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IoT Based Smart Security System for Prevention of Industrial Hazards

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Abstract - *In the case of a man-made disaster, sometimes the detection is so late that the disaster has already spread widely. The project plans to make a mobile robot that would be able to alert and react to emergency situations. In the recent past, there have been many cases in which the conventional security systems have proven to be a failure. Moreover, current systems are based on Wi-Fi connectivity which is unreliable in the situation of the disaster. The advancement is in the form of GSM (Global System for Mobile Communication) for communication so that the response is building independent and disaster cannot hamper the working of the system. Further, the real-time sensor data will be transferred to the IoT server via GPRS (General Packet Radio Service) connectivity. The position of the vehicle will be determined by a color sensor which will read the color of the nearby wall skirting.*

Key Words: **Internet of Things (IoT), GSM, GPRS , ATMega32, UART**

1.INTRODUCTION

Disaster planning and response require complex and more scientific analysis. The phases of the detection and rescue process need a highly efficient management system, which can predict the disaster, prevent, prepare, trigger immediate medical response, assistance, and rehabilitation [1]. The disaster that causes severe losses in human lives and associated goods because of a large amount of heat produced is called as a thermal disaster. In case of a burn disaster, a known thermal agent acts on living beings giving rise to a number of injuries and even death. The heat dissipation is generally on a very large scale [2].

The project focuses on the man-made disasters like leakage of gas or the worst case of a fire. Toxic and inflammable gases are widely used in industry, heating systems, home appliances and vehicles. This includes combustible gases like propane, ethane, butane, methane, ethylene etc. Liquefied Petroleum Gas (LPG), also referred to as propane or butane are normally stored in pressurized cylinders in liquid form and they vaporize at normal temperatures. A leakage can ignite and cause an explosion [3].

The LPG gas is denser and heavier than the other constituent gases present in the air and it settles close to ground when it leaks. A powerful exhaust system must be used in order to dispose it into the open atmosphere [4]. The preparation section and the response section will be managed by our project. The measured sensor values can be readily monitored by the security agency as well as any person concerned with the help of data logging in Internet Of Things (IoT). The primary focus of the project is to make a building independent monitoring system so that the loss of connectivity does not occur due to the damage in the building.

2. FEATURES

1) Gas Leakage Detector + Response

   Detect the leakage of inflammable gases like LPG, PNG, Methane and respond to the gas department.

2) Fire Detector + Response

   Detect fire throughout the premises and respond to the fire department.

3) Anti-Theft + Response

   Detect the presence of intruder in the premises and respond to the police.

4) Upload the sensory data and connect to different devices on IoT network.

3. SCOPE

When the heat is emitted from a source it gives a different degree of burning and if an individual gets about 30% or more of burning wounds then the possibility of survival becomes very less. Moreover, the smoke emitted from combustion will have an adverse effect on the senses of a person like loss of vision, difficulty in breathing and loss to the sense of direction. [5]

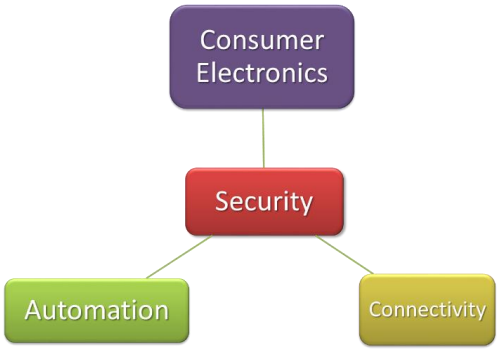

Fig - 1: Scope of Security Applications

So, the project plans to make a robot that would be able to alert and react to an emergency situation. We will be using various sensors to detect the environment variables (smoke, temperature and gas concentration), action mechanisms which will allow movement of the device throughout the premises, GSM/GPRS connectivity for early warning system and a logic which will bind all three things together to produce an actionable intelligence.

The project undertaken focuses on security applications because it covers all the industrial needs. A security device can be implemented and launched as a consumer electronic, it can start automated processes as well as it can provide connectivity to different emergency response teams. The project will be able to handle different emergency situations and act upon them intelligently to make the response automated.

Current systems are not widely in use and moreover, they are based on Wi-Fi connectivity which is unreliable in the situation of the disaster. This project uses GSM for communication so that the response is made building independent and disaster cannot hamper the working of the system.

