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GSM Based Intelligent Home Security System for Intrusion Detection

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ABSTRACT

Conventional security systems which are the commonest form of protection to lives and properties, have certain limitations such as real time monitoring and control of activities such as intruders in the form of human beings, fire, smoke, etc. These limitations in most cases result in high financial loss to properties and lives. This work involves design and construction of GSM intelligent home security system for real time monitoring of intruders. It consist of intrusion detection sensors, (pressure, Smoke/Fire, Gas and PIR motion), wireless sensors, programmable microcontroller in embedded C language, regulated power supply unit, proteus (circuit simulator), relays, GSM modem, mobile phone, data acquisition node and an interface program development. The design calculation and analysis was carried out before it was modeled, simulated in proteus electronic simulator environment. When the PIR finds intruders (in form of variation in temperature, gas leakage, pressure, etc), the relevant sensing device(s) respond and the microcontroller sends encoded alarm signal to the wireless sensor network established in home. The moment the alarm signal is received, it will send alarm short message to the users (owners of the building) through GSM network immediately. The design analysis and calculations were carried out and finally, a positive result was achieved.

Keywords: *Intruder, Detector, GSM, Intelligent and Security*

1. INTRODUCTION

In today's age of digital technology and intelligent systems, home automation has become one of the fastest developing application based technologies in the world. The idea of comfortable living in homes has since changed for the past decade as digital and wireless technologies, are integrated into it. The main concept behind the work is receiving sent Short Message Services (SMS) and processing it further as required to perform several operations. There are several terminologies that are used extensively throughout this paper such as Global System for Mobile Communication (GSM), SMS, etc. It is a service available on most digital mobile phones (also known as text messaging service). Intelligent homes in simple terms can be described as homes that are fully automated in terms of carrying out a predetermined task, providing feed back to the home users and responding accordingly to situations. Intelligent home security systems such as controlled network, and communication systems, emergency response, anti-theft monitoring systems requires automated and controlled system both near and at a distance of control. Intelligent home security systems play important roles in providing an extra layer of security through user authentication to prevent break-ins at entry points and also to track illegal intrusions or activities within the vicinity of the home. There are many researches done in the design of various types of intelligent home security system like sensor-based system that reply and contact-based systems such as finger-print and palm-print scan that requires substantial amount with an input device. Many intelligent home security systems are based on a single system. GSM technology provides the benefit that intelligent home security system is accessible in remote areas as well.

This paper is aimed at designing a GSM based intelligent home security system for detecting an intrusion into a monitored area by a passive infrared detector. For home safety, intrusion detector has a transmitter coupled with portable receiver to alert home owners through SMS in situations of break-ins or entering into the home using force.

Home security system has been a feature of science fiction writing for many years, but has become practical since the early 20th century following the widespread introduction of electricity into the home, and rapid advancement of information technology. Early remote control devices began to emerge in the late 1800s for example, Nikola Tesla, patented an idea for remote control of vessels and vehicles (Tesla, 1898) in a research work titled "Method for Controlling Mechanisms of Moving Vessels and Vehicles". The emergence of electrical home appliances began between 1915 and 1920. More so, the decline in domestic servants meant for the household needed cheap, mechanical replacement. Domestic electricity supply however was still in its infant stage-meaning this luxury was afforded only by the more affluent households as investigated and published by Harper in 2003. Ideas similar to intelligent home security systems originated during the world fairs of the 1930s (Mann, 2005) as reported in the work titled "Smart Technology for Aging, Disability and Independence Depicted Electrified and Automated Homes". In 1966, Jim Sutherland an engineer working for Westinghouse Electric developed home security system called "ECHO IV". This was however, a private project

and never commercialized. The first "wired home" were built by American hobbyist during the 1960's using the available technology of the times. The term "Smart Home" was first coined by the American Association of House builders in 1984 with the invention of microcontrollers. The cost of electronic control fell rapidly as time progresses thus making it more affordable. Remote and intelligent control technologies were adopted by the building services industry and appliance manufacturers worldwide, as they offer end users easy accessibility and/or greater control in their products (Harper, 2003). During the 1990's, home security systems rose to prominence by the end of the decade, domotics was commonly used to describe any system in which informatics and telematics were combined to support activities in the home. The phrase appears to be a portmanteau word formed from domus (Latin meaning house) and informatics referring specifically to the application of computer technology to domestic appliances (Gerhart, 1999). As described by the author in the work titled "Home Automation and Wiring". Despite interest in home security systems, by the end of 1990's, there was still no widespread uptake with such systems as it was still considered as the domain of hobbyist or the rich. The major challenge was however traced to lack of a single, simplified, protocol and high cost of the device, thus resulting in not making customers to be able to afford it.

While there is still much room for growth, according to researchers, one million, five hundred thousand home security systems were installed in the US in 2012 and sharp uptake could see shipments topping over eight million in 2017 (ABI Research, 2012).

Intelligent home security system involves automation of homes or household activities such as security locks of gates and doors. The overall idea is to provide improved efficiency and security in their place /areas of applications. In recent years, the popularity of home automation has been increasingly great because of its affordability and simplified design through smartphones, internet connectivity/facilities and cable connectivity. Devices may be connected through a computer network to allow control by a personal computer, and may allow remote access from the internet. Through the integration of information technologies with the home security, systems are able to communicate in an integrated manner which results in convenience, energy efficiency and safety benefit.

