An industrial safety automation system using GSM technology

Un sistema de automatización de seguridad industrial con tecnología GSM

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Das, P.S; Pathak, M. An industrial safety automation system using GSM technology. *Tecnología en Marcha*. Vol. 37, special issue. June, 2024. IEEE Latin American Electron Devices Conference (LAEDC). Pág. 60-74.

https://doi.org/10.18845/tm.v37i5.7219

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Keywords

Industrial automation; L.P.G. (Liquefied Petroleum Gas); gas sensor; temperature sensor; smoke sensor; GSM modem; relay drivers; relays; motor driver; DC motor.

Abstract

The primary aim of the proposed system is to develop a compact industrial security product based on emerging GSM technology. The project parallelly aims at providing an automized platform, enhancing the application diversity. The project basically focuses on developing the protection of dangerous gas leakages (basically methane, butane, propane, L.P.G. and Carbon mono-oxide gases) which are most common gases in the industrial sector. The system also focuses on smoke detection sensor along with temperature sensor. So as to minimize industrial hazard occurring due to gas leaks and sudden temperature divergences. The proposed system will be modelled to perform on both automatic and manual controls where the former will ensure security even when employees/workers might be absent inside an industry. Further the auto-mode would ensure relay drivers, relays, and alarm along with additional motor drivers that would systematically function coolers, emergency vents, and other emergency devices connected with the loads.

Palabras clave

Automatización industrial; L.P.G. (Gas de petróleo licuado); sensor de gas; sensor de temperatura; sensor de humo; módem GSM; controladores de relevos; relés; controlador de motor; motor de CC.

Resumen

El objetivo principal del sistema propuesto es desarrollar un producto de seguridad industrial compacto basado en la tecnología GSM emergente. Paralelamente, el proyecto tiene como objetivo proporcionar una plataforma automatizada, mejorando la diversidad de aplicaciones. El proyecto se centra básicamente en desarrollar la protección de fugas de gases peligrosos (básicamente metano, butano, propano, L.P.G. y monóxido de carbono) que son los gases más habituales en el sector industrial. El sistema también se enfoca en el sensor de detección de humo junto con el sensor de temperatura. Para minimizar el riesgo industrial que se produce debido a fugas de gas y divergencias repentinas de temperatura. El sistema propuesto se modelará para funcionar tanto en controles automáticos como manuales, donde el primero garantizará la seguridad incluso cuando los empleados/trabajadores estén ausentes dentro de una industria. Además, el modo automático garantizaría controladores de relés, relés y alarmas junto con controladores de motor adicionales que funcionarían sistemáticamente con enfriadores, ventilaciones de emergencia y otros dispositivos de emergencia conectados con las cargas.

Introduction

The automation systems based on GSM technology are becoming very much important in modern field of science, primarily in first world country [1]. Though industries are fascinated and looking for automization and digital security systems but due to high cost of product and implementation cost (i.e., not very much implemented in developing countries) automation is lacking far behind in these countries. The complexity encircling in designing an efficient as well as economic solution for a proficient Industrial security system is huge. But meeting up to

the bullet objectives of this significant security and automized system will be sure to cater the industrial needs. This will aid the production system with a whole new dimension of security, providing a secured progress. Few solutions are available as a product in the market but they are either focusing on security or focusing on automation system [2]-[4]. Apart from mono type operation they are also addressing very functionalities. A system which can address the security and automation within affordable cost will be highly in demand.

Simulation Framework

The article describes a simulation framework that uses Proteus 7 Professional for circuit simulation and Keil CX51 C compiler software for embedded C programming. This approach provides a comprehensive solution for designing and testing embedded systems [5]-[6].

Proteus 7 Professional is a powerful tool for designing and simulating circuits. It provides a user-friendly interface and a wide range of simulation capabilities. The software allows users to create complex circuits with ease and simulate their behaviour in real-time. This enables engineers and researchers to test their designs and identify any potential issues before moving on to the implementation stage. Figure 1 shows the schematics view of circuit simulation using Proteus.

