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Research Article

HAZARDOUS GAS DETECTION AND ALARMING SYSTEM (HGDAS) TO PREVENT HUMAN CASUALTIES

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ABSTRACT

In recent years the number of causalities that are reported by the noxious gases have increased very rapidly. This has led to major crisis not only on the environment but also on the health of the humans. The core causes of these aftereffects are that the pollution levels are well beyond the safe limits in the environment. In this paper hazardous gas detection and alarming system is proposed which has the ability to detect multiple hazardous gases in the environment under test and also alarm the individuals to take necessary action to avoid exposure to these harmful gases which may put their life under risk. This is suitable in multiple environments such as coal mines, chemical industries, oil and petroleum industries, places where complex welding process is involved and many more. The alarming process used here can be adjusted based on the required threshold PPM which alerts the person in that environment when the gas levels exceed the threshold. This paper also puts forth the different case studies that are carried out in different test environments

INTRODUCTION

Due to the growth of Industries in the country there is an associated economical development involved. In spite of these economical developments this industrial growth has led to the deterioration in the environment which leads to multiple health hazards. The gases expelled by the industries are not only toxic but also hazardous. The environment is not only affected by the industrial exhaust gases but also due to vehicles on road machineries, welding process, burning of waste and many more. These gases lead to air pollution, acid rains, toxicity, flammability etc., The level of hazardous gases are sometime beyond the safe limit which causes inconvenience for the workers in that environment. There are permissible levels of toxic and hazardous gases specified by National Institute for Occupational Safety and Health's (NIOSH). The toxic gas has a lethal concentration (LC50) of 200 Parts Per Million (PPM) in air. According to the compressed gas safety level (CGSL) (ucsd.edu) there are four classes of gases such as

- Class I = < 200 LC50
- Class II = 201–2000 LC50
- Class III >= 2001–5000 LC50
- Class IV >= 5000

defined in parts per million (PPM).

Compressed gases on the otherwise have different levels of hazardousness. Methane is colorless, odorless and a Class IV category gas under CGSL standard is flammable. Carbon monoxide is also colorless and odorless which is of type Class III category. Ammonia is a pungent smell gas and colorless belonging to Class III category. Arsine a colorless and having garlic smell is highly toxic and flammable is of Class I category. Carbon dioxide is simple asphyxiate gas which is Class IV category gas that becomes immediate danger to life at higher concentrations. Hydrogen a Class IV that has a pungent smell is a flammable gas. Likewise there are many other gases that are categorized as hazardous beyond certain concentrations. It becomes necessary for the industries to make sure that the workers are exposed to the environments well within safety limits. There are various methodologies and procedures followed by the industries to detect the gas levels in the working environment (Adefila, K., Yan, Y., Wang, T, 2015) (Chaitas P., Domanski W., Laopoulos Th., Zakrzewski, J., 2004) (Adefila, K.; Yan, Y., 2013). In spite of the safety measure followed by the industries multiple accidents and mishaps are taking place due to lack of alerting procedures to evacuate the workers from work place during

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emergencies(Theofylaktos Pieri, Michalis P Michaelides, 2016) (C. Sansone, S. Manfredi, E. Di Tucci, S. De Vito, G. Fattoruso, and F. Tortorella, 2013). This paper deals with one such safety procedure for the people working in hazardous gas environment. A hazardous gas detection and alarming system (HGDAS) is developed which continuously monitors for the surrounding gases and based on the threshold level set in the device it can alert the person and help in evacuating the place immediately. This procedure helps in minimizing the risk of human life.

System Architecture

Proposed System

The architecture of the proposed system (Fig 1) consist of the Raspberry Pi, MCP3008, gas sensors (MQ4, MQ6, MQ7, MQ8), buzzer and Raspberry Pi Touch Panel. The details of Raspberry Pi used in the system is discussed in (K. Senthil Babu, Dr. C. Nagaraja, 2018). The proposed system is built which can be used in multi-environment to detect the presence of multiple gases and alarm the user when the gas concentration is beyond the specified threshold level. Here the HGDAS system uses the sensor MQ4 to detect methane, MQ7 to detect carbon monoxide, MQ6 to detect LPG and MQ8 to detect hydrogen gas. All these sensors are connected to the MCP3008(10 bit ADC). Here the Raspberry Pi is also connected with the touch panel which is used for running the script and also display the concentration of the gas that is detected by the gas sensors.

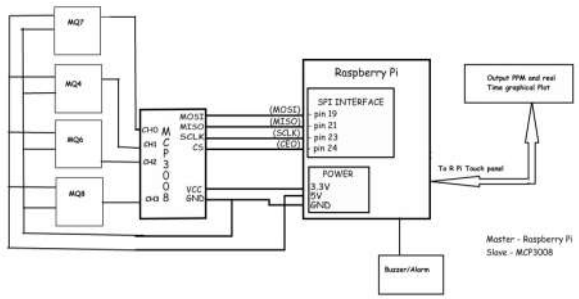

Figure 1 Block diagram of the proposed system

The system is provided with the buzzer which alarms the user when any one of the gas exceeds the predefined concentration threshold. The entire system is powered by the battery which makes the system portable. The system is built for deploying it in multiple environments such as home, sewage treatment plants, dense vehicle traffic areas, industries that deal with noxious gases, etc.,. The sensors used here are calibrated and the concentration in PPM is displayed on the screen. The procedure for calibrating the MQ7 sensor is discussed in (K. Senthil Babu, Dr. C. Nagaraja, 2018). Similarly all the other sensors are calibrated to display the appropriate concentration of the gas in the environment.