GSM based intelligent home security system refers to the use of device and information technology to control home features/systems (such as windows, doors, etc.). Parameters to be controlled in any system could be very simple/complex. These can range from single control of lighting through complex computer/microcontroller based networks with varying degrees of automation. Home security system is adopted for reasons of ease, security and energy efficiency. The controller devices are properly interconnected such that there is obvious communication between the home appliance/device and the controller. For example, an alert message is sent through telephone line in case of any intrusion taking place. The automated device then makes the home intelligent and will call neighbour(s), or any other emergency line dedicated to intrusion(s) cases/attempt. It does the monitoring via GSM handset or web browser. One of the areas of application of intelligent home automation system is in smoke detection. An example of remote monitoring in intelligent home security system could be triggered when a smoke detector detect a fire or smoke condition. The system could also call the home owner on their mobile phone to alert them, or alert the neighbour(s).

Table 1, describes sensors selected for intelligent security systems. It describes the sensor chosen, type and names to match the purpose of the work.

Table 1: Sensors Selected For Intelligent Security Systems

SENSOR TYPE	SENSOR CHOSEN	SENSOR NAME
Motion	Passive infrared	PIR motion sensor (N55)
Temperature	Band-gap	SHT 75
Humidity	Capacitive	SHT 75
Light	Light dependent resistor	Light Dependent Resistor chip
Smoke	Ionization	CHUBB smoke detector

2. OVERVIEW OF INTRUDER ALARM SYSTEM

The intruder alarm systems and detectors, giving special focus on the several technologies applied, include wireless transmission and reception of alarm messages and commands through GSM/GPRS, TCP/IP and it involves development of web-based intruder alarm monitoring and control hardware and software. Useful techniques concerning the installation of intruder alarm systems for home owners are also described in detail. New developments for distributed web-based intruder alarm systems, which can include not only traditional signaling functions but also new intelligent decision functions, are challenges today for the intruder alarm designers. Web-based intruder alarm systems may include the use of distributed nets ("grid") giving each node the ability to dynamically configure its

functions within entire respect for the security scope issues (Antunes, 2007). The distributed network intelligence will allow an intruder alarm system to react to multi-signalization intrusion situations in much more efficient ways, being also able to distinguish more accurately real security violation adverted operations.

2.1 Basic Specification in GSM

Table: 2 GSM Air Interface Specifications. (http://www.gsmworld.com/)

S/N	Parameter	Specifications
1	Reverse Channel frequency	890-915MHz
2	Forward Channel frequency	935-960 MHz
3	Tx/Rx Frequency Spacing	45 MHz
4	Tx/Rx Time Slot Spacing	3 Time slots
5	Modulation Data Rate	270.833333kbps
6	Frame Period	4.615ms
7	Users per Frame	8
8	Time Slot Period	576.9microsec
9	Bit Period	3.692 microsecond
10	Modulation	0.3 GMSK
11	ARFCN Number	0 to 124 & 975 to 1023
12	ARFCN Channel Spacing	200 kHz
13	Interleaving	40 ms
14	Voice Coder Bit Rate	13.4kbps

Supplementary ISDN services, are digital in nature, and include call diversion, closed user group, and caller identification. Supplementary services also include the short message service (SMS).

3. MATERIALS AND METHODS

3.1 POWER SUPPLY UNIT (PSU)

The power supply unit (figure 1) consists of 240V/12V; 500mA; step down transformer, bridge rectifier, 1000µF/35V capacitor, 7805 voltage regulator status indicator LED, and 1KΩ resistor to limit the voltage entering the LED. The 240V/50Hz input supplies the transformer and the voltage is then stepped down to 12V, which then passes through the rectifier where it is then converted to D.C voltage. Smoothening the direct current (D.C.) is carried out by the capacitor .The 7805 regulates the voltage to give a voltage of 5Vdc required as V_{cc}. This V_{cc} is delivered to various loads that need the supply. The characteristics of the power supply unit and distribution of the D.C. voltage to various parts of the system have some effects on the performance of the circuit.

D.C. voltage is isolated from the mains by the 240V/12V transformer before delivering to the output of the bridge rectifier. The rectifier circuit consists of diodes configured into a full wave bridge rectifier mode. The regulator used in the design provides regulated and stable D.C. voltage (5v+/-0.1%) and these output drive all chips used for the design .The capacitor is designed to filter and remove surges that appear on either the input or output of the supply.

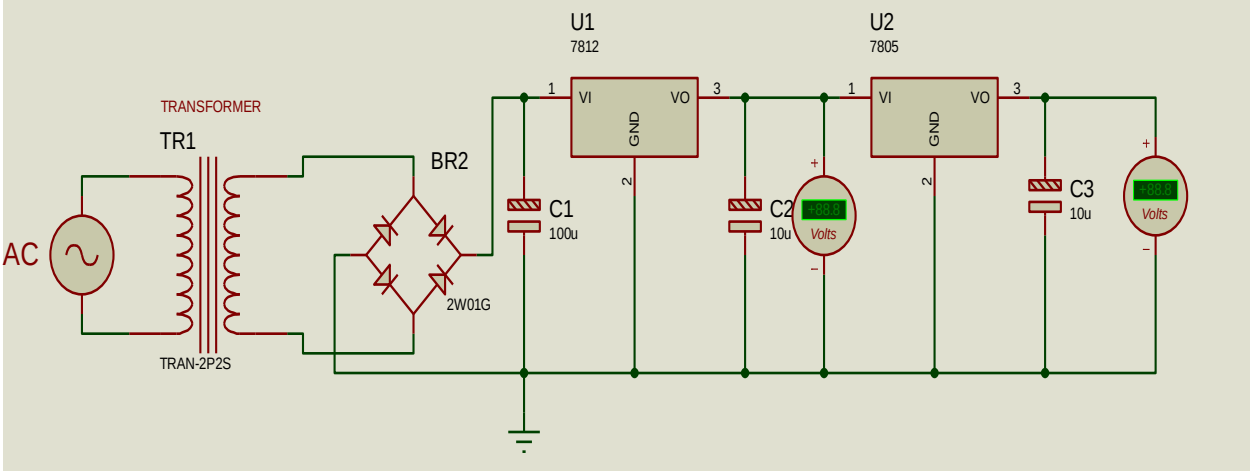


Figure 1: Circuit Diagram of a Regulated Power Supply

The implementation of this work involves the use of hardware and software components. A list of the hardware components are as follows: GSM Module, Serial driver or communicator (RS 232), Microcontroller, Transistor, Relay. And the software used includes: C^{++} Embedded programming language and Proteus Software (Circuit Simulation). Figure 2 shows the block diagram.

