SEWER GAS SCRUTINIZER

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ABSTRACT:

Sewer gas, a complex mixture of toxic and non-toxic gases produced and collected in sewage systems by decomposition of organic household or industrial wastes. These gases are at a very high risk of explosion when their concentration reaches a certain level and when they get mixed up with the atmospheric air. Due to these even the manholes explode at times and people cleaning the sewage have no idea of the toxicity levels, which sooner or later leads to loss of life and properties. In recent times there are many occurrences where individuals lost their life while cleaning the sewage. To avoid the threat, this paper proposes a system which scrutinizes the toxicity levels of gases and alerts the sanitary officer regarding the situation of the sewage area.

INTRODUCTION

An embedded system is a system with the dedicated function within a larger mechanical or electrical system, often with real time computing constraints. It is embedded as part of a complete device including hardware and mechanical parts. Embedded systems control many devices in common use today. 98% of all microprocessors are manufactured as components of embedded systems. Modern embedded systems are often based on microcontrollers.

Embedded Wi-Fi modules provide a simple means of wirelessly enabling any device which communicates via a serial port. The program instructions written for embedded systems are referred as firmware, and are stored in read-only memory or flash memory chips.

Embedded system talk with the outside world via peripherals, such as:

- Serial Communication Interfaces
- Synchronous Serial Communication Interfaces
- Universal Serial Bus(USB)
- Multimedia Cards
- Field Buses
- Timers
- General Purpose Input/Output(GPIO)
- Analog to Digital/Digital to Analog Converters

Microprocessors are computer processors which incorporates the functions of a computer's central processing unit(CPU) on a single integrated circuit(IC),or at most a few integrated circuits. Figure 1.1 shows the basic block diagram of Microprocessor. The microprocessor is amulti-purpose, clock driven, register based, programmable electronic device which accepts digital or binary data as input, process it according to instructions stored in its memory and provides result as output.

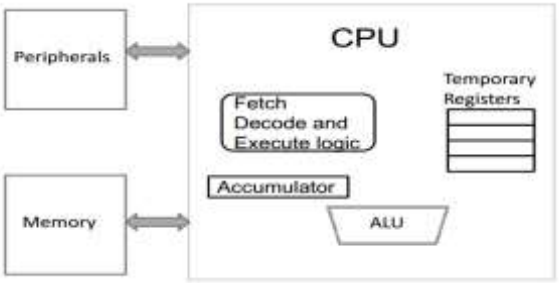

Figure 1.1: MICROPROCESSOR - BLOCK DIAGRAM

Microcontrollers integrate a microprocessor with peripheral devices in embedded systems. Figure 1.2 shows the basic block diagram of Microcontrollers. Microcontroller is a small computer on a single integrated circuit containing a processor core, memory and programmable input/output peripherals.

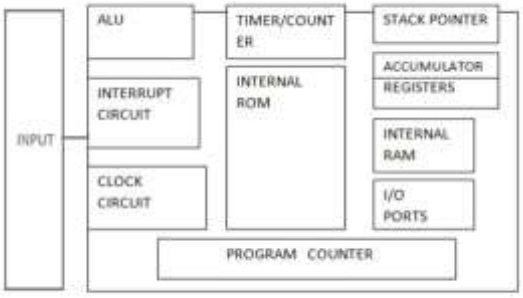

Figure 1.2: MICROCONTROLLER – BLOCK DIAGRAM

TYPES OF SEWER GASES

Sewer gas is a complex mixture of toxic and nontoxic gases produced and collected in sewage systems by the decomposition of organic household or industrial wastes. Sewer gases may include hydrogen sulphide, ammonia, methane, carbon monoxide, etc. Sewer gas has a distinct "rotten egg" smell, especially in sewage mains, septic tanks, etc, it may be due to hydrogen sulphide content, which can be detected by human olfactory senses in parts per billion.