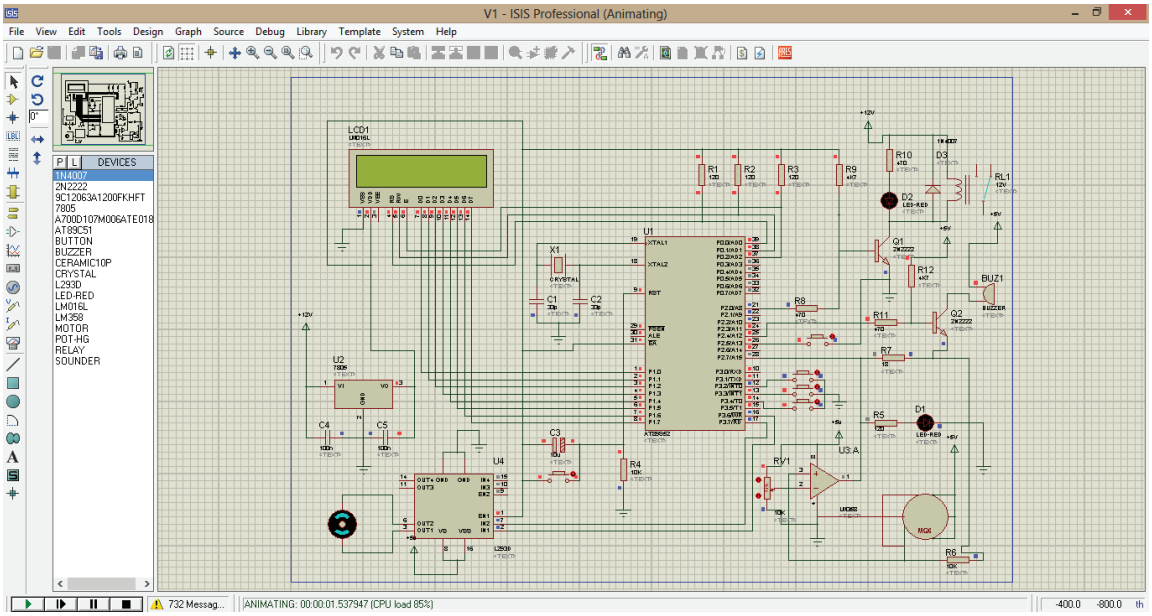


Figure 1. Simulating the proposed system using Proteus 7.0 Professional for comprehensive circuit analysis.

Keil software, on the other hand, is a popular integrated development environment (IDE) for embedded C programming. It provides a complete solution for developing, debugging, and testing software for microcontrollers. Keil software supports a wide range of microcontrollers and provides a rich set of features to simplify the development process.

By combining these two tools, we have designed and tested the complete embedded systems, including both the hardware and software components. This approach provides us a powerful solution for embedded system development, enabling us to create the proposed systems that meet the required design specifications.

The overall experiment which is performed with the help of software coding mentioned in APPENDIX-I.

Methodology and Working Principle

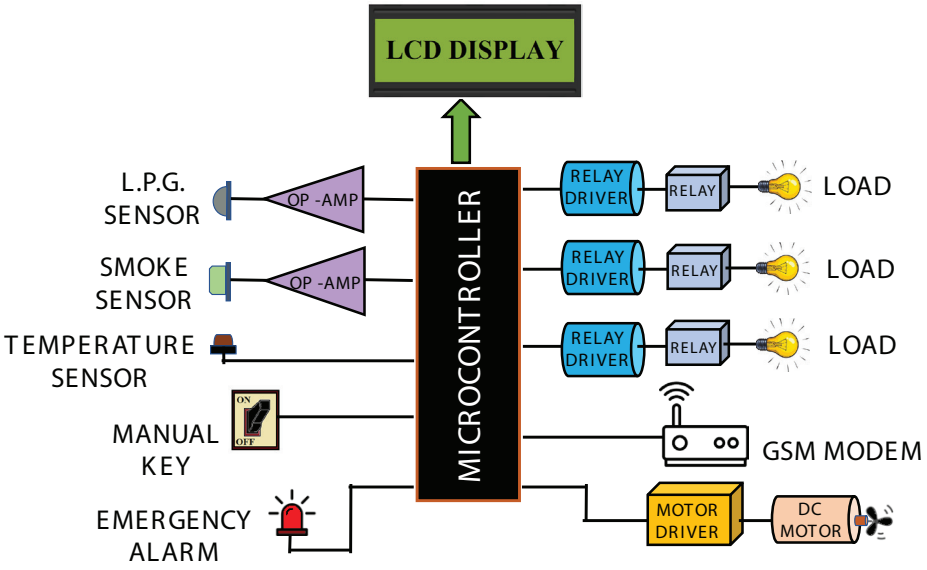


Figure 2. Methodology showing interface connections of different components required to build the proposed system.

The proposed system is mainly designed to protect workers, equipment, and property from harm, thereby minimizing the risk of injury, equipment damage, and property loss. The system uses various sensors, relays, and communication devices to detect and respond to hazardous conditions in the workplace. The working principle of an industrial automation safety system using a microcontroller, L.P.G. sensor, smoke detector, temperature sensor, relays, emergency alarm, and GSM modem is as follows:

- **Sensing hazardous conditions**: The L.P.G. sensor, smoke detector, and temperature sensor are used to detect the presence of hazardous conditions such as gas leaks, smoke, and high temperatures (temperature higher than the required condition).
- **Alerting personnel**: The alarm is used to alert personnel to the presence of a hazardous condition. The GSM modem can also be used to send SMS or email alerts to designated personnel or emergency services.
- **Activating relays**: When a hazardous condition is detected, the sensors activate the corresponding relays, which in turn trigger the safety mechanisms. For example, a gas leak could trigger the shutdown of the gas supply or ventilation system by activating the motors connected to it.
- **Monitoring and control**: The microcontroller monitor the status of the various sensors and relays, and can be programmed to perform certain actions in response to specific conditions.

Figure 2 shows the interfacing of different components required the built the proposed system.

