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Design and Development of IoT based Industrial Gas Leakage Monitoring System

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Abstract: Gas leakages are a hazardous threat to living beings present in the vicinity and cause serious health issues when exposed. Employees need to constantly monitor the situation and if any leak occurs he/she needs to make the right decisions which sometimes may be prone to error.

A system needs to be created that bypasses human intervention and constantly monitors around the clock. The input to the system is given by a sensor whose sensitivity depends on the gas it needs to detect. The concentration of the gas is directly proportional to the voltage output. On receiving the information, a microcontroller operates an alarm, monitoring system and displays the output with the help of LCD, LEDs.

An Internet of Things (IoT) infrastructure is created in such a way that people, who are connected to the same Wi-Fi, will get a message and authorities present outside the organization will get an email via a cloud-based applet wherein officials can monitor using data analytics platform from a safe location via the internet. Officials will be able to monitor all the areas placed with a sensor on a single dashboard. From the dashboard, the data is received by a microcontroller which then initiates the sprinkler system. The microcontroller, present at the leak, operates a solenoid valve thereby directing the sterilizing agent at the site of the leak.

Keywords: Gas Detection System, Sensor, Alarm, Monitoring System, IoT Infrastructure, Cloud-Based Applet, Data Analytics.

I. INTRODUCTION

Gas leaks can be attributed to a man-made disaster. Improper design, damage to the material, improper installation and maintenance, lack of handling expertise are some of the ways that lead to gas leaks. Common types of industrial gases include carbon dioxide, carbon monoxide, mono oxides of nitrogen. Dust, smoke released from industries causes air pollution. They hinder muscular functioning. Gases like CO₂, SO₂, and NO₂ combine with rainwater creating respective acids. The productivity of the soil is impeded due to acidification. The acidity of water bodies increases which cause the decline in the population of aquatic organism. Acid rain also leads to corrosion of historical monuments. Industrial gases create photochemical smog which causes eye itching and respiratory problems. The smog reduces the transparency of the atmosphere and creates a problem for pilots and planes. A potential leak of any lethal gas may pose a significant threat to living things and the environment. It will have a lasting effect spanning decades and inhibiting serious health issues. Some gases lead to genetic abnormalities. Gas leaks into the atmosphere cause global warming and ozone depletion. Some gases rapidly diffuse with air thereby decreasing countermeasure time. The risks of explosion, fire, suffocation are based on the properties of the gas.

Underground gas leaks lead to land degradation, pollution of underground water making the land uninhabitable for decades to go. The number of gas-related accidents is on the rise. This situation requires immediate attention so that future devastating accidents can be mitigated. This paper talks about gas detection system which does not include human participation. The system monitors around the clock. Whenever the concentration of particular gas increases, the system takes the necessary steps to inform concerned authorities. The alarm, lights, display come into action. With the help of local networks and IoT-based platforms, the employees working in the organization will get messages, notifications, and emails. The sensors can be installed in critical areas and can be monitored simultaneously on a common dashboard at any location with stable internet. The system can be further improvised by pulling data from the dashboard and sending it to the microcontroller which then initiates the sprinkler system. Relays, which can be used to operate solenoid valves, are present on every microcontroller present in the vicinity of the leak. The solenoid valve directs the neutralizer agents towards the point of the leak. Additional upgrades can be implemented by creating automatic exhaust systems; lockdown protocols can be initiated in the form of gate systems. The system requires little wiring, is portable, and is maintenance-friendly. It is easy to install and takes up a very small space. The system can be customized to detect any type of gas. It is cost-effective, reliable, and can be quickly produced.

II. LITERATURE SURVEY

I have explored various articles, posts, documentaries regarding gas leaks in the past. There are myriad reasons that led to the leaks. The damage it caused is unfathomable whether it may be in terms of money, lives, or the environment. Controlling the system needs patience while monitoring and decision-making capabilities under difficult situations. Some of the most prominent problems found in current industries are as follows.