Exposure to low levels of this chemical can irritate the eyes, cause a cough or sore throat, shortness of breath, and fluid accumulation in the lungs. Prolonged exposure may cause fatigue, pneumonia, loss of appetite, headaches, irritability, poor memory and dizziness. At higher concentrations (>300 ppm), hydrogen sulphide can cause loss of consciousness and death.

HYDROGEN SULPHIDE GAS

Hydrogen sulphide is the chemical compound with the formula H_2S. It is a colorless gas with foul odor of rotten eggs; it is heavier than air, poisonous, corrosive, flammable, and explosive. Hydrogen sulfide results from the prokaryotic breakdown of organic matter in the absence of oxygen gas, such as in swamps and sewers which is commonly known as anaerobic digestion.

Exposure to lower concentrations can cause eye irritation, a sore throat and cough, shortness of breath and fluid in the lungs. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory and dizziness. Breathing very high levels of hydrogen sulfide can cause death within just a few breaths.

AMMONIA

Ammonia or azane is a compound of nitrogen and hydrogen with the formula NH_3. Ammonia is a colourlessgas with a characteristic pungent smell. It contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. It is classified as an extremely hazardous substance.

It is lighter than air, its density being 0.589 times that of air. It is easily liquefied due to the strong hydrogen bonding between molecules; the liquid boils at −33.3 °C (−27.94 °F), and freezes at −77.7 °C (−107.86 °F) to white crystals.

METHANE

Methane is a chemical compound with the chemical formula CH_4 (one atom of carbon and four atoms of hydrogen). The relative abundance of methane on Earth makes it an attractive fuel, though capturing and storing it poses challenges due to its gaseous state under normal conditions for temperature and pressure.

Apart from gas fields, methane is produced via biogas generated by the fermentation of organic matter including manure, wastewater sludge, municipal solid waste (including landfills), or any other biodegradable feedstock, under anaerobic conditions.

CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that is slightly less dense than air. It is toxic to hemoglobic animals (including humans) when encountered in concentrations above about 35 ppm, although it is also produced in normal animal metabolism in low quantities, and is thought to have some normal biological functions.

Carbon monoxide is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO_2), such as when operating a stove or an internal combustion engine in an enclosed space.

SULPHUR DIOXIDE

Sulphur dioxide is the chemical compound with the formula SO2. At standard atmosphere, it is a toxic gas with a pungent, irritating smell. Sulphur dioxide is a major air pollutant and has significant impacts upon human health. In addition, the concentration of sulfur dioxide in the atmosphere can influence the habitat suitability for plant communities, as well as animal life.

Sulphur dioxide emissions are a precursor to acid rain and atmospheric particulates. Inhaling sulfur dioxide is associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. Symptoms of sensitivity to sulphiting agents, including sulfur dioxide, manifest as potentially life-threatening trouble breathing within minutes of ingestion.

SEWAGE GAS-HAZARDS

Human lives are full of uncertainties, as with many natural phenomena. Many models and algorithms have been continuously formulated for the prediction of matters involving uncertain elements. One such thing is the sewage gas scrutinizer which is being developed to automatically identify the toxic levels of hazardous gases and inform them with precedence to the respective officials.

SEWER GAS:

Before we lodge to the hazards of sewer gases, it is important to know what a sewer gas is and how it is formed from the normal garbage wastes. Sewer gases is a complex mixture of toxic and non-toxic gases which collect in the sewage system at varying levels depending on the sources. Sewer gases is formed during decay of household and industrial waste. Highly toxic components of sewer gas include hydrogen sulphide and ammonia.

EXPOSURE TO SEWER GASES:

Sewer gas can enter a home through a floor drain, from a leaking or blocked roof vent pipe, or through cracks in foundations if the gases are in soil adjacent to house. Sewer gases will be concentrated in the area of the home such as the basement. Sanitary and farm workers can be exposed to sewer gas during the cleaning and maintenance of municipal sewers, manure storage tanks and home septic tanks.