System Description

The circuit for the proposed system is designed around easily available components in the market or through online. The primary components of the circuit are 8051 family microcontroller SST89E516RD2/ V516RD2, MQ6, DS18B20, LM358, L239D and SIM900 Modem. Initially we have started with AT89S52 but during the addition of features the memory space was exhausted,

hence we have shifted SST microcontroller which is having 64K of flash memory as comparing to 8K of AT89S52. The most of the components excluding the relay and GSM modem requires regulated 5V hence we are using KA7805 (LMV805) for voltage regulation. 7805 has 3 pins. Pin 1 is regulated or unregulated input where we can give 5 V to 18 V. Pin 2 is ground and pin 3 is regulated output. Irrespective of input voltage at pin 1 (within the range) at pin 3 we always get +5V. To reduce any noise or repel in the power section, we have to use two 100nf capacitor which are connected across pin 1 and pin 2 and pin 3 of 7805.

A. Interfacing the Microcontroller, LCD and Voltage Regulator

The microcontroller that we are using is PDIP type. It has 40 pins. It is compatible fully with 8051 family with various advantage features and high program memory space. Pin 40 is which is connected to the pin 3 of 7805. Pin 20 is ground. Any microcontroller or microprocessor requires clock source to fetch instruction. The clock source can be a crystal oscillator, function generator and RC oscillator or even we can use a separate microcontroller to provide the clock pulse though we can use different clock source, crystals are more widely used as it is reliable, economic and easily available. Pin 18 and 19 of the microcontroller are XTAL 2 and XTAL 1 respectively. Here we have use a crystal of value 11.0592 MHz. According to data sheet it can work at 0 to 40 MHz at 5V and 0 to 33 MHz at 3V. But we have use 11.0592 MHz as we have to perform serial communication. In case of 8051 family 11.0592 is more precise when we have to perform serial communication as it will effect by less error. Parallel to the crystal that is at pin 18 and 19 we have connected 33pf capacitor (C1 and C2). According to data sheet the C1 and C2 can be anything in between 20 to 40 pf, but 33 is a common practice with 8051 family hence we have selected 33pf only.

The pin 9 of microcontroller is reset pin. Also, according to datasheet if we give logically high i.e. +5V at pin 9 for two machine cycles i.e., 12 x 2 = 24 clock pulse, the device will restart and for normal operation pin 9 must be pull down, hence we have connected a 10K resistance across pin 9 and ground as pull-down resistance. Pin 31 is pin. According to datasheet, if we have to use external program memory pin 31 must be connected to ground and to use the internal program memory it must be connected with . As we are using internal memory (pin 31) is connected with .

For display of various information, status of the devices and the sensor we are using a 16 x 2 LCD module. The module can display two lines and 16 characters per line. It consists of 16 pins. Pin 1 is ground, pin 2 is which is connected to pin 3 of 7805. Pin 3 is contrast control. It is used to provide a referral voltage to adjust the contrast of the display unit. In our circuit a 10K variable resistance is used as potential divider, the output of the variable resistance is connected to pin 3 of LCD. One terminal is connected to and the other terminal is connected to ground (GND).

Pin 4, pin 5 and pin 6 of the LCD are the most important pins, they are marked as RS, WR and EN. Pin 7 to pin 14 of the LCD is Data Bus which is marked as D0 to D7. Pin 15 and 16 are LED + and LED which is having no relation with programming. Instead, it is used to provide power supply to the LED used in the LCD to provide backlight. Hence, many simulations or circuit designing software (like Proteus) keep pin 15 and pin 16 hidden.

The D0 to D7 i.e., pin 7 to 14 is connected to pin 1 to pin 7 of microcontroller i.e., port 1. The RS, RW and EN pins connected to pin 39, 38 and 37, respectively i.e., PO.0; PO.1; PO.2. of the microcontroller.

Figure 3 shows the motherboard interface of the proposed system containing SST89E microcontroller, voltage regulator (KA7805) and LCD display.

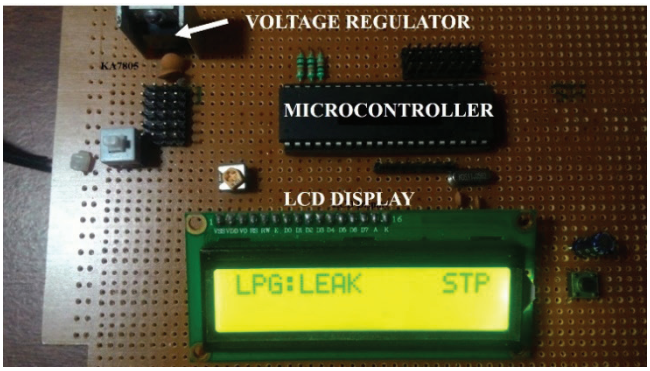


Figure 3. Motherboard interface of the proposed system containing SST89E microcontroller, voltage regulator (KA7805) and LCD display.

The 8051/8052 family with 40 pins PDIP package has 4 i/o ports P0, P1, P2 and P3. The internal resistance of P0, P1, P2 and P3. are activated but the internal pull-up of port 0 is not activated hence we must have to use external pull-ups with the i/o pins of port 0 if it is used. As RS, RW and EN is connected to 39, 38 and 37, we have to use 10K resistance as external pull-ups for these i/o pins.

