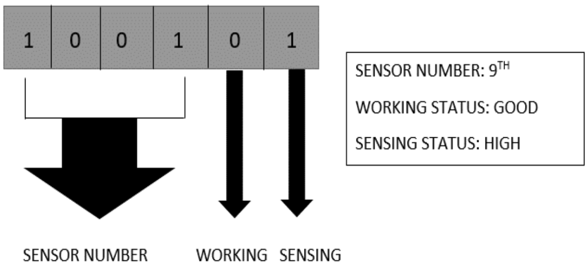

Fig: 2. example of the Encoder signal

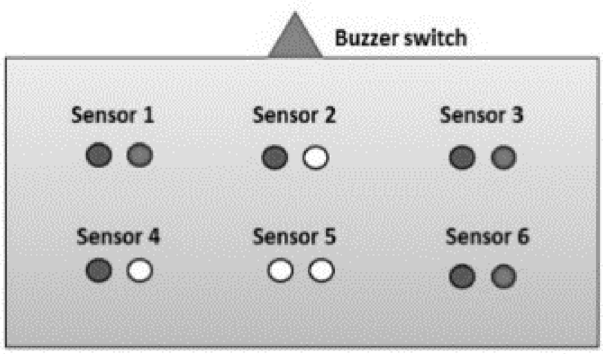

Fig: 3. The 'display board' Decoder side

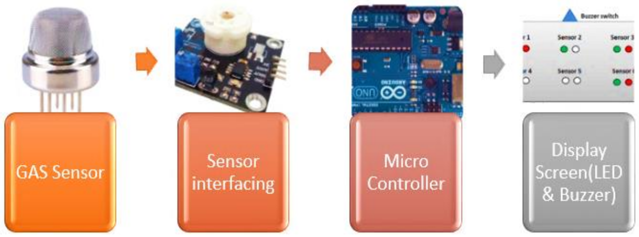

Fig: 4. block diagram of the connections

VI. CIRCUIT CONNECTIONS

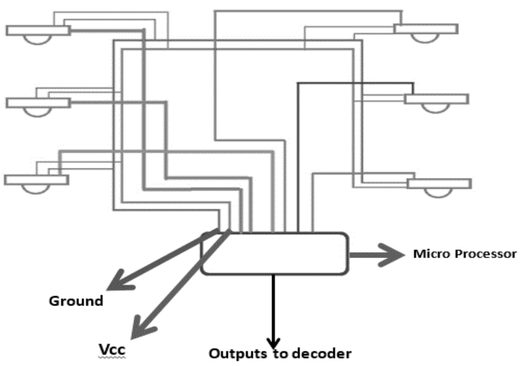

Fig: 5. Circuit connection at the site

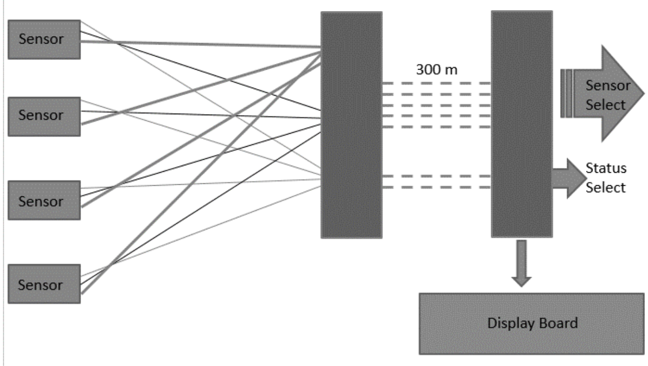

Fig: 6. Block diagram of the entire system

The gas sensors are to be installed at all the potential areas and are to be noted with the respective numbers. Each sensor will have three wires running to the micro controller (5-volt power supply, Ground, Analog data). The box in which the controller is fixed has an option for 3X16 wires those are been marked respectively. Then there should be 6 wires running for 300 meters to the controller at the display board. There is a provision for these 6 wires to get fixed into the decoder micro controller. There are thirty-two outputs in the decoder which will go to the respective LEDs.

