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An Integrated IoT-based Gas-smoke Detection System with Automatic Electronic Alarm System

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Abstract

This paper presents the design, development and deployment of an IoT-based (Internet-of-Things based) real-time embedded system for gas-smoke detection (GASMOD) system with an automatic alarm system. The proposed GASMOD system consist of four major components, namely: *1)* MQ-2 smoke sensor for smoke concentration detection; *2)* MQ-5 gas sensor for gas concentration detection; *3)* Two YJD1602A-1 16-by-2 liquid crystal display (LCD) modules which displays whether or not gas and/or smoke has been detected; and *4)* an automatic electronic alarm system which incorporates a 25-Watt audio power amplifier that is triggered whenever gas and/or smoke is detected. The above modules are integrated and interfaced to an Internet-ready real-time embedded Arduino Mega2560 development board for realization of the proposed GASMOD system. The proposed GASMOD system has been designed, constructed and deployed for gas and smoke detection with real-time excellent performance. The proposed GASMOD system can be adapted and deployed in environments to monitor the concentration of hazardous gases and smoke in homes, industrial, research laboratories, amongst others against an acceptable prescribed threshold values.

Keywords

Automation, Real-Time Embedded System, Gas-Smoke Detection, Internet-of-Things (IoT), Smart Sensors

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1. Introduction

Gas and smoke detectors are designed to detect the concentration of a certain level of gas or smoke respectively at a specified concentration level. These detectors are been used in the industries like wise domestically to inform its users about a certain level of gas and/or smoke concentration in an environment which could be harmful. The sensitivity of these sensors is adjustable thus enabling users to determine what level of concentrations that can be responded to. Although, gas and smoke detectors may generally be characterized by low cost and by their possibility of been used in tough environment and situations where it may be impossible to deploy humans for such task due to the risk involved.

Different authors have analyzed the use of various gas and smoke detectors for detecting hazardous gas leakage and/or harmful smoke discharge into the atmosphere. Patle and co-workers developed a gas detecting system using three gas sensors to detect hazardous gases such as methane and carbon mono-oxide [1]. In detecting the aroma of Ascomycete tuber, Zampioglou and kalomiros developed an olfactory system based on a metal oxide sensor array to detect truffles [2].

The desired objectives of this work are to develop an integrated gas-smoke detection system with automatic

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electronic alarm system that will be capable to detect liquefied petroleum gas (LPG), butane at a pre-set threshold concentration level as well as smoke concentration and trigger the alarm system for notification whenever any or both of the concentration is/are above a specified threshold value.

This paper attempts to: *1).* develop a gas-smoke detection system that is capable of detecting smoke, LPG gas, butane, methane, and propane; and *2).* develop an alarm system for alerting its user whenever these gases or smoke is detected by the sensors. The system comprises of MQ-2 smoke sensor, MQ-5 gas sensor, jumper wires, Arduino Mega 2560 embedded system development board, resistors, light emitting diodes (LEDs) and buzzer. The smoke sensor (MQ-2) and the gas sensor (MQ-5) modules are useful for smoke and gas leakage detection in homes, environments or industries.

This paper is organized as follows. An overview of the study together with the state-of-the-art in gas-smoke detection system development is presented in Section 2. The block diagram and the architecture of the proposed gas-smoke detection (GASMOD) system are detailed in Section 3. Section 4 discusses the development, implementation and deployment of the proposed GASMOD system for real-time gas and smoke detection. Section 5 concludes the paper with some highlights on future directions as part of recommendations on the way forward. The nomenclature and definition of terms used in this paper are listed in the Table 3 of Appendix I.

2. Overview of the Study

This work presents the development of an enhanced gas and smoke detector system capable of detecting the presence of LPG, natural gas and coal gas using an MQ-5 gas sensor. An amplifying circuit is been designed to amplify the output signal when it detects the presence of gas. The desired objective is for the proposed gas detector system to trigger an alarm system when it detects the presence of gas. An Arduino mega 2560 microcontroller has been used as the brain of the device system due to its low cost, availability and reliability. This research work is expected to: *1).* Measure the concentration of gas and smoke detected; *2).* Alerts its user when it detects the presence of smoke, LPG, butane, methane, and propane; *3).* Display a message indicating the presence/absence of gas and/or smoke on a 16-by-2 liquid crystal display (LCD) [3]. Gas and smoke detectors have been used in wide variety of applications and are still under research. The following sub-sections highlights the work done in the field of gas detector.

2.1. Developments in Gas Detection Technology

One of the first challenges for choosing a gas detecting product of sensor is to determine which gas sensor type is needed for a particular application. Sensor technologies have their limitations and are not suitable across all gas types or applications. Understanding the properties of the various types of sensor technologies that are used in detecting gas will support our product selection decision making. Choosing the right sensor type for gas monitoring involves an assessment of many factors: target gas, costs, sensor placement, environmental conditions (temperature/humidity), oxygen content, power consumption, and cross interference.