- 1) The system is very expensive and was found in large-scale industries. The system is not maintained periodically.
- 2) The systems are primitive using relays and timers. Employees are needed for constant monitoring and for controlling purposes.
- 3) Humans are instructed to initiate lockdown protocols and alert authorities when a leak occurs increasing the time to take appropriate measures.
- 4) Everything is wired which makes the maintenance difficult and to alert people the same old siren is used.
- 5) The latest countermeasures such as the deployment of sterilizing chemical agents or venting out the harmful gases into the separate chamber, initiation of sprinkler system are not present.
- 6) Factories have no regard for the environment because in the name of expansion the proprietors are clearing the forest area around. The common public knowingly or unknowingly is relocating to places near factories.

The most prominent factor is time; if authorities had enough time to assess the situation and take appropriate action then a lot of lives could be saved thereby limiting the destruction.

III. WORKING

Figure 1. System Block Diagram

The project uses NodeMCU with a built-in ESP8266 Wi-Fi module. To detect gases MQ-2 semiconductor sensor is installed. The sensor constantly feeds the analog data into NodeMCU when a threshold is reached an appropriate output will be given. The sensor takes input whereas LEDs, LCD with i2c, buzzer gives output. There are two LEDs present which are named green and red. The green LED, as shown in figure 10, is switched on when there are no gases present notifying that the atmosphere is safe. The red LED, as shown in figure 10.2, is switched on when there are gases present notifying the atmosphere is not safe. The buzzer is switched on when gases are present notifying that the atmosphere is not safe. The LCD with i2c flashes messages, as shown in figure 10, such as “SAFE” and “ALL CLEAR” when no gases are present in the atmosphere but when gases are present the messages, as shown in figure 10.2, changes to “ALERT” and “EVACUATE”.

IV. CIRCUIT DESIGN

The diagram shows a NodeMCU V3.0-12C module connected to various components. The module's pins are labeled as follows:

- 1: A0(ADC)
- 2: A1
- 3: A2
- 4: D0(SPI0)
- 5: D1(SPI0)
- 6: D2(SPI0)
- 7: D3(SPI0)
- 8: D4(SPI0)
- 9: D5(SPI0)
- 10: D6(SPI0)
- 11: D7(SPI0)
- 12: D8(SPI0)
- 13: D9(SPI0)
- 14: D10(SPI0)
- 15: D11(SPI0)
- 16: D12(SPI0)
- 17: D13(SPI0)
- 18: D14(SPI0)
- 19: D15(SPI0)
- 20: D16(SPI0)
- 21: D17(SPI0)
- 22: D18(SPI0)
- 23: D19(SPI0)
- 24: D20(SPI0)
- 25: D21(SPI0)
- 26: D22(SPI0)
- 27: D23(SPI0)
- 28: D24(SPI0)
- 29: D25(SPI0)
- 30: D26(SPI0)
- 31: D27(SPI0)
- 32: D28(SPI0)
- 33: D29(SPI0)
- 34: D30(SPI0)
- 35: D31(SPI0)
- 36: D32(SPI0)
- 37: D33(SPI0)
- 38: D34(SPI0)
- 39: D35(SPI0)
- 40: D36(SPI0)
- 41: D37(SPI0)
- 42: D38(SPI0)
- 43: D39(SPI0)
- 44: D40(SPI0)
- 45: D41(SPI0)
- 46: D42(SPI0)
- 47: D43(SPI0)
- 48: D44(SPI0)
- 49: D45(SPI0)
- 50: D46(SPI0)
- 51: D47(SPI0)
- 52: D48(SPI0)
- 53: D49(SPI0)
- 54: D50(SPI0)
- 55: D51(SPI0)
- 56: D52(SPI0)
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- 242: D238(SPI0)
- 243: D239(SPI0)
- 244: D240(SPI0)
- 245: D241(SPI0)
- 246: D242(SPI0)
- 247: D243(SPI0)
- 248: D244(SPI0)
- 249: D245(SPI0)
- 250: D246

