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Gas Leakage Alerting and Accident Control System Using GSM/GPS Technology

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Abstract: ***Gas leakage detection and monitoring through sensor network is considered to be more economical for industries gas leakage. Main purpose of this system model is to avoid damages and safety of gas industry. The entire control system is based on low power AT89c51 microcontroller and GSM/GPS techniques. The sensor and micro-controller node helps in collecting data regarding gas leakage and the particular area of sensor node address is located. The collected information is sent to the monitoring client or user to update the data. Data packets are continuously transmitted from sensor nodes and communication devices. This system helps to minimizing human intervention and reduces power consumption, thus providing greater performance. This paper not only focuses on alerting but also to control the leakage under certain circumstances. Hence several interfaces such as LCD, stepper motor, servo motor, Exhaust fan, GSM/GPS are done for effective functioning. This paper focus on overall modelling and design on both software and hardware part to accomplish it.***

Keywords: LPG detection, AT89C51 microcontroller, stepper motor, servo motor, display unit GPS/GSM , MQ-6 Sensors, Embedded systems

1. Introduction

In recent times the accidents are on high scale due to the advancement of technology and engineering. One such incident which has its drastic effect both on industrial and domestic is the fire accidents. The most notable accidents are due to the gas leakage. The gas leakage causes a commotion in the domestic, so even a small leakage leads to fire .But whereas in industrial the scenario is different. Due carelessness and irresponsibility, finally causes heavy property losses. So there is a need to look for an alert system which is flawless. Hence i put forth an idea which can reduce the accidents by remarkable level. Severity can be brought down. In Industrial level property loss is high but whereas there is a need to concentrate of life loss when considering domestic scenario. Hence a solution with several interfaces and alarming system which would work flawless through any circumstances is to be developed. So the general system consists of a gas sensor which is to detect gases. Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Before modern electronic sensors, early detection methods relied on less precise detectors. Through the 19th and early 20th centuries, coal miners would bring canaries down to the tunnels with them as an early detection system against life-threatening gases such as carbon dioxide, carbon monoxide and methane. The canary, normally a very melodious bird, would stop singing and eventually die if not removed from these gases, signalling the miners to exit the mine quickly. Before the development of electronic household carbon monoxide detectors in the 1980s and 1990s, carbon monoxide presence was detected with a chemically infused paper that turned brown when exposed to the gas. Since then, many electronic technologies and devices have been developed to detect, monitor, and alert the leak of a wide array of gases.

2. Gas Detectors

Gas detectors can be classified according to the operation mechanism (semiconductors, oxidation, catalytic, infrared, etc.). Gas detectors come packaged into two main form factors: portable devices and fixed gas detectors.

Portable detectors are used to monitor the atmosphere around personnel and are worn on clothing or on a belt/harness. These gas detectors are usually battery operated. They transmit warnings via audible and visible signals, such as alarms and flashing lights, when dangerous levels of gas vapours are detected.

Fixed type gas detectors may be used for detection of one or more gas types. Fixed type detectors are generally mounted near the process area of a plant or control room, or an area to be protected, such as a residential bedroom. Generally, industrial sensors are installed on fixed type mild steel structures and a cable connects the detectors to a SCADA system for continuous monitoring. A tripping interlock can be activated for an emergency situation.

A. Electrochemical Gas Detectors

Electrochemical gas detectors work by allowing gases to diffuse through a porous membrane to an electrode where it is either chemically oxidized or reduced. The amount of current produced is determined by how much of the gas is oxidized at the electrode,[3] indicating the concentration of the gas. Manufactures can customize electrochemical gas detectors by changing the porous barrier to allow for the detection of a certain gas concentration range. Also, since the diffusion barrier is a physical/mechanical barrier, the detector tended to be more stable and reliable over the sensor's duration and thus required less maintenance than other early detector technologies.