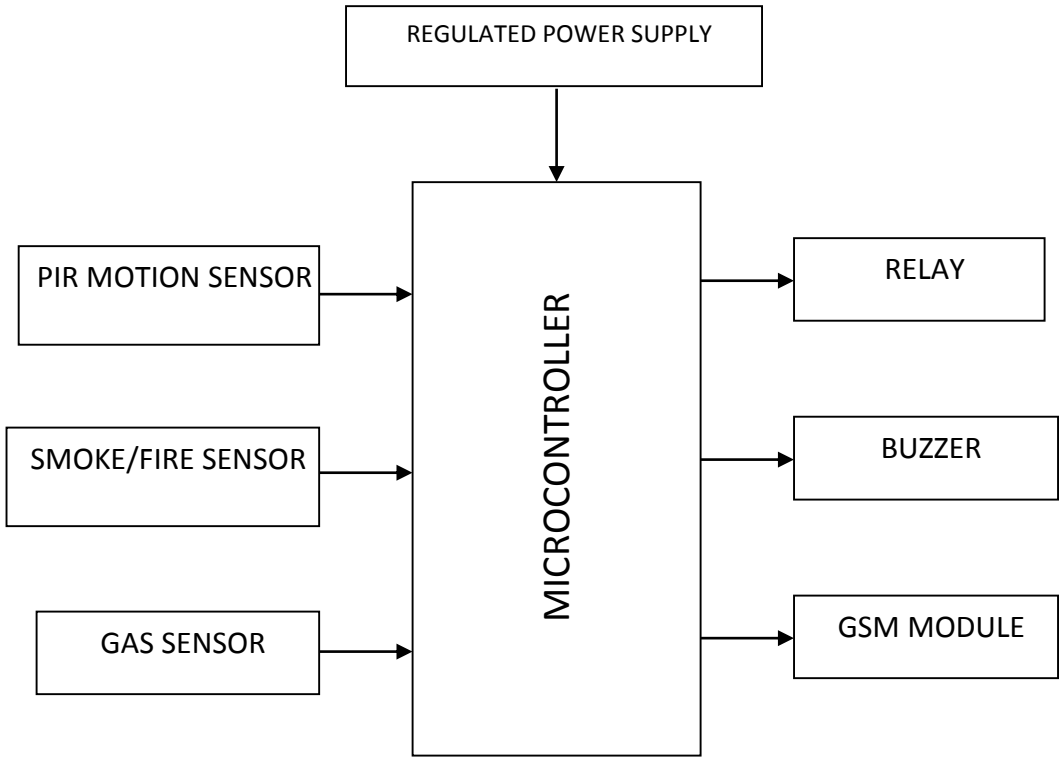


Figure 2: Block Diagram

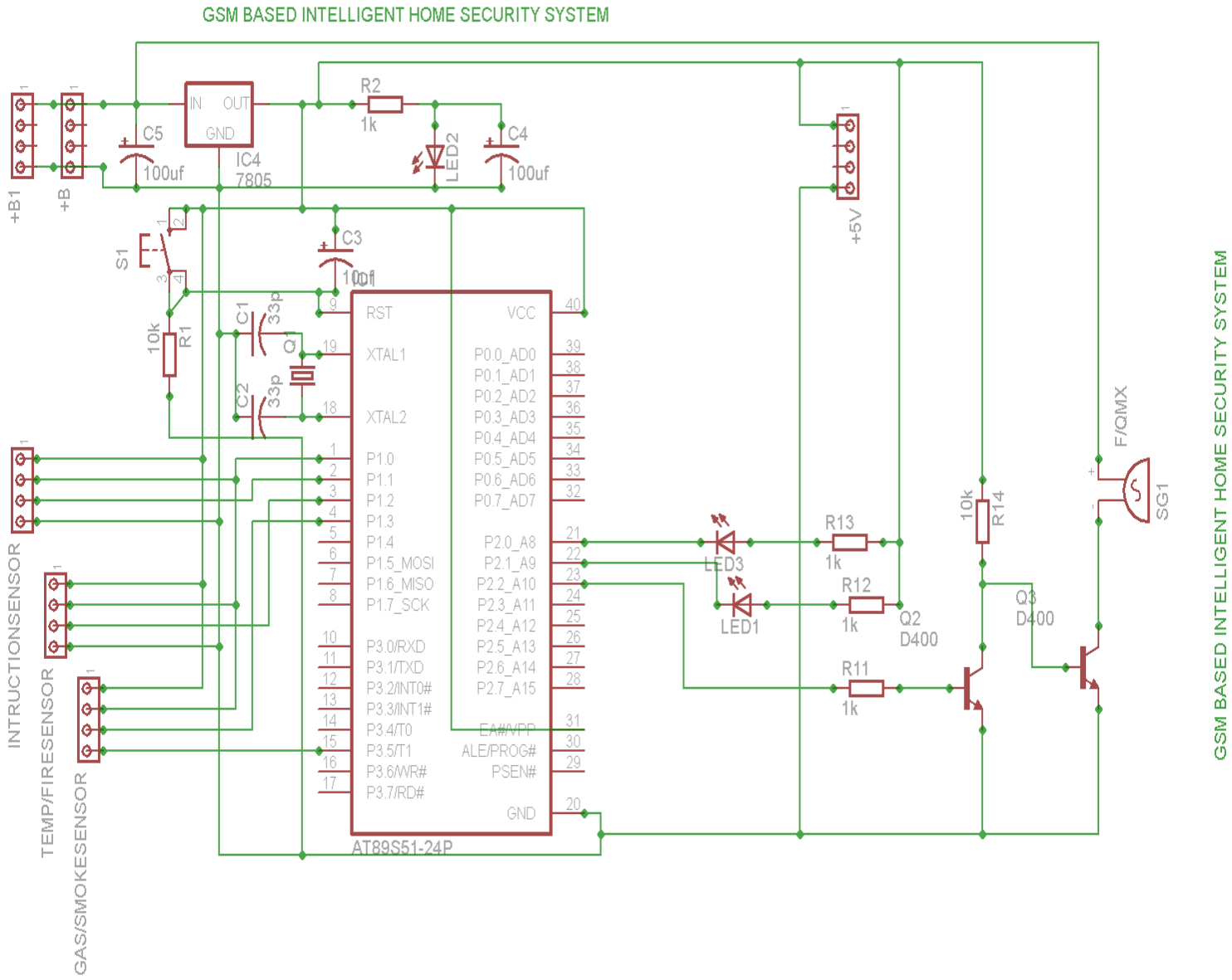
3.2 GSM Module

GSM modem is a specialized type of modem which accepts SIM card, and operates over a subscription to mobile operators. When the GSM modem and computer are interconnected, there is communication over the mobile network. Though these GSM modems are most frequently used to provide mobile internet connectivity, most of them can also be used for sending and receiving SMS and MMS messages.This device can also receive and process GSM signals from virtually all GSM bands.

GSM modem can be a dedicated modem device with serial, USB or Bluetooth connection, or mobile phone that provides GSM modem capabilities. To perform the task, GSM modem must support an "extended AT command set" for sending/receiving SMS messages. The GSM modem used for the work is configured using standard AT commands that can carry out operations of conventional phone. The major usefulness of the module is its ability to interface with other circuit elements like the microprocessor hence making it possible to embed it with other systems.

3.3 Microcontroller

Figure 2 is the circuit diagram of GSM based intelligent home security system. The microcontroller creates/enables interface between two systems and manage communications between them. It is "computer-on-a-chip" and contains all the elements of computer. The microcontroller has been used in this work to measure, store and control, calculate and/or display information after it has been successfully programmed. It has built-in functions to minimize the need for external circuits and devices to the design in the final applications.