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B. Gas Detector 2

Figure 3. Gas detector 2 system design

C. Sprinkler System

Figure 4. Sprinkler system Design

V. SYSTEM DESIGN DESCRIPTION

- 1) NodeMCU supplies power to all the output peripherals (LEDs, LCD with i2c, buzzer, MQ-2 Sensor) as shown in figure 2.
- 2) MQ-2 semiconductor was connected to analog pin A0 of NodeMCU. Power supply, GND to the sensor was given by 3.3v pin, GND pin of NodeMCU.
- 3) The green LED, red LED was connected to the D7, D0 pin of NodeMCU respectively. Both LEDs had a 1K Ω resistor, in series configuration, on their positive end.
- 4) A piezo buzzer was connected to the D4 pin of NodeMCU.
- 5) A common GND is created to accommodate negative terminals of LEDs and buzzer.
- 6) An LCD with i2c was set up. The SCL, SDA pins of LCD with i2c were connected to the D1, D2 pin of NodeMCU respectively. The LCD with i2c draws up the power from Vin (5v) pin from NodeMCU and the GND pin of the LCD with i2c was connected to the GND port of NodeMCU.
- 7) A relay circuit was created using the D5 pin of the NodeMCU. For governing the relay, a 5v supply is required. Hence the 3.3v of NodeMCU is coupled with an amplifier circuit. The D5 pin was connected to the base of the BC547 transistor with a 4.7K Ω resistor in series configuration. The emitter end was grounded. The collector end was connected to the positive pin of the magnetic coil and the negative end, with a 2.2 K Ω resistor in series configuration, was connected to a connector thereby completing the circuit.
- 8) A 10 μ f / 50v capacitor, IN4001 diode was connected to the magnetic coil in parallel configuration. A LED, with a 180 Ω resistor in series configuration, was connected to a 10 μ f / 50v capacitor in parallel configuration. The LED acts as an indicator when the relay is energized.
- 9) Through a series of connectors, the common pin of the relay is supplied with a 220v external power supply through an AC adapter. and the NO pin is connected to the solenoid valve with neutral in direct connection.
- 10) The three IoT platforms namely BLYNK, ThingSpeak, IFTTT were interfaced with NodeMCU through the code. By incorporating the login credentials, the ESP8266 Wi-Fi module connects with the local network. The communication with every platform is mentioned below.

11) Blynk

- Blynk app was installed and the functions to be performed were defined through widgets.
- A connection was established, as shown in figure 6, by defining a virtual pin (a pin that functions as a physical pin on the microcontroller) in the app settings and the authentication token was inserted, generated by the app when a project is created, into the code.
- Appropriate libraries were downloaded that allow the code to recognize the channel through which the data is to be transmitted.

12) IFTTT (if this, then that) - Applet creator

- In IFTTT, a Webhooks trigger was created, as shown in figure 8(b), and the following action of pushing an email was created in the next step as shown in figure 8(c).
- The Webhooks generated a trigger by creating a web request which consists of a key unique to the project.
- Libraries were used in the code to recognize and implement the trigger at the right time.

13) ThingSpeak (IoT analytics platform)

- A channel, as shown in figure 7, was created thereby creating a path for the user to publish the data.
- Based on the number of inputs to be published the fields that display the data in the graph were decided.
- The Application Programming Interface (API) key was inserted, generated by the platform when a channel is created, into the code.
- Appropriate libraries were downloaded that allow the code to recognize the channel through which the data is to be transmitted.

- 14) A charger (a cable connected to the socket and the male of the charger cable is interfaced with the female port of NodeMCU) was used to power the NodeMCU.

- 15) A similar system, as shown in figure 5.3, was developed to demonstrate that the data from multiple sensors can be collected, viewed on a single dashboard. The system is governed by the same protocols with only changes in paths to publish data on the IoT platform dashboard.
 - Blynk- A new monitoring widget, as shown in figure 11.5 (bottom meter), was added to display the data. The software was notified of the inclusion of the new NodeMCU. A virtual pin was assigned to establish communication between the platform and the ESP8266 Wi-Fi module. An authentication code was generated which was embedded into the code.
 - IFTTT- Similar to the process mentioned above and the process is shown in figure 9.
 - ThingSpeak- A new field, as shown in figure 11.6(Field 2 chart), was created in the existing channel. As for the code, the API key and the channel number remain the same but the data was directed to the dashboard by mentioning the appropriate field number.
- 16) The data from the ThingSpeak platform was transferred to another NodeMCU which initiated the sprinkler system. By incorporating the login credentials, the ESP8266 Wi-Fi module connects with the local network. The communication with the platform was established by giving instructions, such as the read API key and the channel number, to the NodeMCU.
- 17) The sprinkler system, as shown in figure 4, architecture remains the same with only change is that the system uses an AC motor to pump the sterilizing agent to the required location.