B. Interfacing the GSM Modem with the Microcontroller

The microcontroller communicates through serial communication with TTL mode but the modem that we are using (SIM900), shown in Figure 4, has to be connected with RS232 protocol, hence we are using a TTL to RS232 converter circuit based on MAX232. The MAX232 is having 16 pins with DIP package. It has two channels i.e., pin 7 and pin 8 with pin 9 and pin 10; and pin 11 and pin 12 with pin 13 and pin 14. As we need only one channel for communication, we have used Pin 11, 12 (TTL) and pin13 and 14(RS232). The GSM modem SIM900 is used to establish remote communication with GSM technology. It is used to receive command in terms of SMS and hand it over to the microcontroller. The microcontroller is responsible to process the received SMS and identify the acceptance or rejection of the messages as command. If it has received predefined command as a message, it perform the required task.

For example – if it received #DEV 1: ON, it will switch ON the device. Similarly, if it has received #DEV 1: OFF, it will deactivate the 1st device.

Figure 4. SIM900 GSM Modem.

C. Interfacing the Sensor Circuits with the Microcontroller

The system is equipped with three different sensors namely-

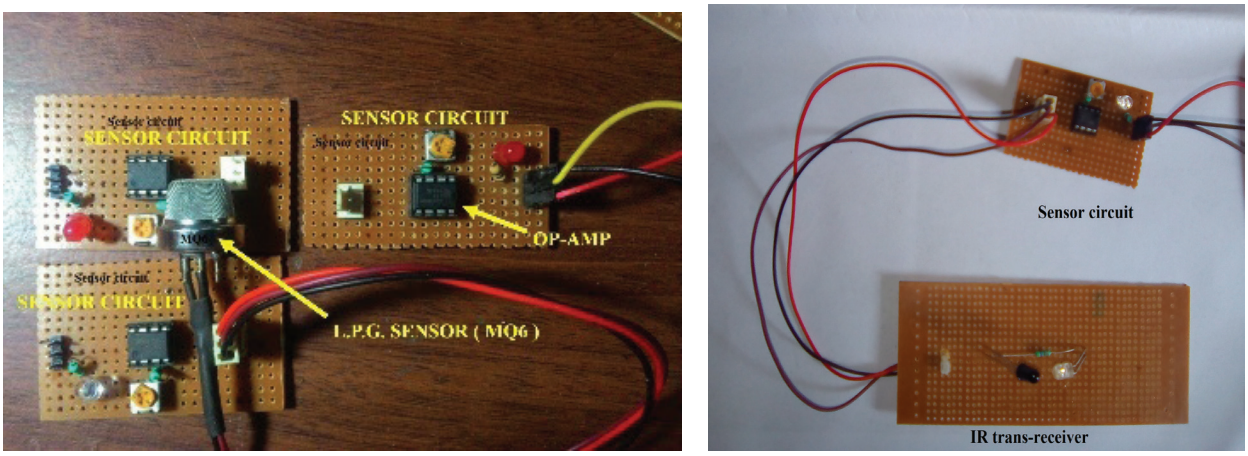
(i) the temperature sensor (DS18B20),

(ii) the L.P.G. sensor (MQ6), and

(iii) the smoke detector.

To detect the temperature, we are using digital temperature sensor DS18B20 from Dallas semiconductors. It has internal converter and it profiled the data with serial mode (1-Wire communication); hence it does not require any additional ADC. The DQ pin i.e., pin 2 is connected with pin 28 i.e., P2.7 of the microcontroller. To read the temperature, the microcontroller sends specific command to DS18B20 with the DQ pin and in reverse DS18B20 give the temperature to the microcontroller. Through DQ pin, pin 1 of the DS18B20 is ground and pin3 is (+5V). DS18B20 can be powered by parasite power supply also. But we are using 5V only.

To detect L.P.G. or inflammable gas like methane, propane or butane, we are using MQ6, shown in Figure 5(a). But the current pass through the MQ6 is not enough to directly interface with digital i/o pin of the microcontroller. Hence, a current to voltage converter is used as amplifier as well as digital converter. A popular dual op-amp IC LM358 is used for this purpose. LM358 is having dual comparator but we are using only the first comparator, pin 1 is the non-inverting output of the first comparator, pin 2 is the inverting input of the first comparator, and pin 3 is non-inverting input for the first comparator. Hence, MQ6 output is connected to pin 3 of LM358. Pin 4 is ground and Pin 8 is . LM358 can be powered with single power supply with a wide range. Here, we are using 5V as output of comparator is connected to the i/o pin of the microcontroller. The pin 2 is connected with a 10K variable resistance where one terminal is connected to ground. Using these variable resistance we can set the sensitivity level of the sensor by proving different threshold value.



(a) (b)

Figure 5. (a) L.P.G. sensor (MQ6) along with sensor circuits (b) IR trans-receiver (photo diode and IR LED) used as smoke detector along with its sensor circuits

The similar circuit is used for smoke detection where we have connected a pair IR trans-receiver (photo diode and IR LED) placed in angular position so that can detect the smoke with the help of optical reflection method, shown in Figure 5(b).