SOME HEALTH EFFECTS:

Possible risks and health effects associated with sewer gas exposure include:

1. Hydrogen sulphide poisoning:

People can smell hydrogen sulphide in concentration at very low levels and far below what could be toxic. This gas smells like rotten eggs, even at extremely low concentrations. Exposure to low levels of hydrogen sulphide can irritate eyes, cause a cough, sore throat, shortness of breath and fluid accumulation in lungs. Other symptoms include nervousness, dizziness, nausea, and head-ache, loss of appetite, irritability, poor memory and drowsiness. Extreme levels of hydrogen sulphide may cause to death.

2. Asphyxiation:

High concentration of methane in enclosed areas can lead to suffocation since elevated levels of methane will decrease the amount of oxygen in the air. The effects of oxygen deficiency can include head-ache,

nausea, dizziness and unconsciousness. When oxygen concentration level less than twelve percent occur, unconsciousness and death may occur very quickly and without warning.

3 Explosion and/or fire:

Methane and hydrogen sulphide are flammable and highly explosive. An ignition source such as a spark from an electrical appliance, turning on lights, matches or cigarette lighter can cause explosion and/or fire.

ROLE OF MICROCONTROLLERS

In the proposed system the microcontrollers plays a major role in linking the sensed levels of toxiousness of the sewage gases to the central location where the control officer resides. The microcontroller used in the proposed system belongs to the PIC family, more precisely it is denoted as PIC 16F887.

PIC MICROCONTROLLERS:

PIC (Peripheral Interface Controller) is a family of microcontrollers developed by General instrument's Microelectronics division.

PIC 16F887

The PIC 16F887 is used which has special features to interface peripheral devices. It is a 8-bit Microcontroller easy to program with architecture of 40 or 44 pin package. It features 256 bytes of EEPROM data memory, self-programming, an ICD, two comparators, 14 channels of 10 bit analog to digital converter and one capture/compare/PWM function and one enhanced capture/compare/PWM function. A synchronous serial port that can be configured as Serial Peripheral Interface (3 wired) or the Inter Integrated circuit (2 wired) and EUSART (Enhanced Universal Synchronous/Asynchronous Receiver and Transmitter).

1. High-Performance RISC CPU:

Operating speed is at DC-20 MHz oscillator/clock input and DC-200ns instruction cycle. It has a high level of interrupt capability and 8-level deep hardware stack. There are three various addressing modes- Direct, Indirect and Relative Addressing modes.

2. Special Microcontroller Features:

- Precision Internal Oscillator.
- Power saving sleep mode.
- Wide operating Voltage Range (2.0V-5.5V).
- Industrial and extended Temperature Range.
- Power-On Reset (POR).
- Brown-out reset (BOR) with software Control option.
- Programmable Code Protection.
- High endurance Flash/EEPROM Cell:
- Program Memory Read/write during run time
- In-Circuit Debugger

3. Low-Power Features:

- Standby current:50 nA at 2,0V, typical

11 Operating current:µA at 32 kHz, 2.0V 220 µA at 4 MHz, 2.0V

- Watchdog Timer Current:

1µA at 2.0V

4. Peripheral features:

- 24/35 IO pins with Individual Direction Control
- Analog Comparator Module
- A/D Converter
- Timer0: 8-bit Timer/counter with 8-bit
- Enhanced Timer1.
- Timer2: 8-bit Timer/Counter with 8-bit Period
- Enhanced capture, compare, PWM and module.

- Capture, Compare, PWM Module
- Enhanced USART Module
- In-Circuit Serial Programming via Two pins.
- Master Synchronous Serial Port Module supporting 3-wire SPI and I2C Master and Slave Modes with I2C Address Mask.

SENSORS AND MODULES

SENSORS:

The Gas sensor module consists of 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 it, the gases coming close to the sensing elements get ionizes 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.

1. CARBON MONOXIDE SENSOR (MQ-7)

This is a simple-to-use Carbon monoxide (CO) sensor, suitable for sensing CO concentrations in the air. The MQ-7 can detect CO-gas concentrations anywhere from 20 to 2000ppm.This sensor has a high sensitivity and fast response time.