VI. ALGORITHM

- 1) Include the libraries through which the user communicates with physical peripherals or the IoT platforms and define the functions.
- 2) For the implementation of the IoT platforms, a connection must be made with the local network and ESP8266 wifi module. Channels are established to export the data from the sensor to the IoT platform.
- 3) Visualize how the system should behave in different situations, when deployed in the real-time environment, and develop scenarios that specify how a particular peripheral should function.
 - a) *During clear air scenario (figure 10)*
 - The green LED is ON.
 - The red LED is OFF.
 - The buzzer is in the OFF state.
 - The relay is in the OFF state thereby keeping the solenoid valve in standby state. Hence, the white LED is OFF.
 - The display shows words such as “SAFE” and “ALL CLEAR”.
 - The leakage can be monitored on both BLYNK (meter form) and Thingspeak (graph form).
 - b) *During gas scenario (figure 10.2)*
 - The green LED is OFF.
 - The red LED is ON.
 - The buzzer is in ON state.
 - The relay is in the ON state thereby energizing the solenoid valve. Hence, the white LED is ON.
 - The display shows words such as “ALERT” and “EVACUATE”.
 - An email is pushed through webhooks and IFTTT.
 - BLYNK app, as shown in figure 10.5, pushes a notification.
 - The changes in data are plotted in a graph, as shown in figure 10.6, on the ThingSpeak platform.
 - The data can be downloaded in an excel format as shown in figure 10.7.
- 4) Irrespective of the scenario, monitoring features of Blynk, ThingSpeak publishes data round the clock but the user needs to define a particular scenario to enable the trigger feature of IFTTT and notify feature of Blynk.
- 5) Determine the response time (how fast data need to be transferred) and the action time of a particular component if it is triggered.
- 6) Multiple systems are developed using the above protocols with only changes in the paths for publishing the data onto a common platform.

- 7) The data from the sensor which is in analog format is sent to NodeMCU where the data is converted to digital format and the appropriate result is shown whether it be visual (LCD, LEDs), sound (buzzer), IoT platform (email, message, website), switching of the relay (solenoid valve).
- 7) A relay is interfaced with every NodeMCU present at different locations across the plant. The relay is used to operate the solenoid valve which is used to direct the neutralizing agent towards the leak.

A. Sprinkler System

- 1) Include physical peripherals and associated libraries.
 - 2) A connection must be made with the local network and ESP8266 Wi-Fi module.
 - 3) Established channel addresses are to be mentioned to import the data from the IoT platform to the microcontroller.
 - 4) Based on the acquired data, develop scenarios that specify how a particular peripheral should function.
- a) *During Clear Air Scenario (Figure 10.1)*
- The green LED is ON as it is normally closed (NC) switch type.
 - The red LED is OFF as it is normally open (NO) switch type.
 - The buzzer is in the OFF state.
 - The relay is in the OFF state thereby keeping the AC motor in standby state. Hence, the white LED is OFF.
 - The display shows words such as “Chamber 1 SAFE” and “Chamber 2 SAFE” when no leak is detected at both the detectors.
- b) *During Gas Scenario (Figure 10.3)*
- The green LED is OFF.
 - The red LED is ON.
 - The buzzer is in ON state.
 - The relay is in the ON state thereby energizing the AC motor. Hence, the white LED is ON.
 - The display shows words such as “Chamber 1”, “Gas Leak” if there is a leak at gas detector1, and “Chamber 2”, “Gas Leak” if there is a leak at gas detector 2.
- 5) Determine the response time (how fast data need to be transferred) and the action time of a particular component if it is triggered.
 - 6) The prime importance of this microcontroller is that during a leak, the NodeMCU (microcontroller) operates the sprinkler system by switching on an AC motor through the relay.

VII.RESULTS

A. Setup

Figure 5. Overall setup (side view)

Figure 5.1 Overall setup (top view)

Figure 5.2 Gas detector 1 setup (top view)

Figure 5.3 Gas detector 2 setup (top view)

Figure 5.4 Sprinkler system setup (top view)

B. BLYNK App setup

Figure 6. Creation of BLYNK application according to our system requirements

C. ThingSpeak setup

Figure 7. Creation of ThingSpeak channel according to our system requirements

D. IFTTT Setup

1) Gas Detector 1 Details

The image shows the IFTTT service creation interface. On the left, a blue card titled "If Maker Event 'Chamber A Gas Leakage', then Send me an email at 17311A0355@sreenidhi.edu.in" is displayed. Below it, a "Connected" status bar shows a blue toggle switch. A list of activities includes "Connected Jun 09, 2021", "Last activity Feb 09, 2022", and "Run 693 times". Buttons for "View activity" and "Check now" are present. On the right, a blue card titled "Then" with a mail icon and the text "Send me an email" is shown. The interface includes a central vertical line with a plus sign at the top and bottom, indicating the flow of the service.