3.1 TODAY'S SCENARIO

The study of accidents revealed that the information of the disaster was known only when the case was spread and after it had made an impact on human lives and infrastructure and these accidents could have been avoided if there have been a prior or before impact information available before the disaster which was pretty easy to do.

It is noted that most of the fire accidents happening, the fire was detected only when it has been spread over the place and was visible outside the building.

So, this project aims at providing a prior information about the risk of a disaster to the right safety department like the fire department, the police department and the gas department.

3.2 COMMERCIAL UTILITY

It can be used in high-risk factor industries like chemical, petroleum industries as well as homes as a security and data logging device which can detect the problems early and generate an alert. Minimization of the system can be done based on specialized designs featuring only essential requirements.

4. BLOCK DIAGRAM

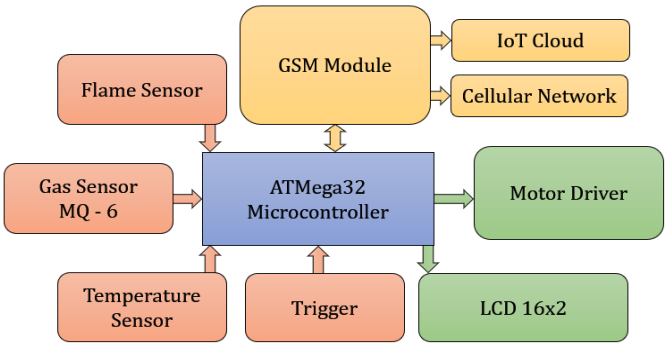

Fig -2: Block Diagram of the System

5. RESOURCES USED

The block diagram represents various sensors and peripherals that are required for execution of this project. The ATMega32 Microcontroller is the heart of the system and is connected to input devices connected to the left and output devices connected to the right of the diagram. A logic is required to bridge the behavior between input and output devices.

ATMega32 Microcontroller is manufactured by "Atmel Corporation". It also provides "Atmel Studio" software for programming the microcontrollers using "Embedded C". The program is developed in the IDE and on the compilation, it gets converted into a HEX code which can directly be written to the memory of the microcontroller.

5.1 ATMega32 Microcontroller

This is a high-performance, low-power microcontroller chip which is based on 8-bit AVR RISC. It has a 32KB flash memory which is supported by read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 54/69 general purpose input/output lines, 32 general purpose working registers, a JTAG interface and on-chip debugging/programming.

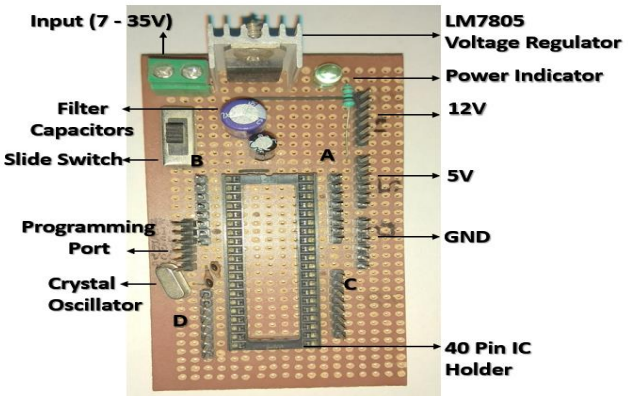

Fig -3: Custom-made AVR Board

There are three timer/counters with different modes, internal and external interrupt triggers, serial interface USART, a universal serial interface (USI), an 8-channel 10-bit analog to digital converter, programmable watchdog timer with inbuilt oscillator, SPI serial port, and five software dependent power saving modes. The device's operating voltage is between 1.8-5.5 volts. By execution of powerful instructions in a single clock cycle, the device achieves throughputs as high as 1 MIPS per MHz, which balances power consumption and processing speed.

The custom-made AVR board is based on minimum design considerations and only has bare essentials required for accomplishment of the job.

5.2 GSM Module SIM900A

Fig -4: SIM900A Module

GSM module is used to send an SMS to the user cell phone. It requires one SIM card and is capable to accept any network SIM card. This module has a unique identity number like mobile phones have. It can use 900/1800 MHz dual frequency bands for communication. The inbuilt RS-232 interface allows serial communication from laptop or from a microcontroller. It has internal TCP/IP stack that allows internet connection via GPRS. This module works on 12V DC supply. We can send SMS and also send a voice message. These SMS or voice messages are saved in the microcontroller memory.