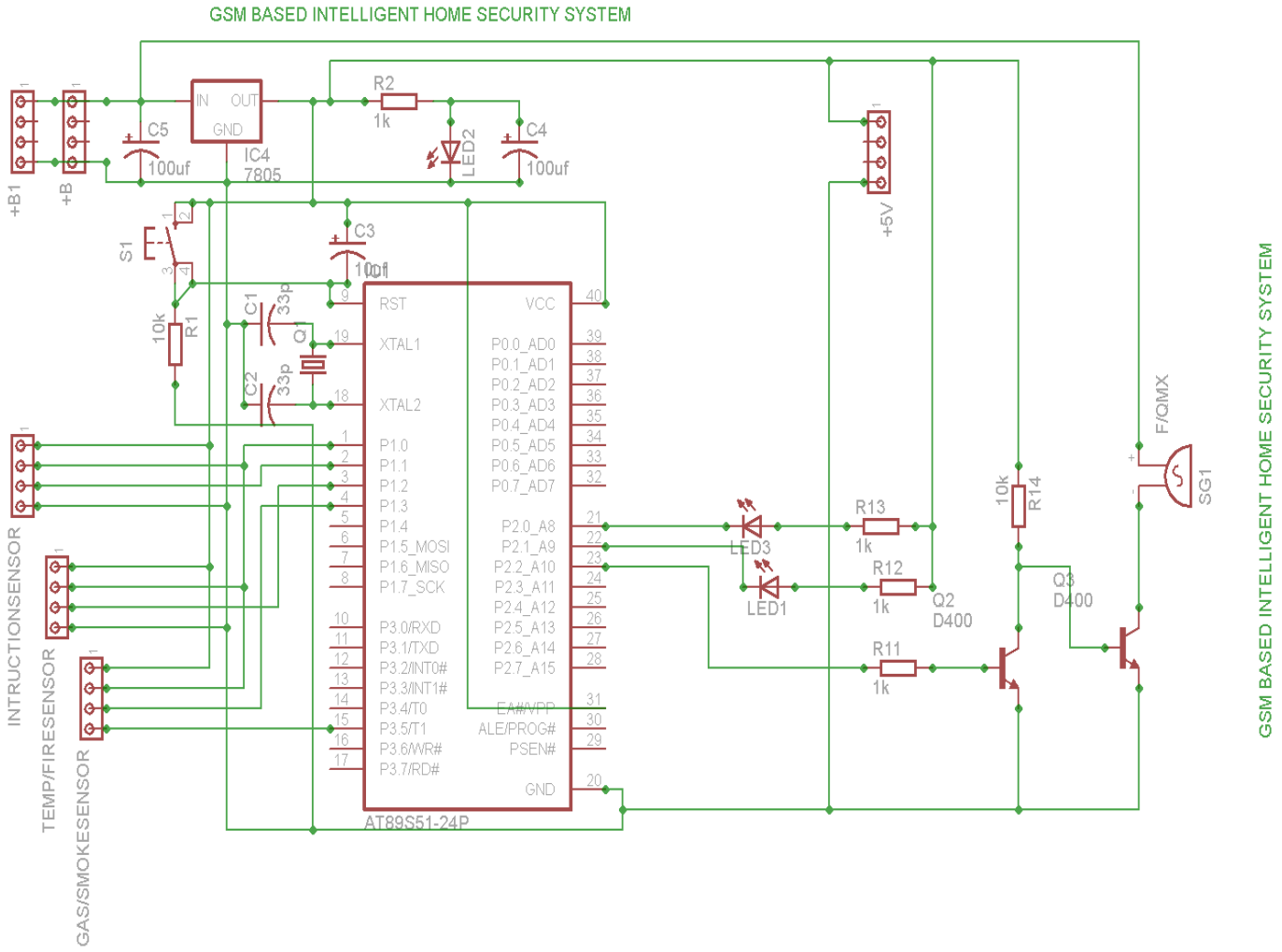


Figure 2: Circuit Diagram of GSM Based Intelligent Home System

3.4: Circuit Analysis

The sources of power to the intelligent home security system are from AC mains and/or from rechargeable battery. Either the ac mains or the battery can serve as the sole power source to the home security system. Also the AC supply and the battery can be connected at the same time, in which case the battery supplies power to the system only when the ac power source is absent, as in the case of an AC power outage, then the batteries act as a backup. When the power is switched to the "ON" position, the whole circuit is complete and current flows. 2051 ATMEL microcontroller is used. 2051 ATMEL is a powerful microcomputer which provides a high flexible and cost effective solution to many embedded cost application. It is flash programmable and erasable electrically. The memory is 256bytes by 8bits of internal RAM streams of information and 32 programmable I/O lines. It is powered by 5volts. It has different ports, these ports can be used to send and receive information.

The input is filtered and regulated to 5V with voltage regulator 7805, R_2 is a current limiting resistor, it limits the current supplied to the LED which is used for power indication. This is done to protect the diode from excessive current a resistor is placed in series with the LED. The value of the series resistor R_s depend on the forward voltage V_f of the LED, the supply voltage V_t, and desired forward current I_f. To find the value of R_s, applying ohm's law;

Given current limiting resistor,

$$R_S = \frac{V_t - V_f}{I_f} = R_{S=} \frac{5V - 1.6V}{100MA}$$

$$R_S \frac{3.4}{100x10^{-3}} = 0.34K\Omega.$$

But 1kΩ is resistor is used in the circuit.

Power is supplied to the microcontroller through pin 40, V_{cc} = 5V and GND pin 20. At this point when power is supplied the microcontroller remains or stays in a low state waiting for an input signal. Port1.0 is used as input to the microcontroller, port 1.1 senses intrusion, port 1.2 senses high temperature, port 1.3 senses concentrated gas. Port 2 is used as output port from microcontroller to input of the buzzer and also for LED displays. When an input pass through anyone sensors input, this is sensed by the microcontroller is interrupts. As such the microcontroller stops other software program running. It goes to access the

address bus of the input signal and loads the program stored in the address register, after loading, it sends to control register, compute the signal based on the stored program and runs the instruction. It sends out streams of instruction to the output register or ports. The output instruction which set output high and to send information to the GSM Modem, initializing to send SMS to a program number and turn "ON" the indicator and buzzer. The crystal oscillator determines the external frequency of the microcontroller, the rate at which it processes information is 11.0592MHz. From power supply unit (PSU), the power is supplied from the battery and filtered through capacitor C_1, to remove ripple or unwanted signal from the battery. The output port 2.2 is low and can't drive the buzzer .Therefore transistors Q_2, Q_3 are used to amplify the output to drive the buzzer; R_{10} is used to bias the input to base of the transistor Q_2, to set the current fed to the resistor. Q_2 starts conducting when the transistor's base receives a control voltage/current, the transistor will turn "ON" the buzzer. Switch S_1 is the reset button; is used to reset the microcontroller to its initialize state. The microcontroller in a voltage- deprived state and will have the tendency to behave erratically when the power supply voltage falls below the required 5V. For this reason, a reset chip I is incorporated into the design, forcing the PIC to reset to the beginning of the program and hold until the supply voltage is within acceptable limits.