(a)

The image shows the "Webhooks Settings" interface. The top section is a blue header with the IFTTT logo and the text "Webhooks Settings". Below this, a blue card titled "Receive a web request" is displayed. It includes a "View activity log" button. The "Event Name" field is set to "Chamber_A_Gas_Leakage". The "Details" section on the right shows the event ID "17311a0355", the status "Active", and the URL "https://maker.ifttt.com/use/dVKYCU43e31KsM9FEoql3".

(b)

The image shows the "Email Settings" interface. The top section is a blue header with the IFTTT logo and the text "Email Settings". Below this, a blue card titled "Send me an email" is displayed. It includes a "View activity log" button. The "Subject" field is set to "The event named 'Chamber A Gas Leakage at Sentinel Chemicals' occurred on the Maker Webhooks service". The "Body" field contains the text "Name: Sentinel Chemicals
Where: Block A, 530 Apex industrial center, Park lane, Antilla
type: Methane
". The "Details" section on the right shows the status "Active" and the email address "17311A0355@sreenidhi.edu.in".

(c)

Figure 8. (a) Creation of IFTTT service according to our system requirements (Gas detector 1). (b) Creation of webhooks request.

(c) Creation of email service

2) Chamber B Details

(a)

The 'Webhooks Settings' form for 'Receive a web request' includes an 'Event Name' field with the value 'Chamber_B_Gas_Leakage'. The 'Details' section shows the ID '17311a0355', status 'Active', and a URL: 'https://maker.ifttt.com/use/dVKYCU43e31KsM9FEoql3'. A 'View activity log' button is present.

(b)

The 'Email Settings' form for 'Send me an email' includes a 'Subject' field with the text 'The event named "Chamber B Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service'. The 'Body' field contains the text: 'Name: Sentinel Chemicals
Where: Block B, 530 Apex industrial center, Park lane, Antilla
type: Methane
'. The 'Details' section shows the status 'Active' and the email address '17311A0355@sreenidhi.edu.in'. A 'View activity log' button is present.

(c)

Figure 9. (a) Creation of IFTTT service according to our system requirements (Gas detector 2). (b) Creation of webhooks request. (c) Creation of email service

E. Gas Detector 1

1) Case 1: Clean air

Figure 10. Gas detector 1 during clean air scenario

a) Sprinkler System

Figure 10.1 Sprinkler system during clean air scenario

2) Case 2: Gases present

Figure 10.2 Gas detector 1 during gas leak scenario

a) Sprinkler System

Figure 10.3 Sprinkler system during gas leak scenario

b) Complete Operation

Figure 10.4 Overall setup during gas leak scenario

c) BLYNK Response

Figure 10.5 BLYNK app response from gas detector 1 during gas leak scenario

d) ThingSpeak response

(NOTICE: Timestamp on all the following images read 7:28 pm and the peak value)