Originally, gas detectors were produced to detect a single gas. However, modern units may detect several toxic or combustible gases or even a combination. Newer gas analyzers can break up the component signals from a complex aroma to identify several gases simultaneously. There are various types of gas detectors available and the majority serves the same function: to monitor and warn about dangerous gas level. Examples of gas sensors exist which include electrochemical sensors [4]; catalytic bead sensors [5]; infrared sensors [6]; proportional-integral-derivative (PID) sensors [7]; metal oxide semiconductor (MOS) sensors [8]; flame ionizing detector (FID) [9].

An embedded system for hazardous gas detection and alerting was also proposed [10]. Wellem and Setiawan designed and implemented a microcontroller-based room temperature in a computer server room to monitor the temperature in a computer server room [11]. The system was made of LM35 temperature sensor which measures temperature, Atmel Atmega 8535 which served as the brain.

2.2. Developments in Smoke Detection Technology

The first low-cost smoke detector called "*SmokeGard-700*" for domestic use was developed by Duane D. Pearsallin in 1965 with an individual replaceable battery-powered unit that could easily be installed. The *SmokeGard-700* is a beehive-shaped, strong fire-resistant steel unit [12]. The company began *SmokeGard-700* mass-producing these units in 1975. Studies in the 1960s determined that smoke detectors respond to fires much faster than heat detectors.

The first single-station smoke detector was invented in 1970 and made public the next year. It was an ionization detector powered by a single 9-Volt battery. Several technological developments occurred between 1971 and 1976, including the replacement of cold-cathode tubes with solid-state electronics, which greatly reduced the detectors' sizes and made it possible to monitor battery life [13]. The photoelectric (optical) smoke detector was invented by Donald Steele and Robert Emmark of Electro Signal Lab and patented in 1973 [14].

2.3. State-of-the-Art on Gas-Smoke Detection Systems

The monitoring and controlling of hazardous gases inside vehicle and alerting using global system for mobile communication (GSM) technology for the safety of people inside the vehicle was proposed by Patil and Singh [15]. On the other hand, Krishna and co-workers proposed a smoke detection system using internet-of-things [16]. Again, in the context of IoT, Pandey and co-workers proposed the design of an IoT-based gas leakage monitoring and alert system with MQ-2 sensor [17]. Rather than a single gas sensor, Patle and co-workers developed a gas detecting system using three gas sensors to detect hazardous gases such as methane and carbon mono-oxide [18].

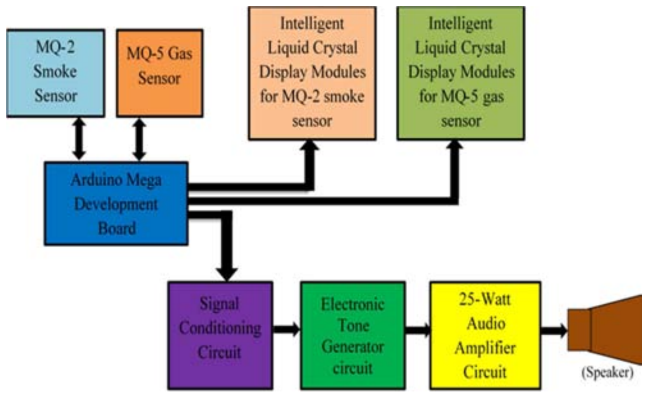

Figure 1. Block diagram of the gas-smoke detection system.

3. Block Diagram and the Architectures of the Proposed GASMOD System

3.1. Block Diagram of the Gas-Smoke Detection System

The gas-smoke detection system is implemented on a single Arduino Mega 2560 microcontroller. The block diagram of the proposed gas-smoke detection system is shown in Figure 1 which consists of MQ-5 and MQ-2 gas and smoke sensors respectively that can detect the presence of LPG gas and smoke respectively, a liquid crystal display (LCD), signal conditioning circuit, a tone generator, an Arduino Mega 2560 microcontroller, and a 25-Watt audio amplifier. An analog-to digital converter on the Arduino Mega 2560 microcontroller does the conversion of the analog signal to digital to be read from the Arduino Mega 2560 microcontroller and displayed on two LCDs. The outputs from the Arduino Mega 2560 microcontroller is connected to the signal conditioning circuit which is made up of four NAND gate connected in a manner to form a NOR gate and a TIP120 N-P-N transistor which is designed such that it requires a Logic LOW to switch ON and a Logic HIGH to switch OFF.

The electronic alarm system is built around two NE555CN timer integrated circuits. The first NE555CN timer integrated circuit is connected in monostable mode while the second NE555 timer integrated circuit is connected in astable mode. The cascaded two NE555 timer circuit forms the tone generator circuit. The output of the tone generator circuit is the input to the 25-Watt audio amplifier built around a TDA2050 integrated circuit (IC).