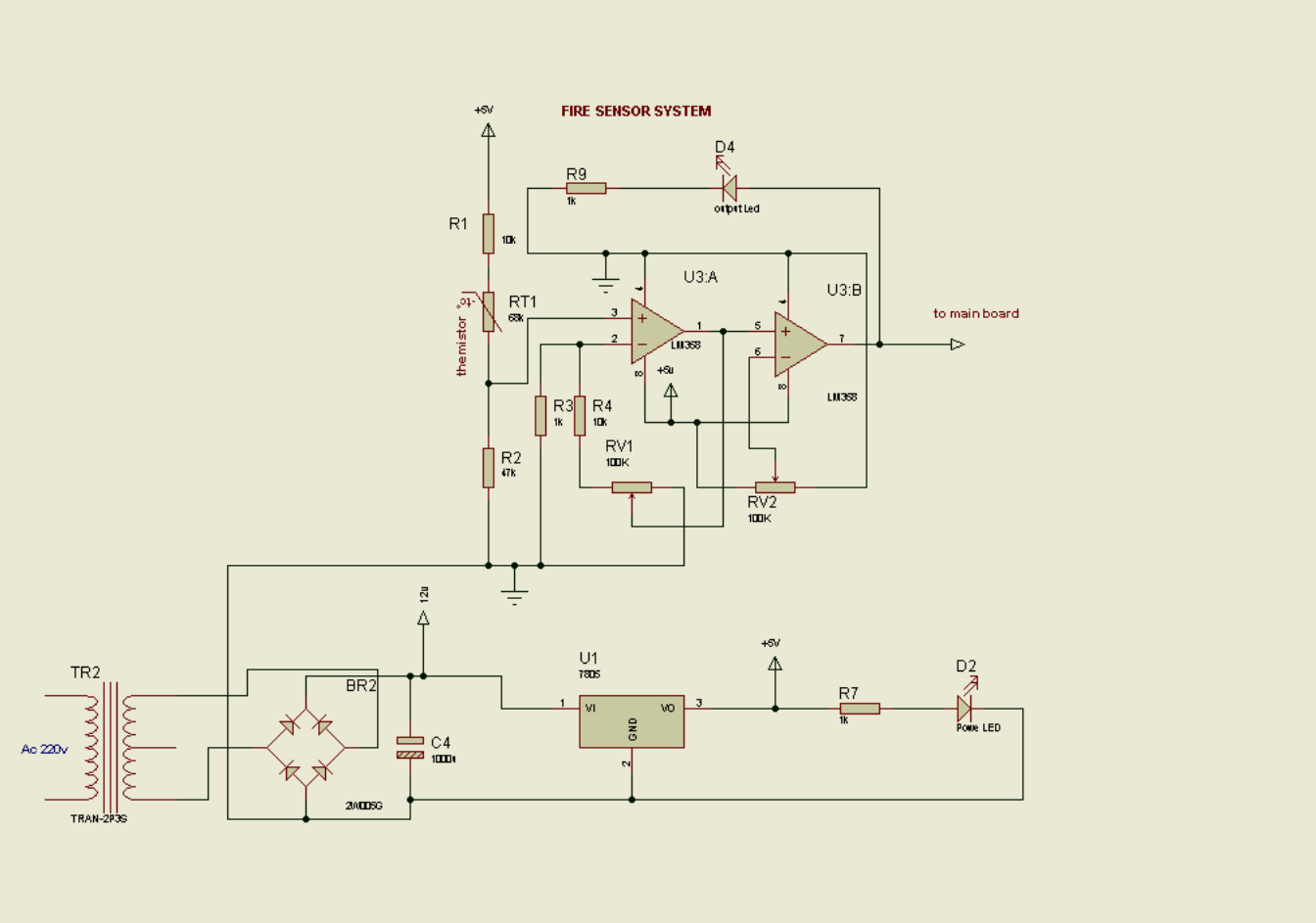


Figure 3: Circuit Diagram of Fire Sensor System

3.5 Fire Sensor

Thermistor is a temperature sensing device whose resistance changes with temperature. Thermistors, however, are made from semiconductor materials. Thermistors exhibit a highly nonlinear resistance versus temperature curve. In the Thermistor's operating range, a large resistance change can be observed for a very small temperature change. This makes it a highly sensitive device, which is ideal for set-point applications.

Thermistor is used to sense temperature of the home, when the temperature of the room increases beyond the reference temperature. It senses that the temperature of the home has increased. When it now senses heat, it converts temperature to voltage and the signal from it is small therefore it's amplified through the amplifier, LM385 and its amplified twice, before it is sent to the main board (microcontroller). It is powered from power supply unit (PSU)