Figure 10.6 ThingSpeak continuous monitoring in graph format

M6536							
	A	B	C	D	E	F	G
6516	2022-02-09T19:24:57+05:30	6515		12			
6517	2022-02-09T19:25:12+05:30	6516	29				
6518	2022-02-09T19:25:28+05:30	6517		9			
6519	2022-02-09T19:25:44+05:30	6518		13			
6520	2022-02-09T19:26:00+05:30	6519		7			
6521	2022-02-09T19:26:15+05:30	6520		12			
6522	2022-02-09T19:26:31+05:30	6521		12			
6523	2022-02-09T19:26:46+05:30	6522	29				
6524	2022-02-09T19:27:01+05:30	6523		17			
6525	2022-02-09T19:27:17+05:30	6524		13			
6526	2022-02-09T19:27:33+05:30	6525	30				
6527	2022-02-09T19:27:48+05:30	6526	29				
6528	2022-02-09T19:28:04+05:30	6527		12			
6529	2022-02-09T19:28:20+05:30	6528		13			
6530	2022-02-09T19:28:35+05:30	6529	540				
6531	2022-02-09T19:28:50+05:30	6530		12			
6532	2022-02-09T19:29:05+05:30	6531	65				
6533	2022-02-09T19:29:21+05:30	6532	52				
6534	2022-02-09T19:29:37+05:30	6533	49				
6535	2022-02-09T19:29:52+05:30	6534		14			
6536	2022-02-09T19:30:07+05:30	6535	43				
6537	2022-02-09T19:30:22+05:30	6536	41				
6538	2022-02-09T19:30:38+05:30	6537		9			
6539	2022-02-09T19:30:53+05:30	6538	40				
6540	2022-02-09T19:31:09+05:30	6539	38				
6541	2022-02-09T19:31:24+05:30	6540		208			
6542	2022-02-09T19:31:40+05:30	6541		196			
6543	2022-02-09T19:31:55+05:30	6542	37				
6544	2022-02-09T19:32:11+05:30	6543	36				
6545	2022-02-09T19:32:27+05:30	6544	36				
6546	2022-02-09T19:32:43+05:30	6545		182			

Figure 10.7 ThingSpeak continuous monitoring in Excel sheet format

e) IFTTT Response

(NOTICE: Timestamp on all the following images read 7:28 pm and the peak value)

Figure 10.8 IFTTT email alerts from gas detector 1 during gas leak scenario

Figure 10.9 IFTTT applet activity of gas detector 1

F. Gas Detector 2

1) Case 1: Clean air

Figure 11. Gas detector 2 during clean air scenario

b) Sprinkler System

Figure 11.1 Sprinkler system during clean air scenario

2) Case 1: Clean air

Figure 11.2 Gas detector 2 during gas leak scenario

a) Sprinkler System

Figure 11.3 Sprinkler system during gas leak scenario

b) Complete Operation

Figure 11.4 Overall setup during gas leak scenario

c) BLYNK response

Figure 11.5 BLYNK app response from gas detector 2 during gas leak scenario

d) IFTTT Response

(NOTICE: Timestamp on all the following images read 9:32 pm and the peak value)

Figure 11.6 ThingSpeak continuous monitoring in graph format

	A	B	C	D	E	F	G	H
6951	2022-02-09T21:27:35+05:30	6950		12				
6952	2022-02-09T21:27:51+05:30	6951	12					
6953	2022-02-09T21:28:06+05:30	6952	12					
6954	2022-02-09T21:28:22+05:30	6953	12					
6955	2022-02-09T21:28:37+05:30	6954	12					
6956	2022-02-09T21:28:52+05:30	6955		87				
6957	2022-02-09T21:29:08+05:30	6956		55				
6958	2022-02-09T21:29:23+05:30	6957		40				
6959	2022-02-09T21:29:39+05:30	6958		32				
6960	2022-02-09T21:29:54+05:30	6959		29				
6961	2022-02-09T21:30:10+05:30	6960	8					
6962	2022-02-09T21:30:25+05:30	6961	12					
6963	2022-02-09T21:30:41+05:30	6962		26				
6964	2022-02-09T21:30:56+05:30	6963		24				
6965	2022-02-09T21:31:11+05:30	6964	13					
6966	2022-02-09T21:31:27+05:30	6965	12					
6967	2022-02-09T21:31:42+05:30	6966		21				
6968	2022-02-09T21:31:57+05:30	6967		20				
6969	2022-02-09T21:32:13+05:30	6968		20				
6970	2022-02-09T21:32:29+05:30	6969		301				
6971	2022-02-09T21:32:44+05:30	6970	9					
6972	2022-02-09T21:33:00+05:30	6971	12					
6973	2022-02-09T21:33:15+05:30	6972	12					
6974	2022-02-09T21:33:30+05:30	6973	14					
6975	2022-02-09T21:33:46+05:30	6974	9					
6976	2022-02-09T21:34:01+05:30	6975	5					
6977	2022-02-09T21:34:16+05:30	6976		20				
6978	2022-02-09T21:34:32+05:30	6977		20				
6979	2022-02-09T21:34:47+05:30	6978		19				
6980	2022-02-09T21:35:02+05:30	6979		19				
6981	2022-02-09T21:35:17+05:30	6980		19				