However, the sensors are subject to corrosive elements or chemical contamination and may last only 1–2 years before a replacement is required. Electrochemical gas detectors are

used in a wide variety of environments such as refineries, gas turbines, chemical plants, underground gas storage facilities, and more.

B. Semiconductor Sensor

Semiconductor sensors detect gases by a chemical reaction that takes place when the gas comes in direct contact with the sensor. Tin dioxide is the most common material used in semiconductor sensors, and the electrical resistance in the sensor is decreased when it comes in contact with the monitored gas. The resistance of the tin dioxide is typically around 50 kΩ in air but can drop to around 3.5 kΩ in the presence of 1% methane. This change in resistance is used to calculate the gas concentration. Semiconductor sensors are commonly used to detect hydrogen, oxygen, alcohol vapour, and harmful gases such as carbon monoxide. One of the most common uses for semiconductor sensors is in carbon monoxide sensors. They are also used in breathalyzers. Because the sensor must come in contact with the gas to detect it, semiconductor sensors work over a smaller distance than infrared point or ultrasonic detectors.

C. Ultrasonic Sensor

Ultrasonic gas detectors use acoustic sensors to detect changes in the background noise of its environment. Since most high-pressure gas leaks generate sound in the ultrasonic range of 25 kHz to 10 MHz, the sensors are able to easily distinguish these frequencies from background acoustic noise which occurs in the audible range of 20 Hz to 20 kHz. The ultrasonic gas leak detector then produces an alarm when there is an ultrasonic deviation from the normal condition of background noise. Ultrasonic gas leak detectors cannot measure gas concentration, but the device is able to determine the leak rate of an escaping gas because the ultrasonic sound level depends on the gas pressure and size of the leak.

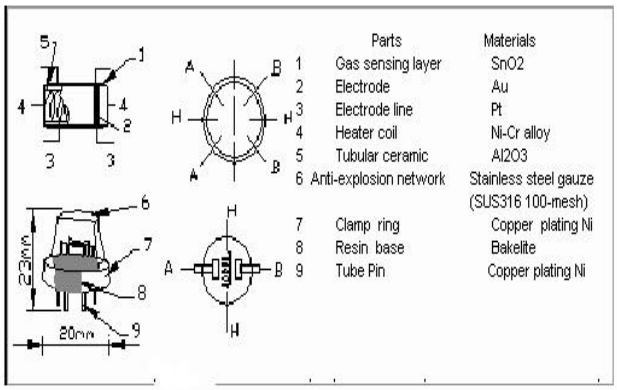
Ultrasonic gas detectors are mainly used for remote sensing in outdoor environments where weather conditions can easily dissipate escaping gas before allowing it to reach leak detectors that require contact with the gas to detect it and sound an alarm. These detectors are commonly found on offshore and onshore oil/gas platforms, gas compressor and metering stations, gas turbine power plants, and other facilities that house a lot of outdoor pipeline.

2.1 Domestic Friendly Prototype

In domestic usage the gas fuel generally used is LPG which contains Propane and Butane in high dosage. It is a by-product during petroleum refining. It is non-toxic and highly flammable which is lighter than air. the sensor type used is of semi-conductor type, which is inexpensive and highly sensitive.

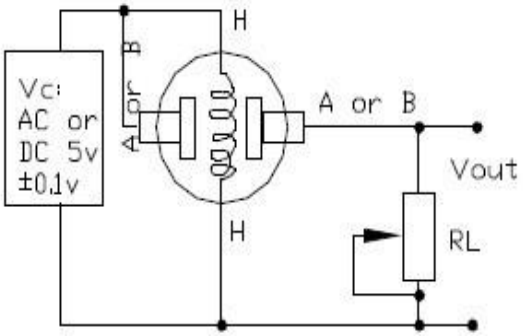
So we can use a sensor named MQ-6 which is sensible to LPG. The internal structure consists of a heater coil and a layer of SnO_2 which makes the main components of the sensor module.