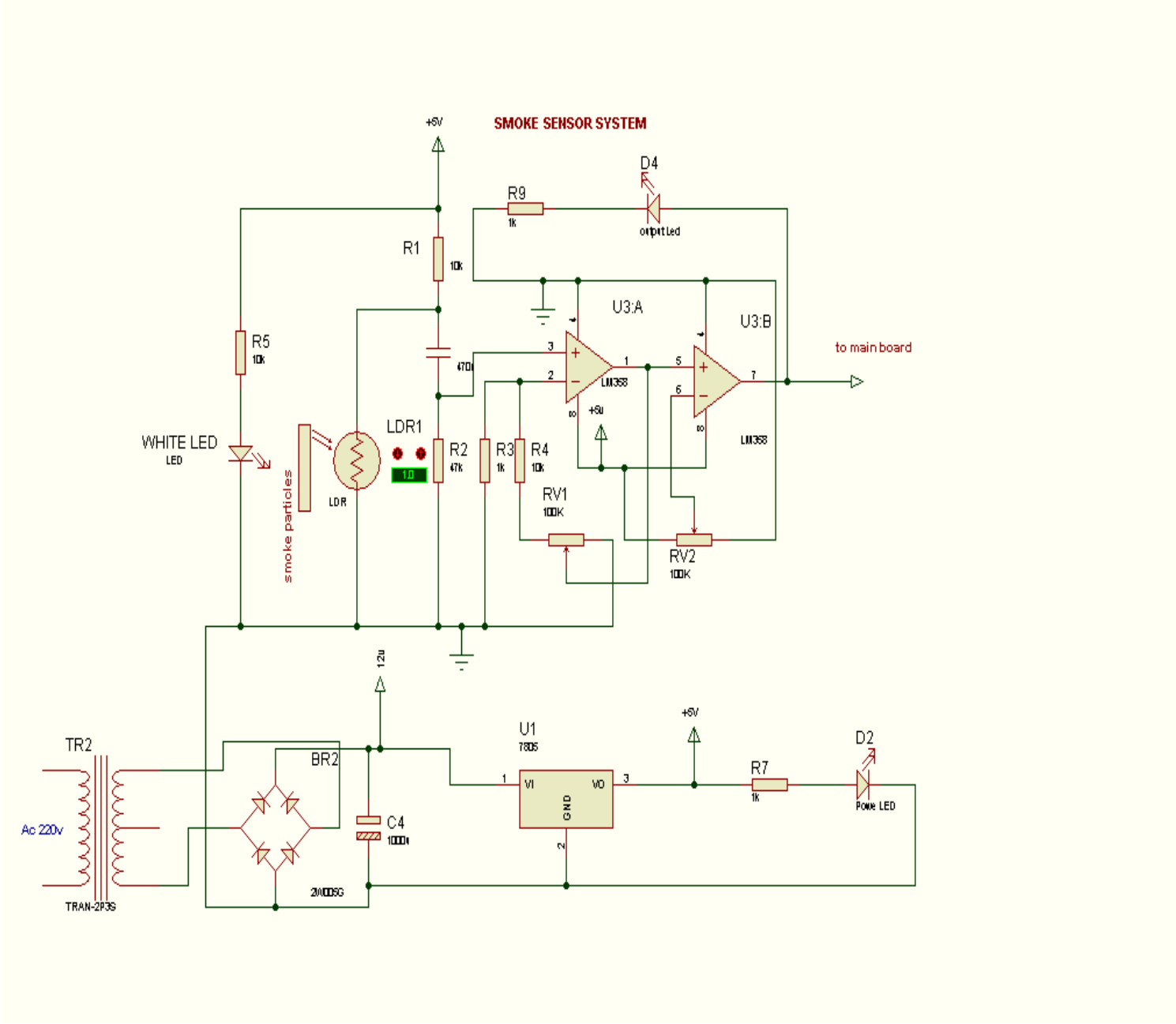


Figure 4: Circuit Diagram of Smoke Sensor System

3.5 Smoke Sensor

The smoke sensor uses two device, which are light dependent resistor (LDR) and light emitting diode (LED). When there is a smoke in the home, it casts a shadow on the LED, thereby Block the flow of light that goes to the LED, it sees the effect as an emergency 'the signal is further amplified and sent to the microcontroller.

3.6 Testing

When the system was connected to power supply the LED lit up indicating the presence