When the gas leakage is detected by the gas sensor, the microcontroller sends a signal to GSM module, in which the tasks is to send the text SMS and message to IoT server. Multiple SMSs can also be sent to user, police and fire station etc. [6].

5.3 Motor Driver LM298D

Fig -5: LM298D Motor Driver

The LM298D driver module is a dual full-bridge driver which comes as integrated circuit in a 15-pin package. This module is required because the ATMega Microcontroller can only supply currents up to 50mA. This is not sufficient to drive the dc geared motors. They require current from about 150 – 350 mA.

So this module is characterized by the support of high voltage and high current. A heat sink is also attached onboard in order to dissipate the heat generated due to high current. It is designed to accept the standard TTL logic levels ranging from 0-5V and drive devices such as solenoids, relays, DC geared and stepper motors. Two enable pins are provided to switch on or off the device independently of the input signals. This is helpful for speed control using PWM. An additional 12V supply is provided so that the logic works at a lower voltage.

5.4 JHD162A Backlit LCD Screen

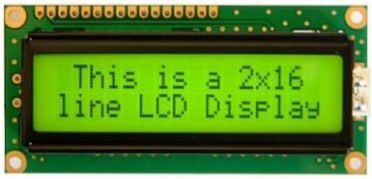

Fig -6: JHD162A LCD

A 16x2 LCD display has a green LED backlight. In this LCD panel each symbol is displayed in a 5x7 pixel matrix. A 16x2 LCD means that it can display 16 symbols per line and there are 2 display lines. This LCD has two registers, the command register and the data register. Command register supports commands like clear screen, next line, previous line, shift cursor and many other commands whereas the data register supports character values.

It is a commonly used module which can be seen readily in various devices and circuits which require any type of character display. The LCD displays are more preferred devices than other displays. The reason is that LCDs are

economical, easily programmable and it can display special characters from other languages and even custom characters. Moreover, it can display animations too.

5.5 IR Flame Sensor

Fig -7: IR Flame Sensor

A flame sensor is used to detect the presence of flame around its range. A fire emits heat waves which are also called infrared rays. So, it consists of an IR receiver, a comparator LM393, resistors, capacitors and a potentiometer to adjust its sensitivity. The infrared waves of 700nm to 1000nm wavelength can be readily detected by this sensor. The IR receiver converts the wave intensity to corresponding current value. It can give analog as well as digital outputs. The sensor has a detection angle of 60 degrees in the forward direction. A voltage of 3.3V to 5.2V can be used to power the sensor.

5.6 MQ-6 Gas Sensor

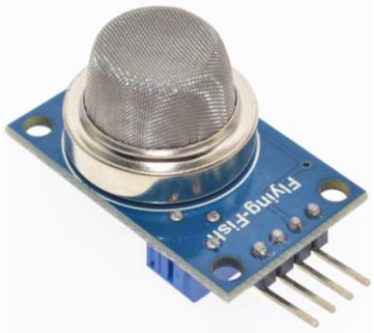

Fig -8: MQ-6 Gas Sensor

The MQ-6 Sensor is a semiconductor-based gas sensor which detects presence of gas in air. They are primarily used in the detection of gas in homes as well as industries. SnO_2 metal oxide is used in gas sensor.

When SnO_2 is heated at a particular temperature in air, the oxygen gets absorbed on the crystal surface with a negative charge. Thus, the surface potential serves as a potential barrier against the electron flow. The electrical resistance of the sensor is recognized by this potential barrier in the presence of deoxidizing gas which reduces the barrier height in the grain boundary. The sensor resistance decreases due to this reduced barrier height.

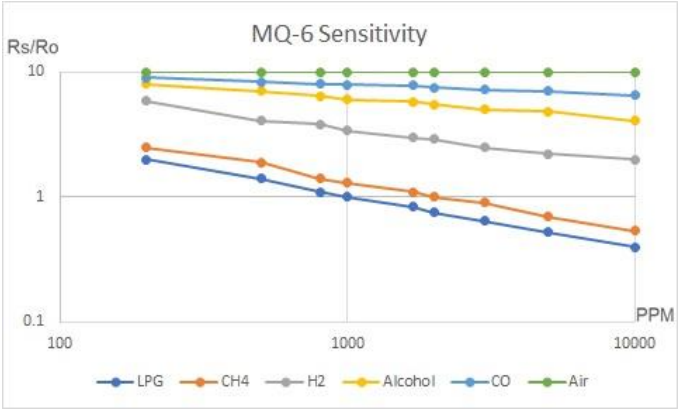

Chart -1: Sensitivity of MQ-6

6. WORKING

The whole apparatus will be triggered with the help of high gas concentration or the detection of flame by the flame sensor or by presence of intruder. A simple proximity sensor can be used for intruder detection. The gas sensing will be done with the help of analog/digital sensor which is coated with a layer of SnO_2 under ambient conditions. [8].