Structure and configuration



a) Basic Internals of MQ-6

The MQ-6 is an LPG detection sensor which gives output one if the gas is detected. The output of the sensor will be analog ranging from +3V to +3.5V. so it is necessary to convert it into a digital form using a comparator. The conversion is necessary because the output of the sensor is to be given to



Generally a gas sensor has 6 pins. Two representing heater coils. Two pins represent inputs (A and A') and other two pins representing outputs (B and B').

The two pins A and A' are shorted together and a separate supply of +5V is given. The output pins B and B' are together taken out as the output.

3. Interfacing with AT89C51

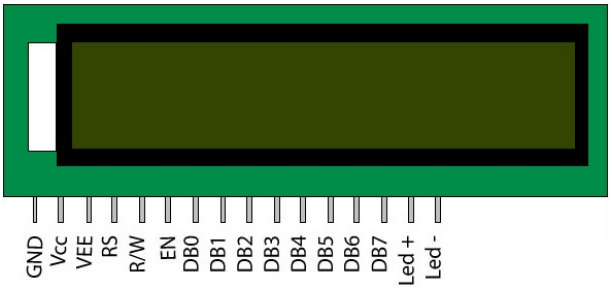
A) LCD Interfacing with 8051

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers.

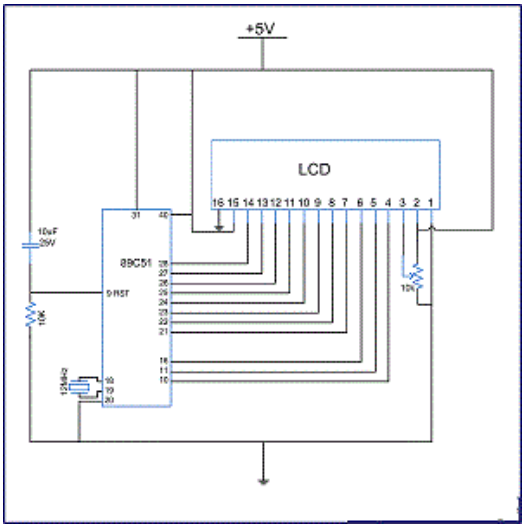
Command/Instruction Register - stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing, clearing the screen, setting the cursor position, controlling display etc.

Hex Code	Command to LCD Instruction Register
1	Clear screen display
2	Return home
4	Decrement cursor
6	Increment cursor
E	Display ON, Cursor ON
80	Force the cursor to the beginning of the 1st line
C0	Force cursor to the beginning of the 2nd line
38	Use 2 lines and 5x7 matrix

Data Register - stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.



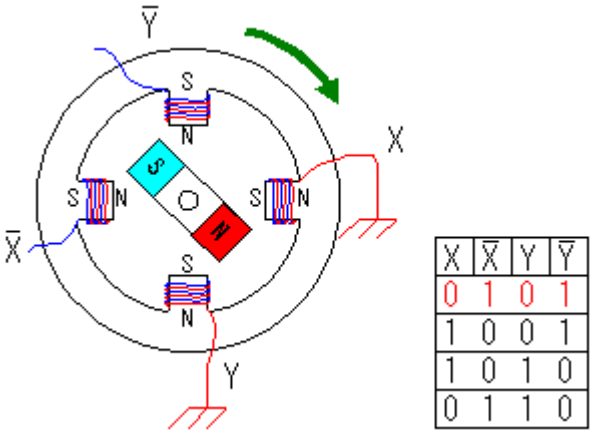
So a LCD is required to display the gas leakage and the density of leakage. This is of much use when it is a commercial building where the security personnel need to know about the leakage in the building.



