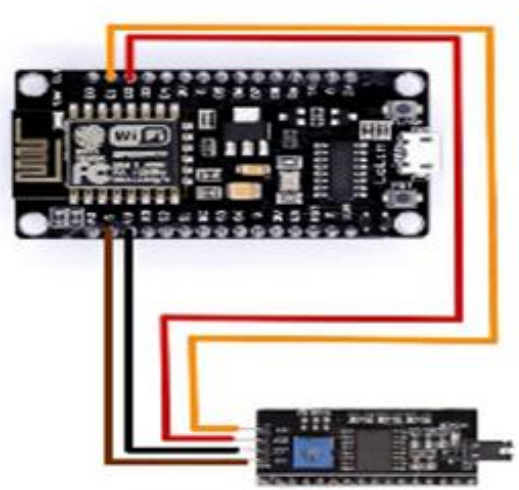
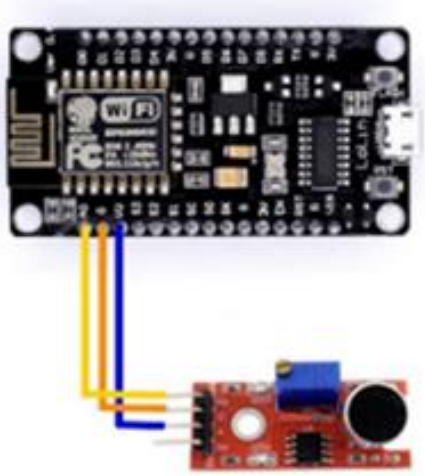
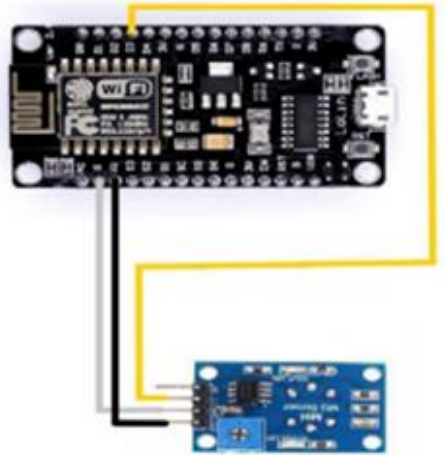
SENSOR ALERT SYSTEM A CASE STUDY OF WORKERS TRAPPED IN CONFINED SPACES







Pornpimol Chawengsaksopark ,Wasurat Bunpheng , Chongkol Sungoum,

Faculty of Engineering and Technology, Shinawatra University,Pathum Thani, Thailand

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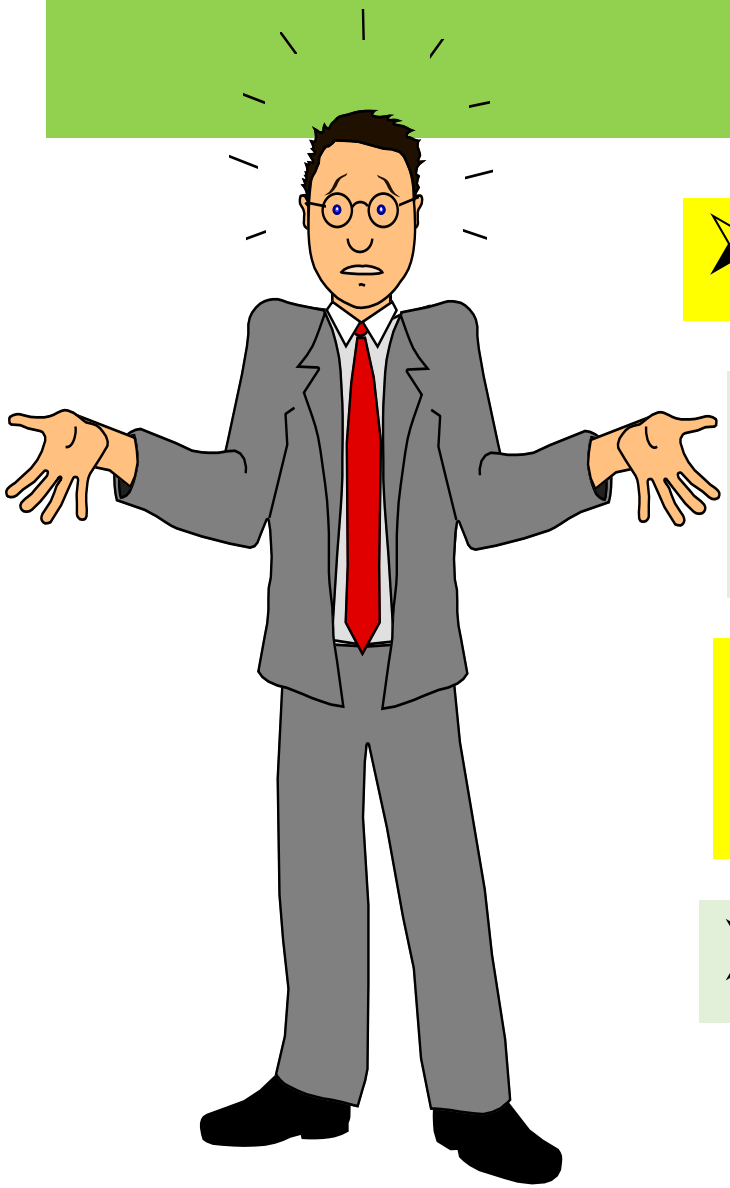
Research questions