3.2. Architecture and Working Principles of the MQ-2 and MQ-5 Sensors

3.2.1. Architecture of the MQ-2 Smoke Sensor

The MQ-2 sensor belongs to the MQ series Semiconductor Gas Sensors [19]. The MQ sensors find application in gas leak and smoke detection applications. Table 1 shows the various MQ series sensors and target gas of detection. Their major advantageous features include: high sensitivity, fast response, wide detection range, stable performance and long life, and simple driver circuit.

The MQ-2 sensor is the most suitable and readily available for smoke detection. Sensitive material of MQ-2 gas sensor is the silicon oxide (SnO_2), whose conductivity is lower in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. MQ-2 gas sensor has high sensitivity to smoke, propane and hydrogen, also could be used for methane and other combustible steam, it is with low cost and suitable for different application. The MQ-2 sensor is shown in Figure 2. The enveloped MQ-2 has 6 pin, 4 of which are used to fetch signals, and the other 2 are used for providing heating current. It falls under the category of electromechanical gas detectors which works by allowing gases to diffuse through a porous membrane to an electrode where it is either chemically oxidized or reduced.

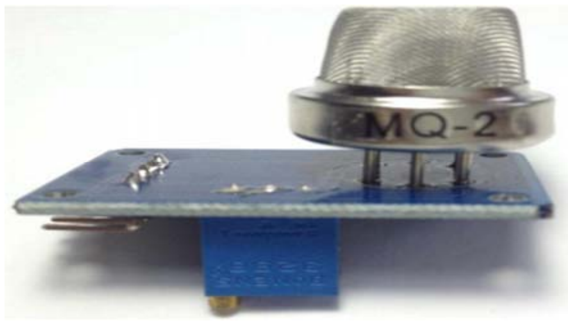

Figure 2. The MQ-2 sensor-based smoke detector.

Table 1. MQ series sensors and target gas of detection [19, 20].

MQ Series	Target gas of detection
MQ-2	Smoke, Propane, Hydrogen.
MQ-3	Alcohol.
MQ-4	Natural gas, Methane
MQ-5	LPG, Natural gas, Coal gas
MQ-6	LPG, Propane
MQ-7	Carbon Monoxide
MQ-8	Hydrogen
MQ-9	CO and combustible gas
MQ-216	Natural gas, Coal gas
MQ-306A	LPG, Propane
MQ-309A	CO, Flammable gas
MQ-303A	Alcohol
MQ-131	OzoneO3
MQ-138	Mellow, Benzene, Aldehyde, Ketone, Ester
MQ-137	Ammonia

3.2.2. Architecture of the MQ-5 Gas Sensor

The MQ-5 gas sensor is a device highly sensitive to LPG, natural gas as shown in Table 1 but has low sensitivity to smoke, alcohol etc [19, 20]. They are used in gas leakage detecting equipment in family and industry, and are suitable for detecting of LPG and natural gas. The MQ-5 sensor is shown in Figure 3. The major difference between the MQ-5 sensor and MQ-2 sensor is that the MQ-5 is highly sensitive to LPG while MQ-2 is highly sensitive to smoke [19, 20].

Figure 3. The MQ-5 sensor-based gas detector.

3.2.3. Working Principles of the MQ-5 Gas and MQ-2 Smoke Sensors [19, 20]

The MQ-5 and MQ-2 gas and smoke sensors operates with the same principle. They are devices which detects the presence of different level of gas in the atmosphere. These sensors interact with a gas to measure its concentration. Each gas has a unique breakdown voltage i.e. the electric field at which it is ionized. The sensors identify the gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device. The MQ-5 and MQ-2 sensors are capable of detecting the presence of LPG and smoke ranging from 100 ppm to 3,000 ppm respectively.

When a gas interacts with this sensor, it is first ionized into its constituents and is then adsorbed by the sensing element. This adsorption creates a potential difference on the element which is conveyed to the processor unit through output pins in form of current. The gas sensor module consists of a steel exoskeleton under which a sensing element is housed. This sensing element is subjected to current through connecting leads. This current is known as heating current through which the gases coming close to the sensing element get ionized and are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.

4. Implementation and Testing of the GASMOD System

4.1. Overview of the Proposed Design Methodology

Air pollution can be defined as the presence of toxic chemicals or compounds (including those of biological origin) in the air, at levels that pose a health risk. In an even broader sense, air pollution means the presence of chemicals or compounds in the air which are usually not present and which lower the quality of the air or cause detrimental changes to the quality of life (such as the damaging of the ozone layer or causing global warming). As discussed in the overview of the study, the proposed autonomous vehicle is expected to detect the presence of smoke and LPG and give an alarm sound whenever the level of this hazardous gas exceeds its preset threshold value. As a result of this, a gas and smoke detecting system is designed which incorporates a 25-Watt audio electronic power amplifier for alarm as illustrated in the block diagram in Figure 1. The gas and smoke detecting system is made up of two LCDs, MQ-2 smoke sensor, MQ-5 gas sensor, a signal conditioning circuit which is made up of four NAND-gate system and a transistor combined with a tone generator and a 25-Watt audio power amplifier which is built around a TDA2050 IC.