of power, initializing the microcontroller and GSM modem to send SMS. The HDMI Cable was connected to the GSM MODEM, and then the interface was lunched from the computer by double clicking on proteus icon, then we clicked the switch of the sensors, after selecting, press play; then it displays as shown in figures 5 and 6.

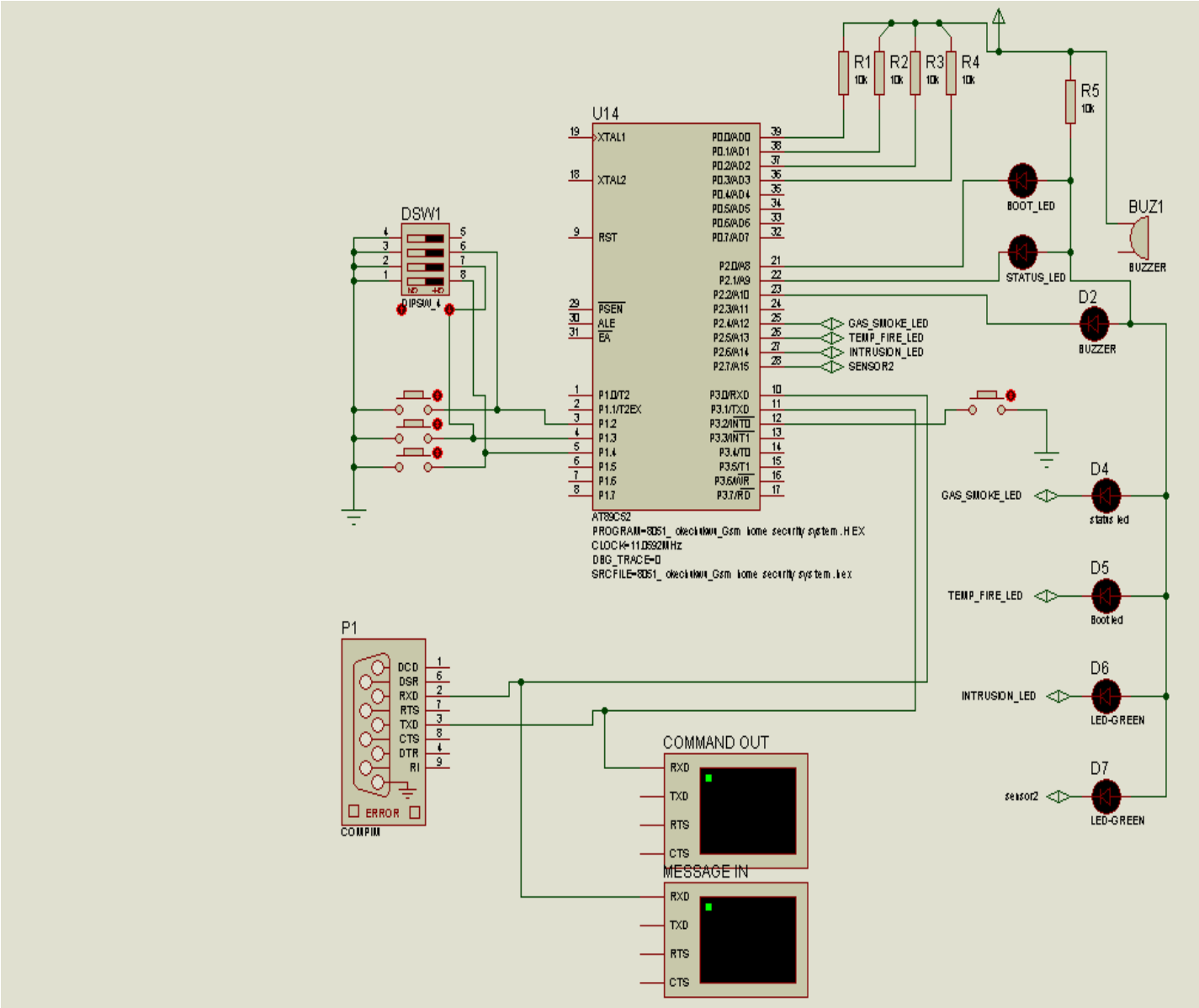


Figure 5: computer display of monitoring interface

Each sensor is tested one after the other to confirm their conditions. Below are the test carried out on each sensor.