- How can we reduce deaths of workers in confined spaces?
- How can a factory know if workers are trapped in confined spaces?
- How do we build a device that sends out an alert to let you know if an employee is trapped in a confined space?
- Can we design and build a sensor alert system ?

Research objectives

- 1.To design and build a sensor alert system for cases of workers trapped in confined spaces
- 2.To study the efficiency of the sensor alert system for cases of workers trapped in confined spaces

Scope of research

Research Hypothesis

- The sensor alert system will send emergency alert signals to both a siren and the LINE application when it detects workers trapped in confined spaces

Research Scope

- 1.The study area is the Physics Laboratory at Shinawatra University
- 2.Testing was conducted in a factory storage room with confined space characteristics, measuring 3 x 8 meters
- 3.The alert sensor system includes: Infrared photoelectric switch sensor,MQ-135 Air Quality Sensor , Carbon dioxide sensor, Sound sensor module hub 360

Research Methodology

1.Research Tools

1.1 Arduino Integrated Development Environment (Arduino Software IDE) is software used for programming Arduino boards using the C language. The program is open-source, making it freely available for use.

1.2 Blynk Application is a smartphone application suite that makes IoT project creation comprehensively simple. It connects to remote devices through the internet network, using smartphones as the main interface between users and endpoint control devices.

1.3 LINE Application is a communication application used for messaging and talking with others. It uses the internet for communication, allowing users to chat or make calls to others without any charges and with unlimited duration.

Instrument and material

Equipment

1) MQ-135 Air Quality Sensor
2) Infrared photoelectric switch sensor E18-D80NK
3) Sound sensor module hub 360
4) relay 2 channel
5) Mini strobe siren sound-light alarm wired sound-light alarm103 speaker12v Anti-theft alarm
6) LCD I2C 16X2
7) Jumper
8) Node MCU ESP8266
9) Lithium-ion JHZS 18650-2600mAh (4C 10.4A
10) Lithuim-ion battery pack 14.8V
11) Protection PCB Board 18650 For Li-ion Lithium Battery 6A-8A Prevent Overcharge & Discharge w/Balance 3S (3cell11.1v/12.6V)
12) DC-022B DC power outlet DC Block 5 5.5x2.1MM power female socket

Research Methods

2.1 Study information, devices, Arduino boards, Module boards, study C language writing from Internet sources, related research results from various websites as a prototype.

2.2 Study information on the Blynk application, which is a set of applications on smartphones that make IoT work connected to distant devices via the Internet, using smartphones as the main device to contact users and end control devices.

2.3 Select the Arduino board device as a wireless transmitter and receiver, controlled by writing a program with C language before connecting to the sensor and siren.

Research Methods

2.4 Write a C language program into the Arduino board to command the board to display the results as we want the board to work and connect the delay to the Arduino board.