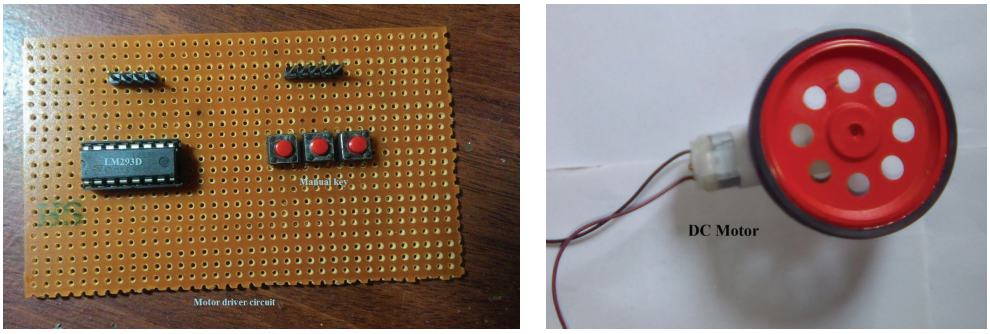
D. Interfacing the Driver Circuit along with the DC Motor with the Microcontroller

The system has the ability to control a DC motor with B- operator clockwise, anti-clockwise and stop, shown in Figure 6 (a) and 6 (b). L293D is having 16 pins with DIP package. Pin 1 is the enable pin for channel (1), if pin 1 is connected to the channel (1) will be activated. And a low at pin 1 will not effect on the control signal of the motor, irrespective of input control signal. Pin 2 and Pin 7 are the input for first channel. Pin 3 and pin 6 are the output of the first channel where we can connect a DC motor. Pin 4 and pin 5 are ground (GND).

Pin 8 of L293D is the power supply for the motor. The input at this pin is depended on the voltage required by the motor connected with L293D.

Pin 9 is the enable pin for channel (2). Pin 11 and pin 14 are the output for channel (2), and pin10 and pin15 are the input for channel (2).

Here in the proposed system, we have use channel (2) of L293D. The input signal to the driver is connected with pin 16 and pin1 7 i.e., P3.6 and P3.7. The motor can be controlled by the SMS as well as the manual switch. Three switches are connected with P3.3; P3.4 and P3.5 for stop, clockwise and anti-clockwise direction of the motor.



(a) (b)

Figure 6. (a) Motor driver circuit (b) DC motor with B-operation used in the proposed system.

When the system detect smoke or any inflammable gas, it activates a buzzer as alarm. The microcontroller cannot drive the buzzer directly. Hence a buzzer device circuit is designed around 2N2222, a 470 resistance and 10K pull up resistance. The controlling signal of the buzzer circuit is drawn from P3.2 of the microcontroller i.e., pin 12.

E. Interfacing the Relay Driver Circuits along with the Relays with the Microcontroller

To control the various devices, we have connected three relay driver circuits for demonstration purpose, shown in Figure 7. The relay device circuit are nothing but switch circuit designed around NPN switching transistor 2N2222 from Philips. The control signal for these three relay drivers is connected from pin 21, pin 22 and pin 23(i.e., P2.0, P2.1 and P2.2 of the microcontroller). Just like motor controlling system, we can control the device with help of SMS, at the same time we have three push to ON momentary or tactile switch to pin 24, pin 25 and pin 26 (i.e. P3.3; P3.4 and P3.5) of the microcontroller.

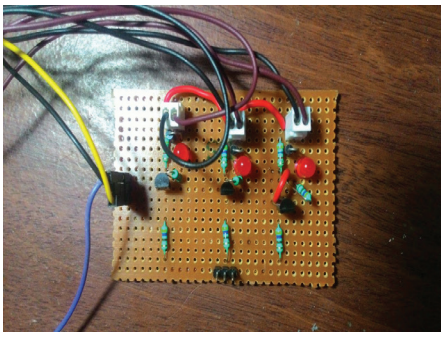


Figure 7. Relay driver circuit used in the proposed system.

The automization part of the prototype is programmed so that if the system temperature reaches upto or above it, the buzzer alarm of the system will get activated which indicates that the temperature must be pulled down for safety reasons. This temperature can be set up according to the required needs of various industrial as well as environmental conditions. Figure 8 shows the hardware prototype of the proposed system.