Figure 11.7 ThingSpeak continuous monitoring in Excel sheet format

e) IFTTT Response

The screenshot shows a Gmail inbox with the following visible emails:

- Webhooks via IFTTT 12**: The event named "Chamber B Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service - Name: Sentinel Chemical... 9:30 PM
- Webhooks via IFTTT 100**: The event named "Chamber B Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service - Name: Sentinel Chemical... 9:28 PM
- Webhooks via IFTTT 20**: The event named "Chamber A Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service - Name: Sentinel Chemical... 9:22 PM
- Webhooks via IFTTT 100**: The event named "Chamber A Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service - Name: Sentinel Chemical... 8:10 PM
- Webhooks via IFTTT 100**: The event named "Chamber A Gas Leakage at Sentinel Chemicals" occurred on the Maker Webhooks service - Name: Sentinel Chemical... 7:46 PM
- GMAT Club**: A Network Like No Other - Tap into the world's most responsive alumni network. Named the world's most responsive alumni network, Tuc... 7:37 PM
- TalentSprint**: TalentSprint Peer Guru Session | IIT Hyderabad | AI and Emerging Technologies Program Alumni - © 2022 TalentSprint Our mailing addr... 7:23 PM
- Study in France**: Your chance to study in top business school in France is now. Apply Now - Reasons to choose France as your study destination: Attractiv... 7:02 PM
- CodeProject**: Daily News - Online civility improved in past year and is the best it's been since 2016, new Microsoft research shows - Your morning up... 5:44 PM
- Quora Digest**: Which course should I choose between IIMA PGPM and ISB PGPM? - VS. I received admission offers to both IIM A PGPM and ISB PGPM for 2... 3:29 PM
- office exams**: Intimation - Examination Fee notification - B.Tech I Year II Semester - Supplementary End Examinations - March - 2022 - reg - Dear Stu... 11:56 AM
- office exams**: Intimation - Examination Fee Notification - B.Tech I Year I Semester - Regular / Supplementary End Examinations - April - 2022 - reg - D... 11:53 AM
- IFTTT**: What's new for February / all about jobs - Looking for a new role? Want to be more productive at work? This one's for you. IFTTT - 226... 3:23 AM
- CodeProject**: The Daily Build - A Generic Form of the NameValueCollection - 6 new and 0 updated articles today Welcome to the CodeProject Daily Bul... Feb 8
- GMAT Club**: GMAT 740 with V44 in 90 days - Learn how Hardik did it - Dear Student, Hardik completed the holy trifecta of GMAT achievements. He s... Feb 8

Figure 11.8 IFTTT email alerts from gas detector 2 during gas leak scenario

Figure 10.9 IFTTT applet activity of gas detector 2

G. Gas Detector 2 Enclosed in a Compartment

Figure 12. Gas detector 2 enclosed in a compartment

Figure 12.1 Operational gas detector 2 enclosed in a compartment

H. Sprinkler System

Figure 13.1 Sprinkler system enclosed in a compartment

Figure 13.2 Operational sprinkler system enclosed in a compartment

VIII. APPLICATIONS

- A. Vehicles using LPG Cylinders and even in households to detect leaks.
- B. Chemical industries, offshore & onshore drilling sites, national pipelines, mines, scientific laboratories, power plants (nuclear, thermal, etc).
- C. Mass transportation systems to facilitate safe commute.
- D. At all sites where hazardous gases pose a significant threat.

IX. FUTURE SCOPE

- A. An outer casing that is vibration, moisture, dust resistant must be designed.
- B. Instead of relying on third-party IoT platforms, one can create and install our firewalls to make the system tamper-proof.
- C. The system can be customized to detect any type of gas by changing the sensor appropriate to the application.
- D. Multiple sensors can be incorporated to monitor multiple parameters in a single environment.
- E. A standalone battery can be interfaced with the system which automatically functions during power outages/fluctuations.

X. CONCLUSIONS

I may infer that I have successfully built a system that is used to detect gas leaks. Under dangerous situations, the system worked admirably. Continued improvisation and sophistication might lead to a foolproof system that can be appropriately customized to function under various situations and applications. One should understand that such systems replace redundant and monotonous jobs and make human lives better by extending the boundaries of innovation.

XI. ACKNOWLEDGMENTS

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