VII. HARDWARE DESIGN

The box that should be installed should be completely flame proof and should be resistant to all weather climates and be able to store the microcontroller and the connection wires with ease. As the micro controller works for 24/7 there is high chance of heating of the controller IC and hence a cooling fan must be installed for the cooling of the controller IC and this fan should also be included again in the box. Therefore, the material to be used for the box is M-grade (Military Grade) Acrylic sheet. Which has been designed and made with specific dimensions. The chances for heating of the device is very high and thus will lead to high risks of catching fire and malfunction of the controller and hence there is a need of installing a heat sink and a cooling fan that works with 12-volt supply. This 12-volt supply can be got from the power that is used to power the Arduino. A parallel connection is made for taking the power to the cooling fan.

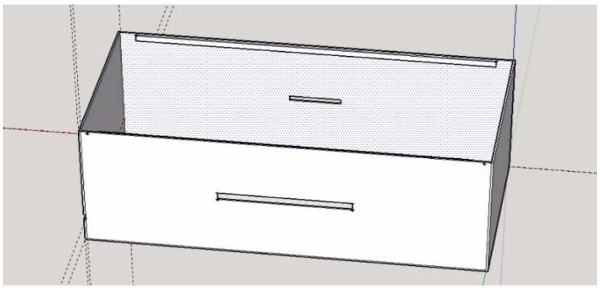

Fig: 7. Drawing of the casing

VIII. SCOPE OF THE PROJECT

The sensors interfacing usually employ an audible alarm to alert people when the dangerous gas has been detected. Exposure to toxic gases can also occur in operations such as painting,

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Fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc. After all the safety, should be the priority of all industries. This sensor interfacing will always be an economical and reliable way for the protection of so many lives and so many industries. As this project focuses on multiple sensing points in a single system the chances of finding the leakage is more efficient in this way and as the monitoring can be done from distant places the chances of alerting the officials are easier and hence required steps can be taken faster. This multiple sensor interfacing can be used in many applications of sensing of hazardous gases. Different MQ gas sensors can be connected to sense different gases. These multiple sensor interfacing can be placed even in underground mines to sense the presence of hazardous gases at any time, industries that deal with hazardous gases like alcohol, ammonia, carbon monoxide, kitchens of big hotels, gas filling stations. Gas transporting trucks, etc.

IX. METHODOLOGY OF THE PROJECT

The methodology of this project includes the study of the problem that occurred at a specific company. The problem was then generalized for similar applications. The research then included the study about the types of sensors that are available in the market. As there are chances of multiple gas leakage areas in the same location there was a need of multiple gas sensors to be interfaced. Using latest IoT technology, multiple sensors were interfaced with a microcontroller. The micro controller had the real-time data coming from the sensors which was processed and sent to the display board. The Display board would show the sensing status of the MQ sensors with the help of LEDs and a buzzer. The testing of data transfer and ammonia sensing was carried out in a laboratory and the results is tabulated in the below Table.

Table: 2. showing the analog data from MQ 137 (without Ammonia)

Time	Tempe rature	Humidity	Analog Value (MQ135)
19:29:53	25	20	219.0001
19:29:54	25	20	219.0001
19:29:55	25	20	219.0001
19:29:57	25	20	219.0001
19:29:58	25	20	218
19:29:59	25	20	218
19:30:01	25	20	218
19:30:02	25	20	218
19:30:03	25	20	219.0001
19:30:04	25	20	219.0001

Fig: 8. Multiple Sensors working simultaneously

X. CONCLUSION

The project concludes that using a passive sensor is safer. The MQ series sensors are the passive type of sensors which can be used for hazardous types of gases like ammonia. Passive type of sensors is found to be less reactive to ammonia and similar hazardous gases. Multiple Sensor interfacing is necessary for a large area plant as there are chances of leakage of gases from any part of the plant. This interfacing was programed in a clever algorithm so that there is a real-time display showing all the sensors status which can be a great help for the industry. The testing was done in laboratory conditions. The Testing showed almost 90% efficiency in sensing the leaked gas and informing the authorities.

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