4.2. The Design and Implementation of the Gas and Smoke Detecting System

In the schematic block diagram implementation shown in Figure 4, we interfaced an MQ-2 sensor-based smoke detector, an MQ-5 sensor-based gas detector, two LCDs to an Arduino mega 2560 microcontroller. The LCDs are used to display the presence of smoke and gas respectively and vice versa. The electronic alarm is trigged whenever smoke and/or LPG are either detected. For simplicity, Table 2 describes the interfaced pins connection of the MQ-2 sensor, MQ-5 sensor, the two LCDs to the Arduino microcontroller and the output pin connection of the Arduino to the NAND-gate system.

The signal conditioning circuit is built around four

NAND-gate system and a TIP 120 N-P-N transistor which is shown in Figure 5. The NAND gate system is connected in such a way to form a NOR gate.

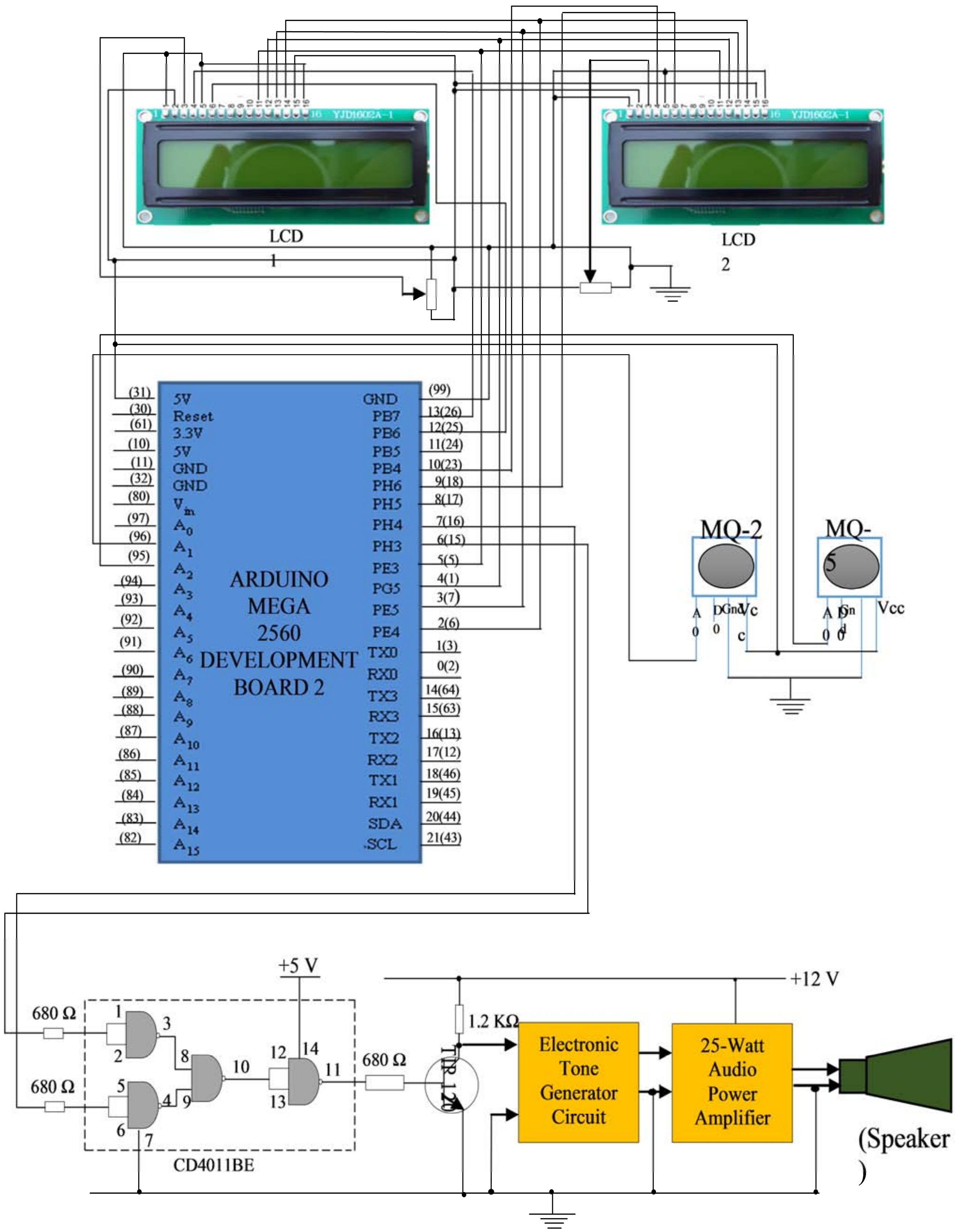

Figure 4. The block diagram implementation of the gas and smoke detection system incorporating an electronic alarm integrating a 25-Wattaudiopoweramplifierbasedon IoT technology with a signal conditioning circuit.