Algorithm of HGDAS

The system procedure can be explained with a able-bodied set of steps as shown below

- Start/ Power the system
- Run/Execute the HGDAS script

The HGDAS script initializes the hardware and boots all the prerequisites necessary for the system to perform.(For better detection of the gases the gas sensors should must be heated up for a while before deploying in the test environment.)

- Run /Execute the GUI

This can be optionally used when the graphical display of the gases detected in the test environment is to be plotted (real time). The GUI has two procedures static and dynamic. In static the data that is stored in the memory can be consolidated and displayed. Whereas in dynamic procedure the real time information of different sensors can by plotted instantly. As the system is powered on the sensors are initialized and are ready to measure the gases in the test environment. The system is designed to provide an alarm when the gases detected by the sensors exceed the threshold level. The system can continuously measure the variation in the concentration of the gases and print the value on the screen. These values that is measured are pumped (logged) in to the memory continuously. Depending on the requirement the GUI script can also be instantiated for real time display of the gas concentration or statically load the logged data to study the environment. In this system the GUI is designed such that the sensor information can be viewed. The dynamic plot is loaded only when the system is turned on, where as the static plot can be used otherwise even when the system is not in use. Both the static and dynamic plot is shown in the figure. Basically the static plot represents the long run logged data where variation in different environments can be simultaneously viewed over a period of time.

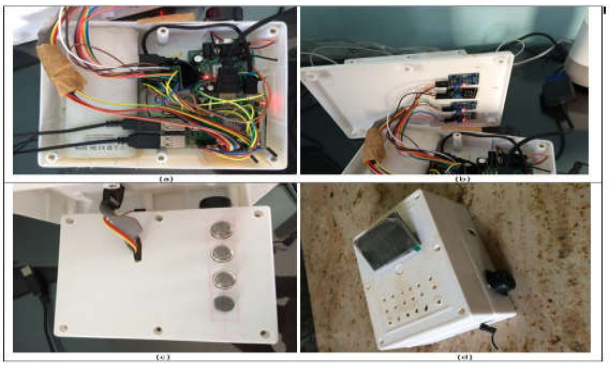

Figure 2 HGDAS System (a) Lower level showing hardware Circuitry, (b) Gas Sensors on the intermediate level, (c) Sensors placed on the upper side of the Intermediate Level, (d) Upper level of the HGDAS system with Buzzer and touch panel

The Block diagram describes the system which includes sensors, raspberry pi, MCP3008-ADC, touch panel for graphical display, buzzer. The system is powered using the power bank which makes the system portable and use it in different environments without connecting to external power jack. The HGDAS system is as shown in the figure. The required circuitry and the battery (power supply unit) are aptly placed in the lower level and the sensors are fixed to the upper plate. The spacing is taken care to prevent short circuit between the hardware. The sensors are positioned appropriately such that they can get in contact with the gases when exposed to the environment. To give more insight about the HGDAS the system is described briefly. The system consist of multiple gas sensors such as

- MQ4
- MQ6
- MQ7
- MQ8

The sensors used in the system can detect gases such as methane, LPG, Carbon monoxide and Hydrogen gas. The gas sensors used can respond to multiple gases considering this the threshold level is set accordingly. All these gases are hazardous beyond certain level of concentration. This system is provided with an alert procedure that can initiate the buzzer when the concentration of the gas exceeds the threshold. The threshold level can be attuned depending upon requirement.

Testing (Hgdas) System

In order to test the system developed different environments are identified. The HGDAS is put under test on the various environments such as

- Home
- Traffic Environment
- Sewage Treatment Plants
- Exposed to different gases

The HGDAS System is a portable and convenient system that can be easily turned on. The touch panel is basically used to initiate (start) the system. The threshold levels are set in the code in prior for alarming. The system has a provision to turn on live display of graphical information of gases. Since there are two procedures such as static and dynamic display the dynamic display is chosen when the system is on test. The Fig 3 shows the display of the measured gases which is sensed continuously.

Figure 3 Screen shot of the Measured gas concentration

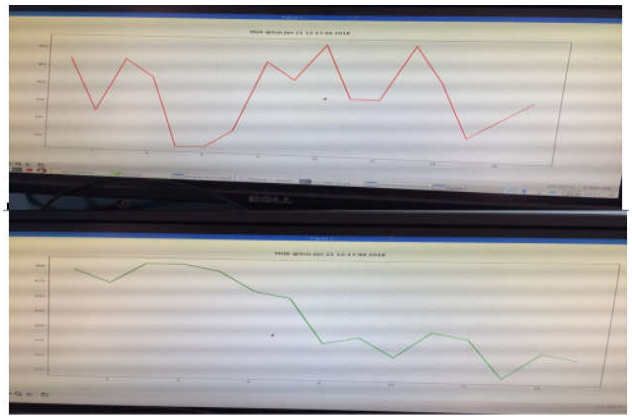

Figure 4 Dynamic view of graphical plot, the upper part represents the MQ4 sensor output and the lower part represents the MQ6 sensor output

This data that is measured can also be viewed on the graphical window by choosing any one of the dynamic window one at a time. The dynamic display is shown in the Fig 4. The data that is displayed is also logged in the local SD card. As the different test are carried out all the data logged over a period of time or the total data can be viewed at once in the static window.

As an added feature the system alarms the user when the gas concentration is beyond the set threshold. The alarm can be viewed in the HGDAS system

CONCLUSION

The HGDAS system serves an immediate solution for deployment in hazardous and critical environments. As a prerequisite the system should be turned on for at least few minutes to heat the sensors to perform better. The HGDAS system when powered through the external can be used continuously else the internal battery can be used for a maximum of three hours in the test environment. This HGDAS system acts as a portable device and serve as a solution to prevent human casualties.

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