B) Stepper Motor Interfacing with 8051

1) Stepper Motor Principle

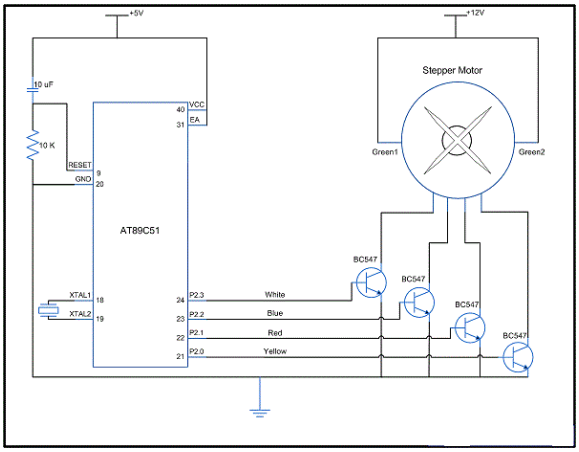
Stepper motors work on the principle of electromagnetism. There is a soft iron or magnetic rotor shaft surrounded by the electromagnetic stators. The rotor and stator have poles which may be teethed or not depending upon the type of stepper. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of a variable reluctance stepper). This way the stators are energized in a sequence to rotate the stepper motor.



2) Interfacing With 8051

Though a simple alarm sound will alert the gas leakage, there is need to avert any kind of fire accident. So a preventive measure is taken by employing a stepper motor. The stepper motor usually makes a revolution in steps. Hence with a definite step angle it has the potential to rotate the shaft connected to it for a definite angle (say 30^0). Accordingly the stepper motor will be connected to a shaft which in turn will be connected to the regulator of the gas cylinder using a knob. Prior to this, the motor will be connected to the micro-controller through a driver circuit. So whenever a gas leakage is detected, the micro-controller will send a signal to the motor driver circuit from any one of the output ports. Hence the controller will be programmed to make the stepper motor to rotate in 90^0. This makes regulator of the gas cylinder to switch off.

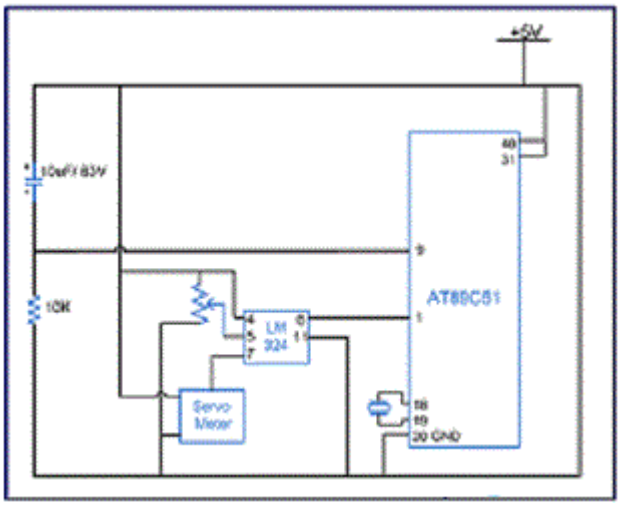
But this is a solution only in case of leakage due to regulator malfunction. If there was a leakage due to other issues such as worn-out cylinder tube, gas burner faults etc... The stepper motor doesn't have any role in it. Hence another solution needs in addition.



c) Interfacing with servo motor

Excessive parts per million (PPM) of gas in the atmosphere may lead to fire accidents even with small sparks. So there is a need to reduce the concentration of LPG in the surrounding (room). Hence using servo motor the room's windows can be made to swing to a certain angle thus making ventilation. The servo motor is controlled by feeding pulse width modulated (PWM) signal at the control wire of the servo motor. In addition a 4.8V (ideally 5V) DC supply

is provided to the red lead of the servo. The black lead of the servo is connected to Ground. The first pin of port P1 (P1^0) of AT89C51 microcontroller is set as the output pin to provide control signal to the servo motor. Before connecting to the control wire of servo, the output from the microcontroller is fed through a comparator IC (LM324) so that the signal is protected from any loss due to overloading.