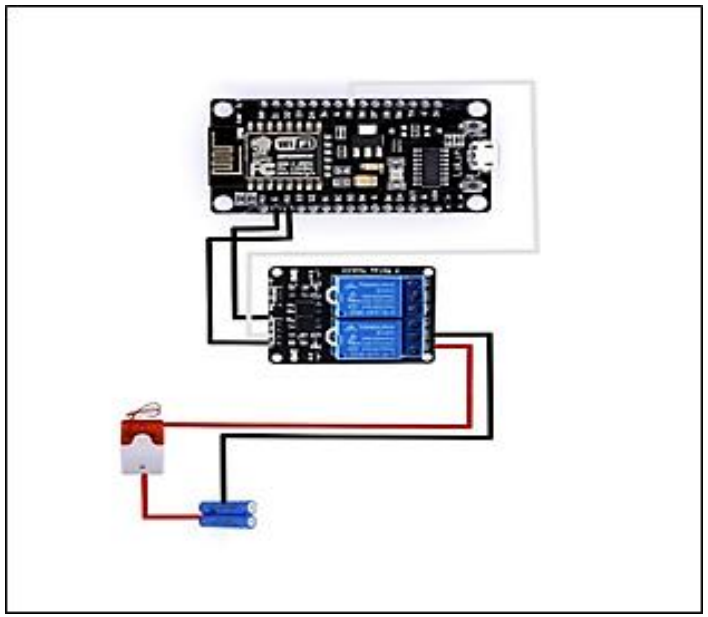


Fig1 Connecting the siren delay circuit to the Arduino board

Research Methods

2.5 Connecting the motion detection sensor to the Arduino board

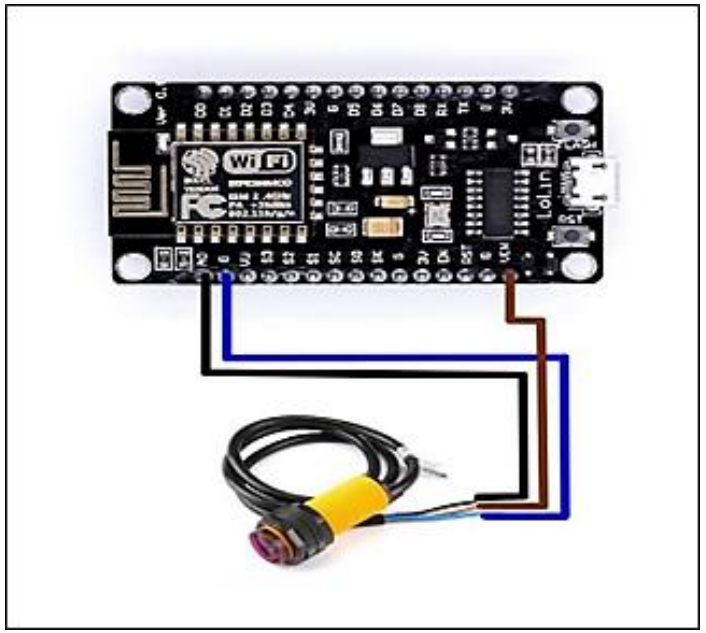


Fig 2 Connecting motion detection sensor to the Arduino board

2.6 Connecting the display circuit to the Arduino board

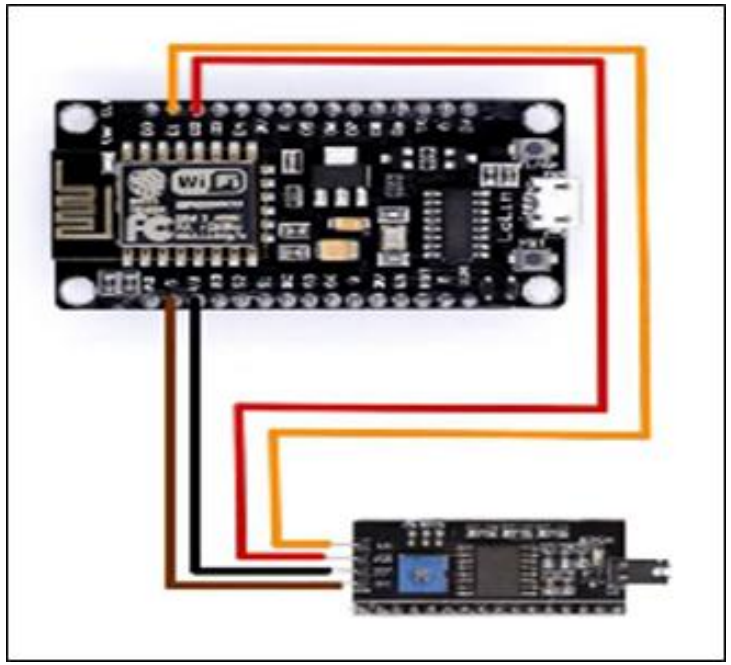


Fig 3 Connecting the display circuit to the Arduino board.