They are well suited for detection of liquefied petroleum gas, iso-butane as well as propane. It has a heater which activates the sensitive Tin Dioxide (SnO_2) layer for detection. It is more sensitive to flammable gases and less sensitive to smoke. So, the presence of both can be distinguished. It then gives analog voltage as output which is read by the ADC of the microcontroller and the digital output can be used as an external trigger to initialize the whole system. [7]

The gas sensors MQ-6 and flame sensors have digital as well as analog output pins. The concentration of the gas will be detected by ADC of the microcontroller. The ATMega32 has 10-bit, 8-channel ADC. The values of gas concentration and infrared present will be read by the microcontroller. If it exceeds a threshold value then the emergency signal will be generated and data will be sent to the IoT server.

The GSM module is connected via UART (Universal Asynchronous Receiver-Transmitter) of the microcontroller which allows transmission of data through 2 wires, the RX and TX. The communication between microcontroller and GSM module is based on serial AT commands which the GSM module supports. After initialization of the system, if gas is detected then the microcontroller sends a command to the GSM module. The GSM module will automatically send an SMS to the mobile number of the user that is predefined in the program.

In addition, the GSM module will connect to GPRS data service and upload the sensor data to the IoT server. The IoT server provides many tools for the analysis of the logged data. It can contain MATLAB algorithms and predefined

sequences that are to be implemented after encountering a particular value from the disaster location.

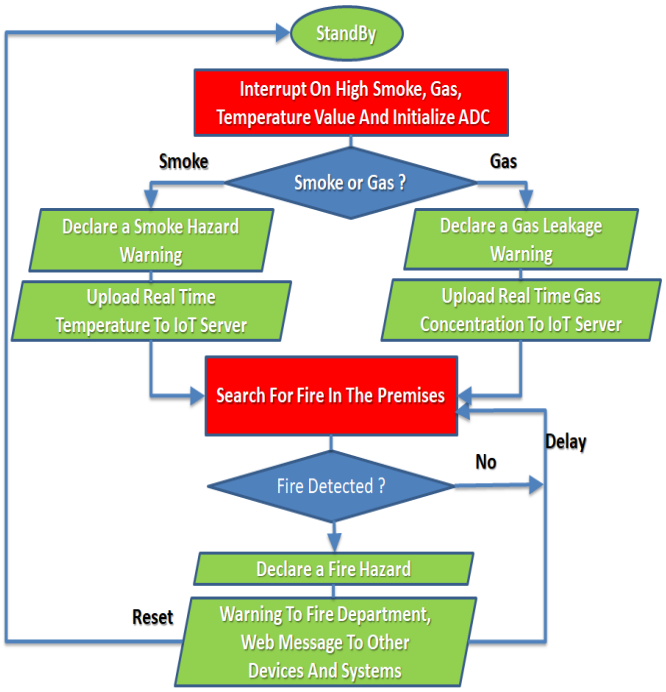

Fig -9 Program Structure

7. RESULTS AND DISCUSSION

The gas sensor gives the detected (ADC) value 600-700 for high gas concentrations and 300-450 for smoke detection. So, both of them are easily distinguishable. The real-time values are sent to IoT through API by using the GPRS connection on the GSM Module. The data logging can be separated channel wise and more actions can be programmed on the IoT platform through MATLAB.

Gas leakages in households and industries cause risk to life and property. A huge loss has to be incurred for the accident occurred by such leakages. A solution to such a problem is to set up a monitoring system which keeps on monitoring the leakage of any kind of flammable gases and protects the consumer from such accidents. The present paper provides a solution to prevent such accidents by monitoring the system but also communicating the same with IoT network to switch off the gas supplies and the main power in case of a leakage. In addition to this, it activates an alarm as well as sends a message to the authorities. A further advancement can be in the form of a skirting color sensor which will be able to sense the location based on color coding.

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