We make use of a NOR gate because we require a Logic LOW signal from pin 11 of the CD4011BE integrated circuit to switch the TIP120 NPN transistor ON when either of the output signal from our Arduino board is HIGH and to switch OFF when both outputs from the Arduino Mega 2560 development board is LOW.

The pins A1 and A2 of the Arduino Mega 2560 development board are connected to pins A0's of the MQ-5 and MQ-2 sensors respectively to receive signal. When the sensor detects the presence of smoke at 400 ppm and LPG at 200 ppm, the pin 7 and 6 of the Arduino board is energized which causes the alarm to trigger while LCDs displays information indicating the presence of gas or smoke. When the pre-set concentration level of both smoke and/or LPG is not exceeded, the pins 6 and 7 of the Arduino Mega 2560 development board is not energized, the alarm is not triggered. The pin 6 and 7 of the Arduino Mega 2560 microcontroller is connected to the pin 2 and pin 5 of the CD4011BE integrated circuit which contains four NAND gates through a 680 Ω resistors. The pins 1 and 2 of the CD4011BE are connected together to form a single input likewise pins 5 and 6. The pin 13 of the CD4011BE is connected to the TIP 120 NPN transistor through a 680 Ω resistor as shown in Figure 5. The NAND gates and the TIP120 NPN transistor form the signal conditioning circuit shown in Figure 5. As shown in Figure 6, the positive pin of the tone generator which is built around two cascaded NE555CN timer is connected to collector terminal of the transistor. A detailed description of how the tone generator is connected to the 25-watt audio power amplifier is discussed in the section below. The Arduino integrated development environment (IDE) is a cross-platform application written in Java and most of the Arduino programs are written in C or C++ [21, 22]. It can run in all operating systems like Windows, Mac OS, and Linux. It is designed to introduce programming skills to artists and other newcomers who are unfamiliar with software development or hardware programming. It includes a code editor with common developer software features like syntax highlighting, brace matching, and automatic indentation. It also provides a function that is capable of compiling and uploading programs to the board via USB. It is a user-friendly interface for everyone from beginner to professional to learn or use. The Figure 7 shows the testing of the gas and smoke detection system based on the IoT technologies.

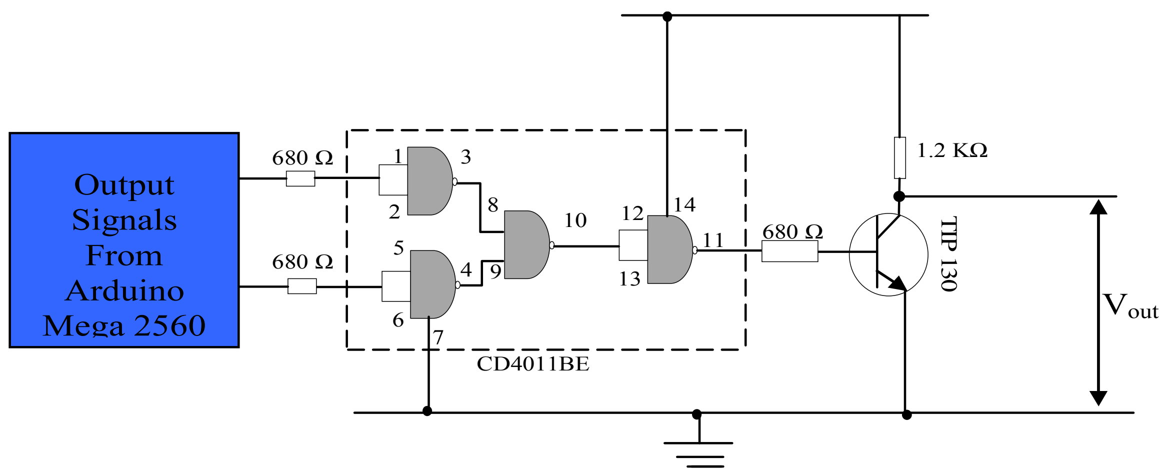

Figure 5. The signal conditioning circuit.

Table 2. Pin connections of the Arduino microcontroller to the LCDs, MQ-2 and MQ-5 sensors.