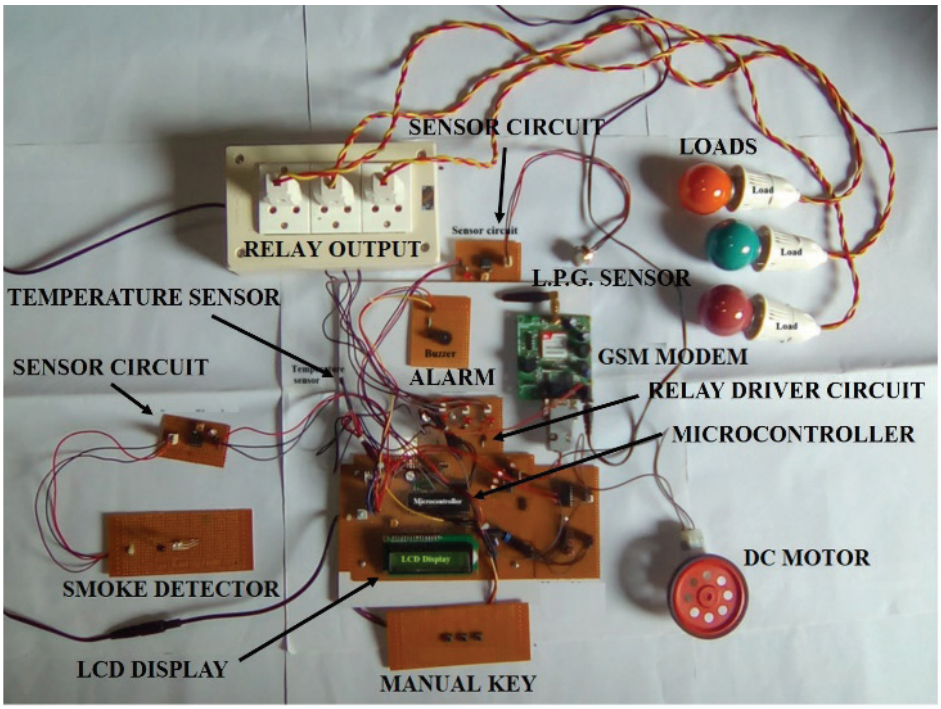


Figure 8. Hardware prototype of the proposed system along with system components.

Experimental Results/Outcomes

- Finally, the proposed system is being successfully designed for fulfilment of the desired needs in the industrial sectors in terms of safety, security and automation.
- Through in the prototype, only three sensors namely L.P.G. sensor, temperature sensor, and IR trans-receiver (photo diode and IR LED) smoke detector are used, there are provisions for addition of more sensors like the Carbon Monoxide sensors, and other harmful gas sensors for harmful gases produced in industries which plays a dangerous role in industrial sectors as well as to the environment near it.

- As the article entitled “A GSM Based Safety Automation System”, the safety automation in the system is provided only to the temperature sensor which can further be modified in driving of the DC motor or any load with respect to the temperature limit.

Figure 9 shows the hardware prototype of the proposed system in active mode along with system components.

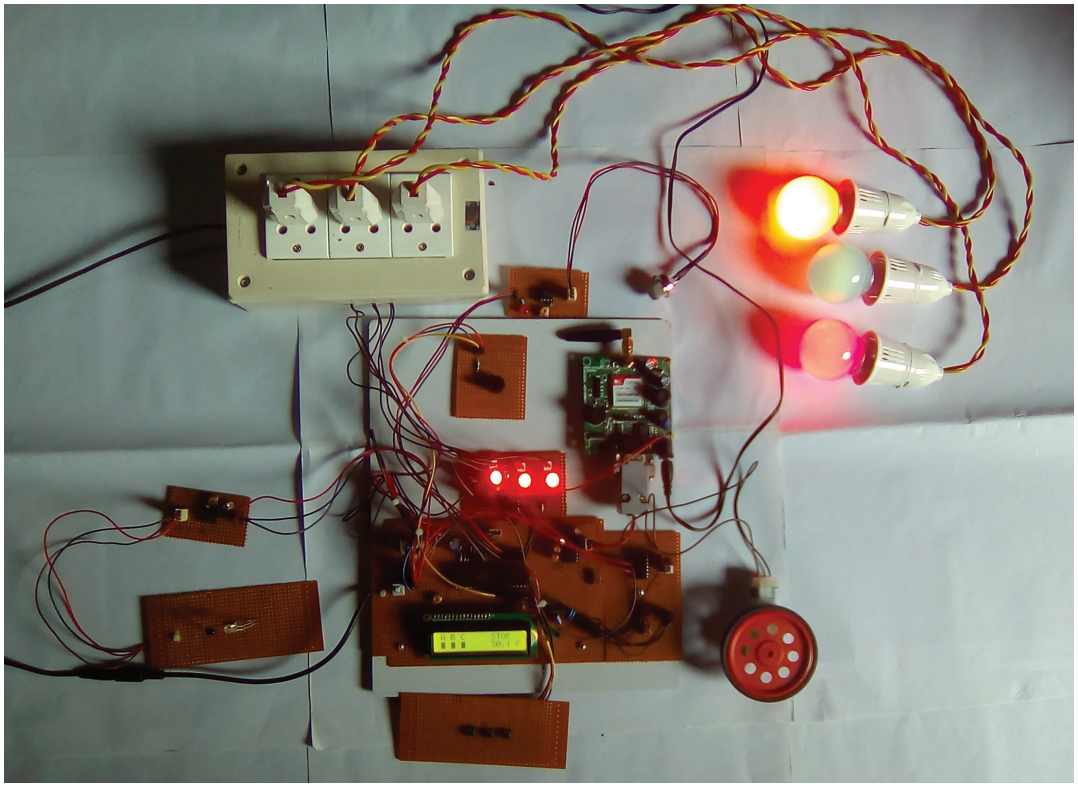


Figure 9. Hardware prototype of the proposed system in active mode along with system components.