Figure 1.3: Carbon Monoxide sensor- MQ 7

The sensor's output is an analog resistance. The drive circuit is very simple: all that is needed is to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC. The figure shows the picture of Carbon monoxide sensor MQ -7.

2. METHANE CNG GAS SENSOR (MQ-4)

This is a simple-to-use compressed natural gas (CNG) sensor, suitable mostly for methane concentrations in air. The MQ-4 can detect natural gas concentrations anywhere from 200 to 10000ppm. This sensor has a high sensitivity and fast response time.

Figure 1.4: Methane Gas sensor – MQ-4

The sensor's output is an analog resistance. The drive circuit is very simple: all that is needed to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC. The figure shows the picture of Methane gas sensor MQ -4, which is being used in our proposed system.

3. HYDROGEN GAS SENSOR (MQ-8)

This is a simple-to-use hydrogen gas sensor, suitable forsensing hydrogen concentrations in the air. The MQ-8 can detect hydrogen gas concentrations anywhere from 100 to 10000ppm. The sensor's output is an analog resistance. The drive circuit is very simple: all that is needed to do is power the heater coil with 5V, add load resistance, and connect the output to an ADC.The figure shows the picture of Hydrogen gas sensor MQ -8, which is being used in our proposed system.

Figure 1.5: Hydrogen Gas Sensor MQ-8

MODULES

WI-FI MODULE (ESP8266)

The ESP8266 Wi-Fi module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller to access the Wi-Fi network. It is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes with pre-programed AT command. The ESP8266 shown in figure supports APSD and VoIP applications and bluetooth co-existance interface.

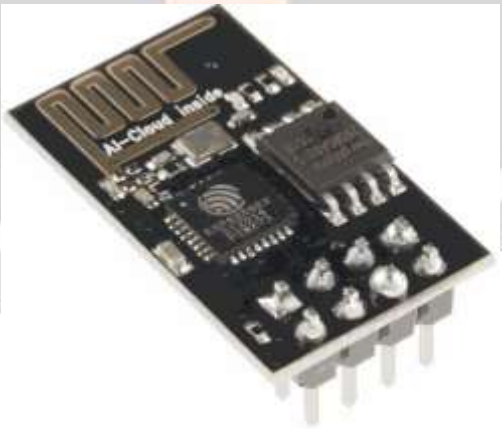

Figure 1.6: ESP8266 Module

VOLTAGE REGULATORS (IC7805)

A voltage regulator is used to maintain a constant voltage level automatically. The figure shows the picture of voltage regulator IC7805 which is used to regulate one or more AC or DC voltages. In the power supply section, it includes a 5V regulator. The microcontroller, logic-level shifter and general input/output devices are powered by 5V.

Figure 1.7: IC7805

LOGIC LEVEL-SHIFTER(LM1117)

The ESP8266 module is not capable of converting 5V to 3.3V so an external logic . The logic level shifter shown in figure 6.6 can convert up to four I/O lines from a high-to-low and low-to-high. Two inputs converts and the other converts bi-directionally.(high-to-low or low-to-high).

Figure 1.8: IC LM1117

PROPOSED SYSTEM

The proposed system focuses on reducing the health hazards and loss of life due to explosions or fire due to the high levels of toxicity in the sewages and to warn the sanitary officer about the levels of toxicity from time to time using embedded system. The basic diagram of the proposed system is given below:

Primarily the gas sensors are part of the system that spontaneously react to the gases present and thus keeping the system updated about any alteration that occur in the concentrations of molecules in gaseous state. When a gas interacts with the sensor it is first ionized into its constituents and is then absorbed by the sensing elements. This absorption creates a potential difference on the element which is conveyed to the processor unit through output pins in the form of current.

The sensor output in the form of analog current is given to the ADC port of the microcontroller. There the analog current is converted to digital number proportional to the magnitude of the current. The ADC does the conversion periodically, sampling the input. The result is a sequence of digital value that have been converted from a continuous time and continuous amplitude analog signal to discrete time and discrete amplitude digital signal.