Pins on Arduino	Connections	Remarks
5V	Connected to V_{CC} of LCD, MQ-5 and MQ-2 sensors and pin 15 on LCD	5V supply
GND	To GND of MQ-2 and MQ-5 sensors, pin 1, 5 and 16 of LCDs	Ground supply
A0	To analog input of MQ-5 gas sensor	Analog input
A1	To analog input of MQ-2 sensor	Analog input
13	To pin 4 of LCD1	Selects command register when low; and data register when high
12	To pin 6 of LCD1	Sends data to data pins when a high to low pulse is given
5	To pin 11 on LCDs	4-bit data pin
4	To pin 12 on LCDs	
3	To pin 13 on LCDs	
2	To pin 14 on LCDs	
10	Top in 4 of LCD2	Selects command register when low; and data register when high
9	To pin 6 of LCD2	Sends data to data pins when a high to low pulse is given

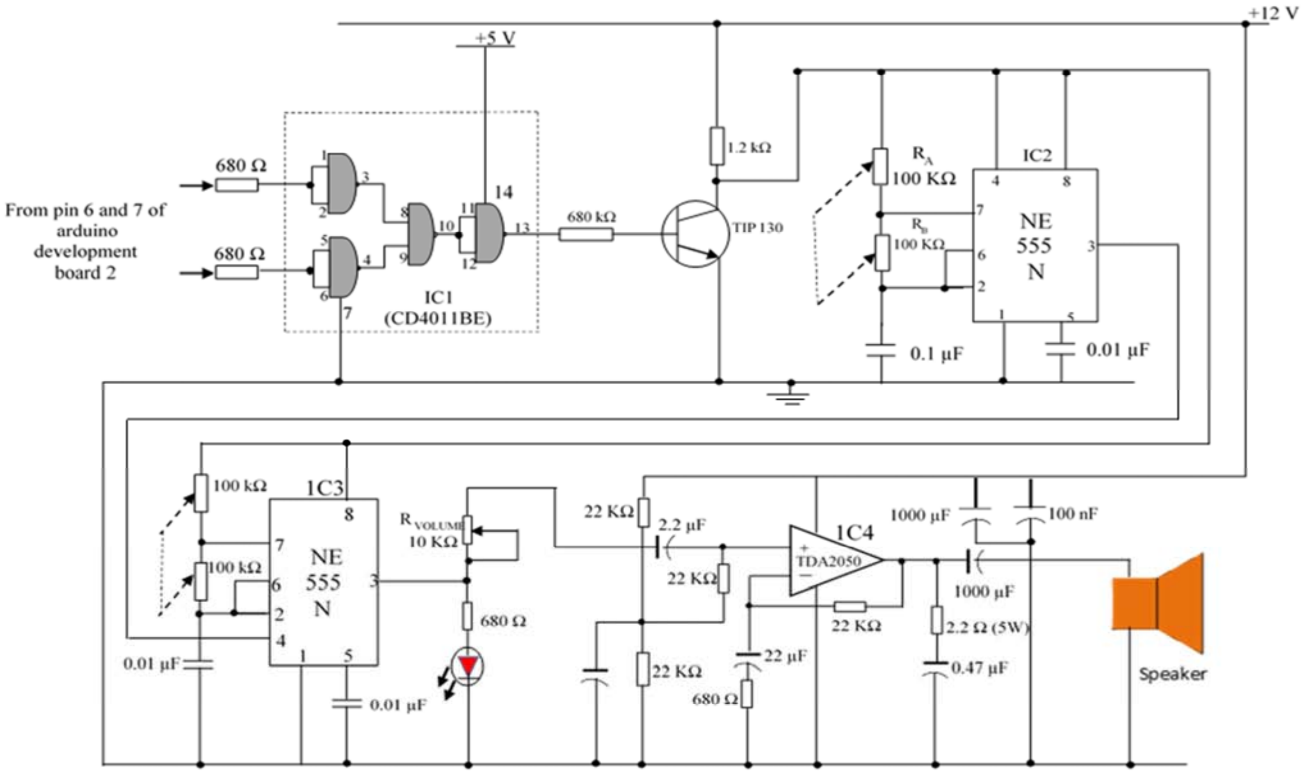

Figure 6. The circuit diagram of the signal conditioning circuit with the tone generator and the 25-Watt audio amplifier circuits which constitute the 25-Watt electronic alarm system.

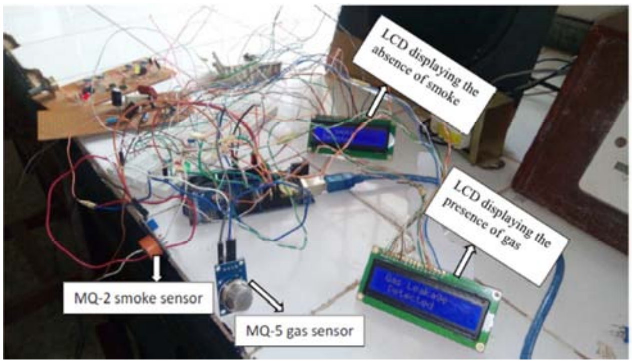

Figure 7. Testing of the gas and smoke detection system before incorporating them into the proposed autonomous vehicle.