2.7 Connecting the sound level sensor to the Arduino board

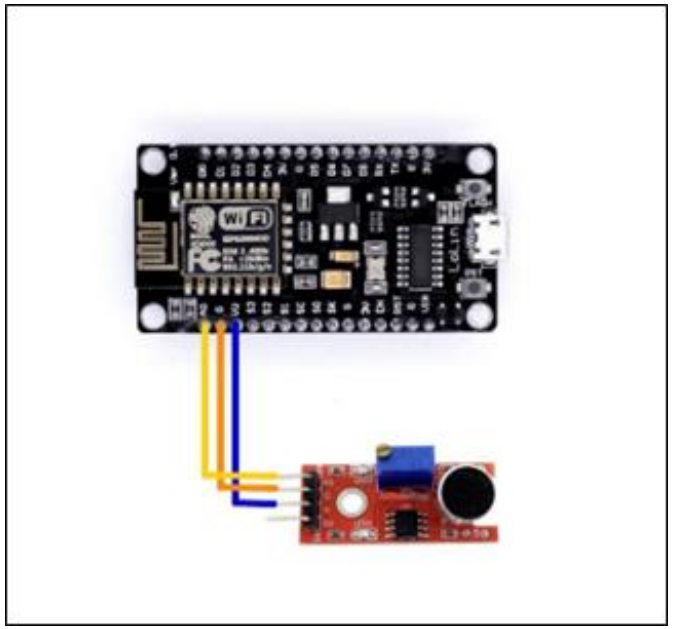


Fig 4 Connecting the sound sensor to the Arduino board.

2.8 Connecting the carbon dioxide level sensor to the Arduino board

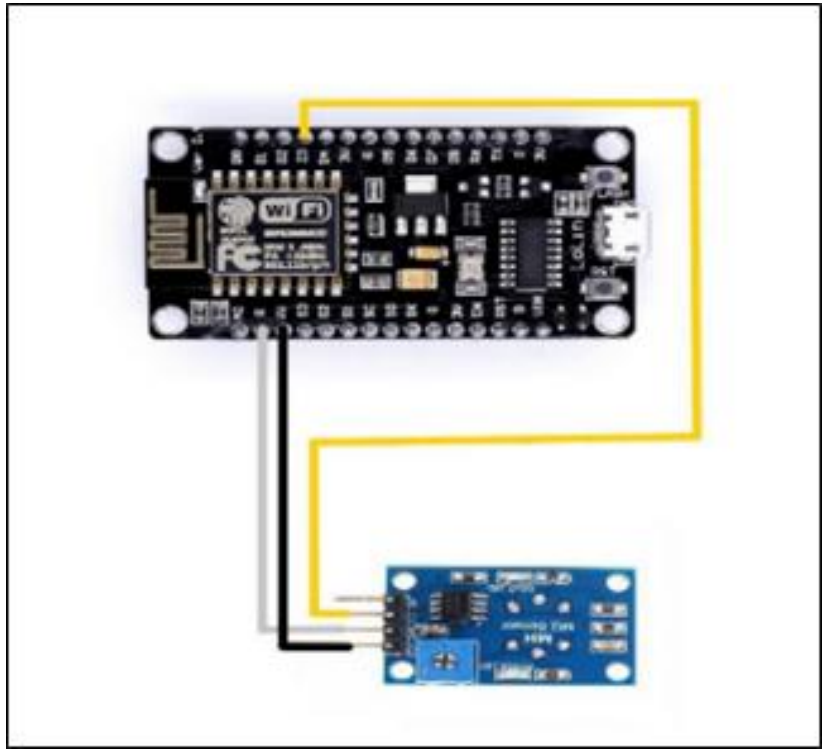


Fig 5 Connecting the carbon dioxide level sensor to the Arduino board.

Steps for Testing program

3.1 Testing program delay before sensor operation: When switched on, the program will have a 30-second delay to allow sensors to set values before starting operation, which follows the conditions specified in the program commands.

3.2 Testing the operation of Infrared photoelectric switch sensor: When switched on, the program will have a 30-second delay to allow the sensor to set values before starting operation. After that, the Motion sensor will begin working to detect movement in confined spaces.