Conclusion

- The article will help to implement or fulfil some of the important needs of modern industries in the field of safety, security and automation using easily available, cheap and economic components.
- At the beginning of designing this system, a lot of difficulties have been faced regarding circuit components, interfacing with different circuit components, GSM technology but with the help of datasheets, application of theoretical concepts, the problems got resolved one by one [7]-[9].
- Moreover, while designing the system, working on embedded C, Proteus 7 professional, Keil compiler played a major role. This project helped more of a practical implementation of using of embedded C, Proteus 7 professional, Keil compiler, GSM technology, interfacing of LCDs, interfacing of sensors, interfacing of relay drivers with microcontrollers, which would have been much difficult to understand while theoretical studies.
- Though the system is designed for industrial sectors it can further be implemented in commercial purposes using desired and required amounts of components based on environmental condition.

Lastly, in future this proposed system can be further developed with the advent of ideas and technologies of science.

Acknowledgment

The authors would like to thank the Department of Instrumentation Engineering, Jorhat Engineering College, for providing all of the necessary electronic components and instruments used for the above experimental purposes.

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APPENDIX - I

The following embedded C codes have been used to design the proposed industrial safety automation system.

```
#include<reg51.h> // Include header file to work with 8051 Series Microcontroller
#define LCD Port P1   // LCD Port i.e. PIN 7 to pin 14 of LCD is Connected to P1(PIN 1 to 8 of 8051)
sbit RS=P0^0;    // RS pin LCD (PIN 4) is Connected to P0.0 of 8051 (PIN 39)
sbit RW=P0^1;  // RW pin LCD (PIN 5) is Connected to P0.1 of 8051 (PIN 38)
sbit EN=P0^2; // EN pin LCD (PIN 6) is Connected to P0.2 of 8051 (PIN 37)
sbit LPGSENSOR =P2^7;
sbit RELAY1=P2^0;
sbit BUZZER=P2^4;
sbit SW1=P2^5;
sbit STOP=P3^2;
sbit CLK=P3^3;
sbit CCLK=P3^4;
sbit M1_A=P3^6;
sbit M1_B=P3^7;
void delay (int t)  // This function will generate tms delay
```

```
{
 int i;     // Declare local variable i to use as counter
 while(t>0)    // Loop until t become ZERO
{
 i=1275; // Set the starting value of i with 1275
// In 8051 with 11.0592MHz Crystal, it consumes
// approxd 1ms to count from 0 to 1275 or vice-versa
while(i>0)i--;  // Decrease the value of i by -1 until it becomeZERO
t--; // Decrease the value of t by -1
}
}
void LCDCommand(char c) // This function will send a Command to LCD
{
RS=0;    // RS=0 means, we are writing Command on LCD
RW=0; // RW=0 means, we are using the LCD in Write Mode
LCDPort=c;  //Copy the Value of c(Command) to LCD Port (P1 in our Case)
EN=1;    // Set the EN pin High       -----+
delay (2); // Wait for 2ms         +-- Generate a High to Low Pulse
EN=0; // REset the EN pin Back to Low ----+
return ; // Return from the Function
}
void LCDData(char c)// This function will send a Data to LCD
{
 RS=1; // RS=1 means, we are writing Data on LCD
 RW=0; // RW=0 means, we are using the LCD in Write Mode
 LCDPort=c;  //Copy the Value of c(Command) to LCD Port (P1 in our Case)
 EN=1;   // Set the EN pin High-----+
 delay(2); // Wait for 2ms         +-- Generate a High to Low Pulse
 EN=0; // REset the EN pin Back to Low ----+
return ; // Return from the Function
}
void LCDInit()//This function will Initilized the LCD
{
LCDCommand(0x38); // 16x2 LCD, 8 Bit Mode
LCDCommand(0x06); // Display From Left to Right
LCDCommand(0x0c); // Display ON, Cursor Hide
LCDCommand(0x01); // Clear LCD
}
void LCDPuts(char *s) // This function will Display a string  on LCD
{
 int i; // Declare Local variable i to use as index
for(i=0;s[i]!='\0';i++) // Scan each and every character of the string
{
LCDData(s[i]); // and display every character one by one
```

```
}
}
void main() // The main function start here
{
int RELAY1_STATUS=0;
RELAY1=0;
BUZZER=0;
M1_A=0;
M1_B=0;
LCDInit(); // Initilizing the LCD
LCDPuts("GSM BASED");
LCDCommand(0xc0); // Move to the Second Line
LCDPuts("Industrial SYSTM");
delay(100); // Wait for 100ms
LCDCommand(0x01); // Clear LCD
LCDPuts("Developed By....");
LCDCommand(0xc0); // Move to Second Line
LCDPuts("Prachuryya Das  ");
delay(100); // Wait for 100ms
LCDCommand(0xc0); // Move to Second Line
LCDPuts("JEC - IN - 2015");
delay(100); // Wait for 100ms
LCDCommand(0x01); // Clear LCD
LCDCommand(0x8d);
LCDPuts("STP");
while(1)
{
 if(LPGSENSOR==1)
{
LCDCommand(0x80);
LCDPuts("LPG:LEAK ");
BUZZER=1;
}
Else
{
LCDCommand(0x80);
LCDPuts("LPG: CLEAR");
BUZZER=0;
}
if(SW1==0)
{
if(RELAY1_STATUS==0)
{
RELAY1=1;
```

```
RELAY1_STATUS=1;
LCDCommand(0xc0); // Starting of Second Line
LCDPuts("DEV1:ON ");
}
else
{
RELAY1=0;
RELAY1_STATUS=0;
LCDCommand(0xc0); // Starting of Second Line
LCDPuts("DEV1: OFF");
}
}
if(STOP==0)
{
M1_A=0;
M1_B=0;
LCDCommand(0x8d);
LCDPuts("STP");
}
if(CLK==0)
{
M1_A=0;
M1_B=1;
LCDCommand(0x8d);
LCDPuts("CLK");
}
if(CCLK==0)
{
M1_A=1;
M1_B=0;
LCDCommand(0x8d); LCDPuts("ACL");
}
}
}
```