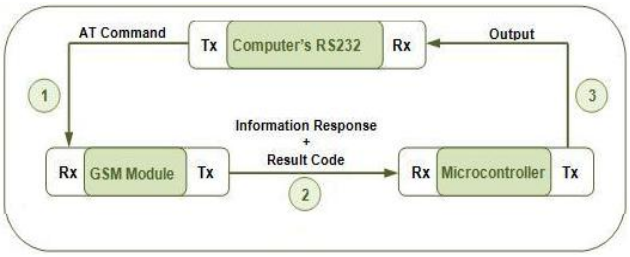
d) Interfacing Exhaust fan with 8051

Though there is a solution of controlling the windows for ventilation, for effective and greater prevention, the exhaust fan of the room is controlled. Since the exhaust fan expels the air, smoke in a room. It can be used to force out LPG along with air. The exhaust fan will be OFF initially but when the leakage is detected, it will be turned ON. This can be achieved by interfacing the fan with micro- controller.

e) Interfacing GSM with 8051

GSM is the Global System for Mobile communication. The above interfacing is possible only when there is a person available at the situation of gas leakage. So in case of unavailability there is a need to alert the person of gas leakage. So we move for GSM.

GSM is widely used mobile communication architecture used in most of the countries. The interfacing of micro-controller 8051 with Hyper-Terminal and GSM module can help the above situation. The AT commands are sent by the HyperTerminal to the GSM module. The Information Response and/or Result Codes are received at the microcontroller and retransmitted to the HyperTerminal by the controller. A GSM module has an RS232 interface for serial communication with an external peripheral. In this case, the transmit pin (Tx) of the computer's Serial port is connected with the receive pin (Rx) of the GSM module's RS-232 interface. The transmit pin (Tx) of the RS-232 of GSM module is connected to receive pin (Rx) of microcontroller's serial transmission pin. And the serial transmit pin of the microcontroller is connected to the receive pin of the computer's Serial port.

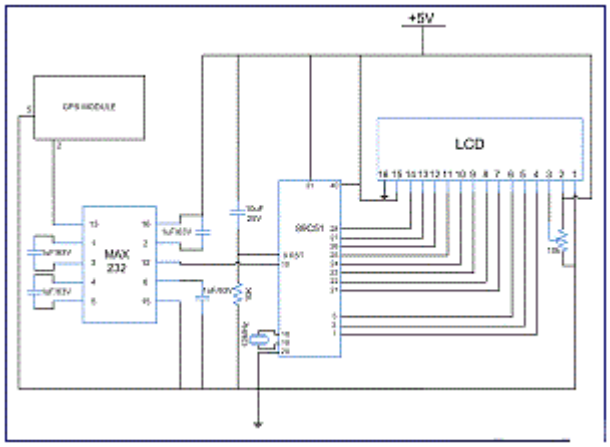


So if there is any leakage beyond certain range and could not be controlled by the above solutions, then micro-controller would send commands to GSM module. The GSM module has the capability of sending a message and a call to a receiver circuit (say mobile phone). The message may contain the information about the leakage, so the receiver may get alerted.

f) GSM/GPS interfacing with 8051

Though the above suggested solutions can prevent serious leakages, there is a question of worst possible situation?

g) Circuit Diagram of GPS interfacing



In that case the even human interference may look risky. So a GPS i.e., Global Positioning System is brought into the scenario. The GPS helps to provide the location of the gas leakage. The location is given in the Latitudes and Longitudes. Using GPS the location can be sent to the fire station. So the fire station will be alerted about the forthcoming fire accident and the exact location. This will help us to prevent the life loss and property loss.

4. Conclusion

Gas leakage is one of the major problems in Industrial sectors. This paper helps in identifying the exact location of gas leakage in working atmosphere and the intimation is given through a text via GSM/GPS. It is monitored live on a screen. Thus it ensures easy maintenance and enhances safety as well as provides low power consumption and cost effective system. Protective environment of any industrial sector involving motors and pipeline will stay safe if this mode of Maintenance scheme is followed.

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