3.3 Testing the operation of MQ-135 Air Quality Sensor: It will begin operation by detecting Carbon dioxide levels in confined spaces. If Carbon dioxide is detected, the Siren will send an alert signal.

3.4 Testing the operation of Sound sensor module hub 360: It will begin operation by detecting sounds in confined spaces. If sound is detected in confined spaces, the Siren will send an alert signal.

Research Results Sensor Testing in Case of Employee Trapped in Confined Space

Table 1 Results of sensor testing in case of employee trapped in confined space

Test No.	Program Delay Before Sensor Operation	Infrared photoelectric switch sensor	MQ-135 Air Quality Sensor	Sound sensor module hub 360
1	Normal	Alert	Alert	Alert
2	Normal	Alert	Alert	Alert
3	Normal	Alert	Alert	Alert
4	Normal	Alert	Alert	Alert
5	Normal	Alert	Alert	Alert
6	Normal	Alert	Alert	Alert
7	Normal	Alert	Alert	Alert
8	Normal	Alert	Alert	Alert
9	Normal	Alert	Alert	Alert
10	Normal	Alert	Alert	Alert

All sensors achieved 100% detection rate

From Table 1

It was found that in testing the sensor system when someone is present in a confined space, the following results were observed:

1.The Infrared photoelectric switch sensor successfully detected movement in all 10 trials

2.The MQ-135 Air Quality Sensor successfully detected CO_2 in all 10 trials

3.The Sound sensor module hub successfully detected sound within the confined space in all 10 trials

Research Results Sensor Testing in Case of Employee Trapped in Confined Space

Table 2 Results of sensor testing in case of no employee trapped in confined space

Test No.	Program Delay Before Sensor Operation	Infrared photoelectric switch sensor	MQ-135 Air Quality Sensor	Sound sensor module hub 360
1	Normal	No Alert	No Alert	No Alert
2	Normal	No Alert	No Alert	No Alert
3	Normal	No Alert	No Alert	No Alert
4	Normal	No Alert	No Alert	No Alert
5	Normal	No Alert	No Alert	No Alert
6	Normal	No Alert	No Alert	No Alert
7	Normal	No Alert	No Alert	No Alert
8	Normal	No Alert	No Alert	No Alert
9	Normal	No Alert	No Alert	No Alert
10	Normal	No Alert	No Alert	No Alert

From Table 2

The results show:

1. The Infrared photoelectric switch sensor detected 0 instances of movement in all trials
2. The MQ-135 Air Quality Sensor detected 0 instances of CO_2 in all trials
3. The Sound sensor module hub detected 0 instances of sound within the confined space in all trials

All sensors achieved 100% accuracy in no detect

Summary and Discussion of Research Results

The performance testing of the device shows that the motion detection sensor, carbon dioxide sensor, and sound measurement sensor can operate according to the created command set. When powered on, the system begins operation with a 30-second delay to allow sensors to set their initial values before starting operation. After this:

1.The Infrared photoelectric switch sensor begins searching for movement in the confined space

2. The MQ-135 Air Quality Sensor works by detecting Carbon dioxide

3.The Sound sensor module hub 360 works by detecting sound

- If any sensor detects its target parameter, it will:
  - Trigger an alert signal
  - Activate a siren
  - Send an alert message via Line application
- In cases where:
  - No movement is detected
  - No Carbon dioxide is detected
  - No sound is detected in the confined space

Summary and Discussion of Research Results

- The programmed system will loop back and command all three sensors to restart their operation in a continuous loop according to the conditions specified in the program commands. The experimental results showed 100% accuracy.

Recommendations

- 1. The casing design should be compact and use durable materials.
- 2. Enhance device functionality by adding more features, such as installing cameras to allow facility owners to conduct self-monitoring, thereby increasing the device's capabilities.
- 3. Each step of device installation should be carried out with caution.
- 4. For future development of the sensor alert system, a detailed study of circuit connections and sensor operations should be conducted.
- 5. For future development of the sensor alert system, the power supply should be improved. Since lithium-ion batteries have a short lifespan and require sensor charging, it is recommended to use power supply equipment with longer operational life, such as connecting to the factory's emergency power system battery

- These recommendations focus on physical improvements, functionality enhancements, installation procedures, technical development, and power supply optimization to make the system more reliable and practical for industrial use.

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