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Abstract

The proposed system aims to develop a compact industrial security product based on emerging GSM technology. It focuses on protecting against dangerous gas leakages, smoke detection, and temperature divergences in industrial settings. The system operates in both automatic and manual modes, providing security even when employees are absent. By integrating security and automation features at an affordable cost, the proposed system addresses the needs of the industrial sector.

Introduction

Automation systems based on GSM technology are increasingly important in the modern scientific field, especially in first-world countries [1]. However, the high cost of products and implementation has hindered the widespread adoption of automation in developing countries. Designing an efficient and cost-effective solution for industrial security systems is a complex challenge. By meeting the objectives of a comprehensive security and automation system, industrial needs can be met, enhancing production with enhanced security measures. Existing solutions in the market typically focus on either security or automation, and they often lack versatility[2]-[3]. There is a high demand for an affordable system that can address both security and automation requirements, offering a valuable solution for industries.

Simulation Framework

- The article presents a simulation framework using Proteus 7 Professional for circuit simulation and Keil CX51 C compiler software for embedded C programming[4-5].

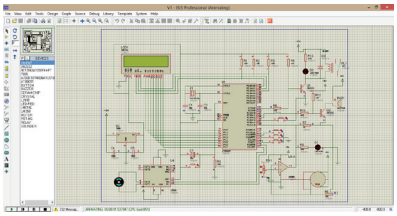


Figure 1. Simulating the proposed system using Proteus 7.0 Professional for comprehensive circuit analysis.

Methodology/Working Principle

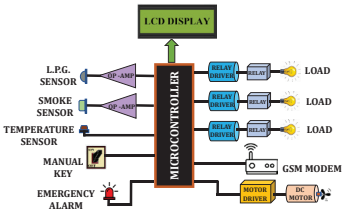
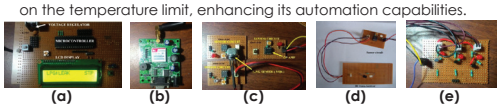


Figure 2. Methodology showing Interface Connections of different components required to build the proposed system.

- The proposed industrial automation safety system uses various sensors, including LPG, smoke, and temperature sensors, to detect hazards like gas leaks, smoke, and high temperatures.
- An alarm system alerts personnel when hazardous conditions are detected, while a GSM modem sends SMS or email alerts to designated individuals or emergency services.
- Safety mechanisms, such as shutting down gas supplies or activating ventilation systems, are triggered by relays. A microcontroller monitors sensor and relay statuses and executes programmed actions accordingly.

Results and Discussion

- The proposed system is designed to meet the needs of industrial sectors in terms of safety, security, and automation. The system includes three sensors: LPG sensor, temperature sensor, and an IR trans-receiver (consisting of a photo diode and an IR LED) smoke detector.
- There is provision for adding more sensors, such as Carbon Monoxide sensors and other harmful gas sensors, to detect dangerous gases produced in industries.
- These additional sensors are important for ensuring safety in industrial sectors and protecting the environment.
- The system can be modified to drive a DC motor or any load based on the temperature limit, enhancing its automation capabilities.



(a) (b) (c) (d) (e)

Figure 3. (a) Motherboard containing SST89E microcontroller, voltage regulator (KA7805) and LCD display **(b)** SIM900 GSM Modem **(c)** L.P.G. sensor (MQ6) with sensor circuits **(d)** IR trans-receiver as smoke detector along with sensor circuits **(e)** Relay driver circuit used in the proposed system.

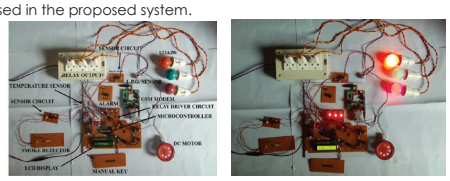


Figure 4. (a) Hardware prototype of the proposed system along with system components **(b)** Hardware prototype of the proposed system in active mode

Conclusions / Future Scope

- **Article focus:** Addressing safety, security, and automation needs in modern industries using affordable components.
- **Overcoming challenges:** Initial design faced difficulties with circuit components, interfacing, and GSM technology, but solutions were found through datasheets and theoretical knowledge.
- **Key tools:** Embedded C, Proteus 7 Professional, and Keil compiler enabled practical implementation of technologies like GSM, LCDs, sensors, and relay drivers with microcontrollers.
- **Adaptability:** While designed for industrial sectors, the system can be adjusted for commercial use by modifying components based on environmental conditions.
- **Future potential:** The proposed system offers opportunities for further development and enhancement by incorporating new ideas and technologies from the field of science.

References

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