4.3. The Automated Electronic Alarm System

The complete circuit diagram for the gas and smoke detecting system incorporated with the electronic alarm system is shown in Figure 4. The electronic alarm system is built around two NE555CN timer ICs which forms the tone generator and a TDA2050 audio amplifier IC. Following the discussions in previous sections, whenever an LPG or smoke is detected, the electronic alarm system is triggered.

In order to protect the Arduino Mega 2560 development board output ports, resistors are connected from the output ports to the CD4011BE to limit the current flowing through it as shown in Figure 5. Note that the output pin 11 of the CD4011BE NOR-gate configuration as shown in Figure 5 is used to bias transistor (TIP130 NPN transistor) via 1.2 kΩ which delivers +12 V which serves as power supply voltages to the circuit of IC2. The circuit of IC2 is a NE555CN timer wired as an astable multivibrator. The output taken at pin 3 of IC2 is high for one half of a cycle for one second and goes low for the next half cycle [28]. When the output is low, IC3 is inhibited and the loud-speaker is off. During the next half cycle, the output is high. Thus, the output of IC2 oscillates at 1 kHz and this oscillating signal was amplified by a 25 Watts audio power amplifier built around IC4, TDA2050 [23, 24] and passed to the speaker situated on the far right bottom of Figure 6. When this electronic alarm is ON, it however signifies that either LPG or smoke has exceeded its threshold level. The sound level (i.e. the volume) of the audio amplifier is regulated by the 100 kΩ potentiometer (R_{VOL}). Finally, Table 2 shows the description of the pin connections of the complete circuit of the gas and smoke detection system.

4.4. Testing and Deployment of the GASMOD System

The Table 2 shows the pins connection of the LCD and the MQ-5 gas sensor for gas detection to the Arduino development board. The pin A0 of the Arduino board is connected to the analog input (A0) of the MQ-5 gas sensor while pin 8 of the arduino board is connected to a red LED through a resistor which comes ON when gas is been detected. The Arduino integrated development environment (IDE) is a cross-platform application written in Java and most of the Arduino programs are written in C or C++. It can runs in all operating systems like Windows, Mac OS, and Linux. It is designed to introduce programming skills to artists and other newcomers who are unfamiliar with software development or hardware programming. It includes a code editor with common developer software features like syntax highlighting, brace matching, and automatic indentation. It also provides a function that is capable of compiling and uploading programs to the board via USB. It is a user-friendly interface for everyone from beginner to professional to learn or use.

4.5. Performance Evaluation of the Proposed GASMOD System

The performance evaluation of the proposed GASMOD system with a view to ascertain the functionality of the designed GASMOD system is presented in this Section. Based on the fabrication and construction of the complete design shown in Figure 7, the complete program for the implementation of the GASMOD is given in Table 4 as listed in the Appendix II was implemented. The experimental setup for the performance evaluation of the proposed GASMOD is shown in the photograph of Figure 7.

The electronic alarm system is initially off with no gas or smoke. However, the proposed GASMOD system has been able to detect laboratory gas as well as smoke from burning paper and from wood as can be seen in the two LCDs in Figure 7 with the simultaneous triggering of the automatic electronic alarm system and displays the corresponding status of the gas and smoke on the respective YJD1602A-1 LCD.

5. Conclusion and Future Directions

5.1. Conclusion

The main objective of this research was to develop a gas and smoke detection system capable of simultaneous detection of LPG and smoke in an environment with high sensitivity. The objective has been achieved since the device works effectively as expected. Furthermore, the advantage of the GASMOD system designed, developed, implemented and validated in this work differs from those proposed in literature in that it incorporates a high sensitivity gas and smoke sensor system as well as electronic alarm system with a 25-Watt audio power amplifier.

When the system detects the presence of LPG gas in laboratory, it triggered the electronic alarm indicating the presence of gas and it also displayed "Gas Leakage Detected" on the LCD screen as can be seen in Figure 7. When there is no gas detected, the LCD displays "No Gas Leakage".

Also, when the system detects the presence of smoke in the laboratory, the electronic alarm is triggered indicating the presence of smoke and also displaying "Smoke Detected" on the LCD screen. When there is no smoke detected, the LCD displays "No Smoke Detected" as evident in Figure 7.

This proposed GASMOD system can be adapted and deployed for both domestic, research laboratories, environmental and industrial settings to help detect harmful and gaseous substances which could affect experiments being carried out as well as the state of health of human beings and animals in that location. The system can also be placed in specific areas where such gas and smoke are not needed.

The cost of implementing this system is relatively low since the components used are relatively cheap and are easily available in the local markets. The single microcontroller can be used to interface several sensors with alarms located in different locations as long as more pins are free for multiple-inputs and multiple-outputs (MIMO) communication.

5.2. Future Directions

The safety of personnel is a very crucial aspect in both domestic and industrial setting; hence the use of gas sensors is inevitable in addition to other more sophisticated security systems.

This system should be placed in a cool and dry place in order to ensure a longer life span. With different tactics been employed terrorist organizations, specific gas sensors should be placed in large shopping malls to detect poisonous and very dangerous gas.