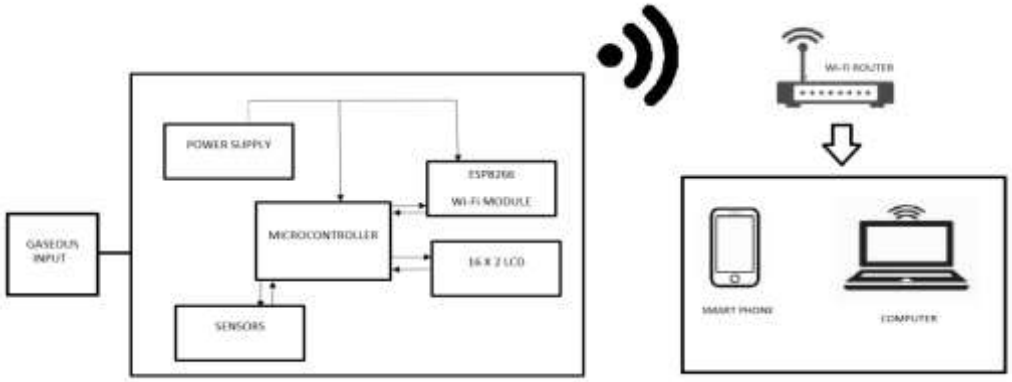

Figure: BLOCKDIAGRAM OF THE PROPOSED SYSTEM

The microcontroller establishes the connection through a Wi-Fi module. The gas sensed data from the sensors is fed into the microcontroller PIC16F887. This data is given to the ESP8266 Wi-Fi module through logic level shifter. The sensed data from the sensors are accessed and viewed on remote devices like a smart phone or laptop using website. The ESP8266 Wi-Fi module used here is to connect the Wi-Fi modem and upload the data in the website.

CONCLUSION AND FUTURE SCOPE

CONCLUSION:

Various investigates has done monitoring of sewer gases, diverse authors and engineers implemented different ways which have the lively arrangement techniques and schematics that help the society to be kept clean and monitored from the effect of the sewer gases in the environment. Decisively, this project is substantial and paves a way, for new researchers to be innovative. In-forthcoming work the monitoring of sewer gases plays a major role since, day-by-day the rate of pollution increases around the world. This will exterminate the loss of human life, who are engaging or working in the sewer gas areas and reduces the people working in it for money, consuming alcohol to avoid foul odour and with no knowledge on effects of sewer gas. Using this system, the persons cleaning the sewage can make sure that it is safe to clean and there is no hazards with the gases present. If the toxicity level reaches a certain level the sanitary officer may inform the labourers to clean the sewage before the level of poisonousness increases and hence avoiding loss of life and damage of properties.

FUTURE SCOPE:

The first Industrial Revolution came with the introduction of water and steam power, then came mass production followed by computerization. Now the internet of things is assuring the fourth industrial revolution to remain competitive in this new global economy, traditional logistics and manufacturing companies must transform operations and offerings.

The fourth industrial revolution has been characterised as a combination of physical systems, virtual systems and the IOT. In this new world smart factories give manufactures visibility across the entire production, valid chain and arm them with information and analytics that have tremendous values. The industrial IoT has the potential to add $15trillion to the global economy by 2030.

This system may be implemented in the digital India scheme. Digital India is a campaign launched by the Government of India to ensure that the government services are made available to citizens' electronically by improving online infrastructure and by increasing internet connectivity or by making the country digitally empowered in the field of technology with the objective of connecting rural areas with high speed internet networks and improving digital literacy. In future, if the digital India scheme comes into existence, then the Sewage gas scrutinizing system may be implemented easily by just simply placing some sensors in the sewage area and using a microcontroller the toxicity levels may be updated to the respective officers.

The outcomes of the proposed system include:

- One of the emerging technologies in the Internet of Things.
- This system can be developed using IOT in future for smart cities.

- Using IOT, the inspector can get the state of the gases in the sewage at any time from the server.
- Even the workers who clean the sewage can make sure that it is safe to do their work.
- Any person with proper authority can view the details of the gas levels.

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