Appendix

Appendix I: The GASMOD System Nomenclatures and Parameter Definitions

Table 3. The GASMOD system nomenclatures and parameter definitions.

Parameters	Definition	Parameters	Definition
H_2	Hydrogen gas	HF	Hydrogenfluoride
CH_4	Methane	HCl	Hydrogenchloride

Parameters	Definition	Parameters	Definition
CO	Carbon II Oxide	$COCl_2$	Phosgene
SMS	Short message service	SnO_2	Silicon oxide
GSM	Global system for mobile communication	CNG	Compressed natural gas
CO_2	Carbon IV Oxide	LPG	Liquefied natural gas
NO_2	Nitrogen IV Oxide	LCD	Liquid crystal display
H_2S	Hydrogen sulphide	LED	Light emitting diode
Cl_2	Chlorine gas	UART	Universal asynchronous receiver and transmitter
ClO_2	Chlorine IVO xide	µs	Microsecond
NH_3	Ammonia	mA	Milliampere
PH_3	Phosphate	V	Volts
HCN	Hydrogen Cyanide	cm	Centimeter
C_2H_2O	Ethylene Oxide	AC	Alternating current
O_2	Oxygen	DC	Direct current
NO	Nitric Oxide	GND	Ground
O_3	Ozone	SS	Slave select
ICSP	In-circuit serial programming	MISO	Master-in slave-out
SPI	Serial peripheral interface	MOSI	Master-out slave-in
SCK	Serial clock	ppm	Parts per million
PWM	Pulse with modulation	SRAM	Static random access memory
EEPROM	Electrically erasable programmable read-only memory	IDE	Integrated development environment
kb	Kilo-bytes	AREF	Analog reference
mm	millimeters	RX	Digital pin 0 (Receiver)
KHz	Kilo-Hertz	TX	Digital pin 1 (Transmitter)
IR	Infrared	Ω	Ohms
PCB	Printed circuit board	SDA	Data line
TWI	Two wire interface	IOREF	Input/output reference
IC	Integrated circuit	TTL	Transistor-transistor logic
m	Meter	DTR	Data terminal ready
USB	Universal serial bus	OS	Operating system
SCL	Clock line	GASMOD	Gas-smoke Detection

Appendix II: The complete program for the implementation of the proposed GASMOD system

Table 4. The complete program for the implementation of the proposed GASMOD system.

```
/*
Program for the implementation of the proposed IoT-based real-time
embedded system for gas-smoke detection (GASMOD) with autmated
electronic alarm system
VCC to arduino 5V; GND to arduino GND
Echo to Arduino pin 13; Trig to Arduino pin 12
Red POS to Arduino pin 11; Green POS to Arduino pin 10
560 ohm resistor to both LED NEG and GRD power rail
*/

#include <LiquidCrystal.h>
LiquidCrystal lcd1(13, 12, 5, 4, 3, 2);
LiquidCrystal lcd2(10, 9, 5, 4, 3, 2);

#define LPG_sensor   A1
#define smoke_sensor   A2
#define alarm 52
#define buzzer 53

void setup() {
  pinMode(LPG_sensor, INPUT);
  pinMode(alarm, OUTPUT);
  pinMode(smoke_sensor, INPUT);
  pinMode(buzzer, OUTPUT);

  lcd1.begin(16, 2);
  lcd1.print("LPG Gas Detector");
  lcd1.setCursor(0,1);
  lcd1.print("Circuit Digest");
  delay(2000);
  lcd2.begin(16, 2);
```

```
     lcd1.clear();
     lcd1.print("Gas Leakage");
     lcd1.setCursor(0, 1);
     lcd1.print("   Alert       ");
     delay(400);
     digitalWrite(alarm, LOW);
     delay(500);
   }
else
   {
     digitalWrite(alarm, LOW);
     lcd1.clear();
     lcd1.print(" No Gas or Fumes");
     lcd1.setCursor(0,1);
     lcd1.print(" Detected      ");
     delay(1000);
}
  if(digitalRead(smoke_sensor) )
   {
    digitalWrite(buzzer, HIGH);

     lcd2.clear();
     lcd2.print("smoke   ");
     lcd2.setCursor(0, 1);
     lcd2.print("Alert       ");
     delay(400);
     digitalWrite(buzzer, LOW);
     delay(500);
   }
else
   {
```

```
  lcd2.print("smoke Detector");
  lcd2.setCursor (0,1);
  lcd2.print("Circuit Digest");
  delay(2000);
}
void loop(){
  if(digitalRead(LPG_sensor) )
  {
    digitalWrite(alarm, HIGH);
    digitalWrite(buzzer,LOW);
    lcd2.clear();
    lcd2.print(" No Smoke");
    lcd2.setCursor(0,1);
    lcd2.print(" Detected      ");
    delay(1000);
  }
}
```

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