- **Gas Sensor**: The varying gas levels were all picked by the sensor and displayed on the interface. This was confirmed when a concentrated gas was brought close to the gas sensor and the gas level increased on the interface.
- **Temperature Sensor**: This was tested by taking the system close to a lighter and the temperature reading increased on the interface.
- **Passive infrared Sensor**: This was tested by taking my hand cross the receiver and transmitter, then buzzer sounded meaning an intrusion has taken place.

3.6.1 Test Result

Each test result is displayed on the interface, and the entire result was satisfactory. Below is the display on the computer during the test:

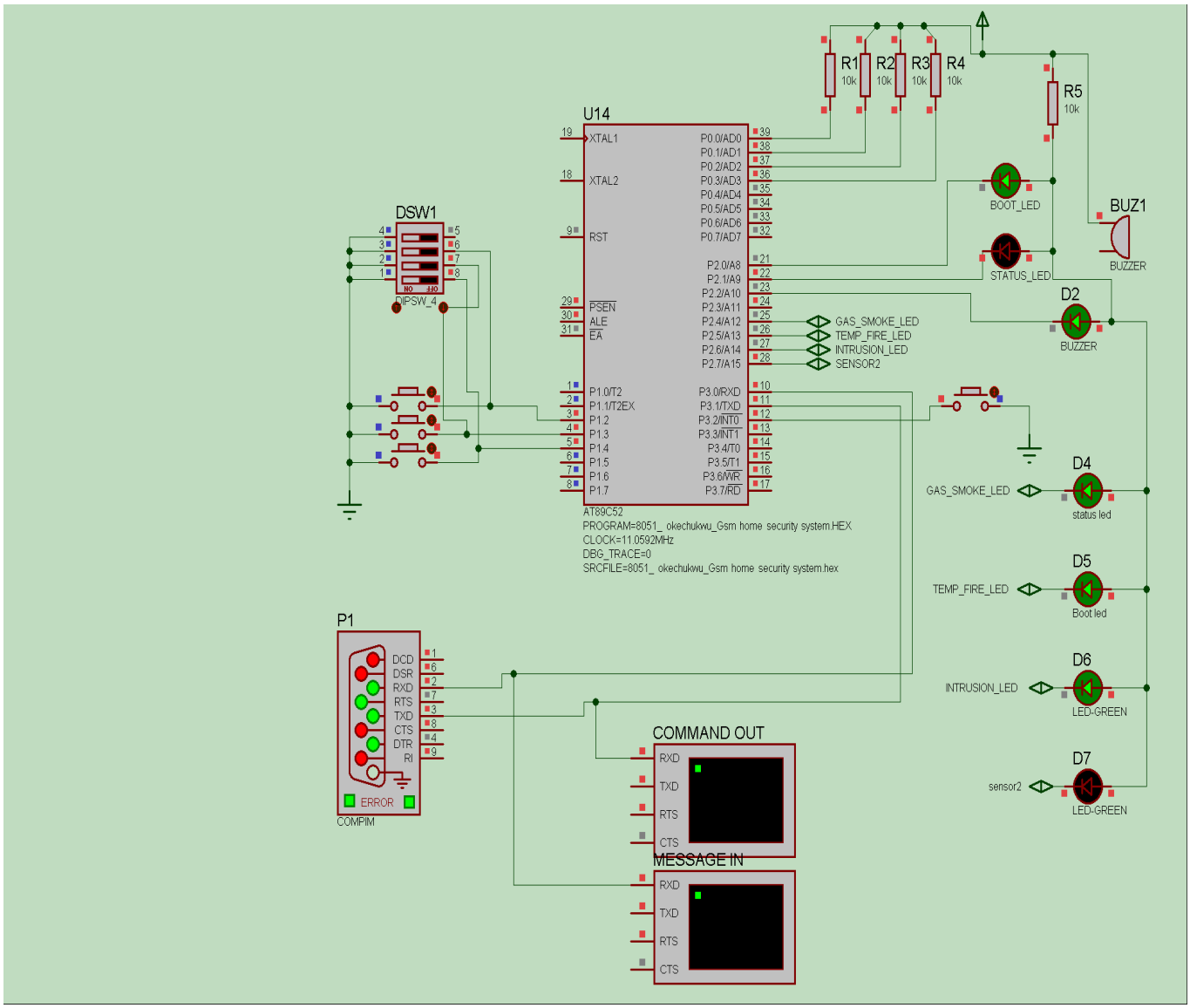


Figure 6: Display of test Result on Computer

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This work has presented the design and of a GSM based intelligent home security system. After the construction and component assembly, it was tested and they were responding to the GSM modem as detected by the infra-red sensors, high temperature sensor and gas sensor etc. But misuse of the system by end users may probably lead to lapses in the system performance. The system was designed and constructed in such a way that maintenance and repairs are easily done in the faults. The design and construction of a GSM based intelligent home security system involves researches in different aspects of physics/electronics technology; this include; power electronics, operational amplifier, telecommunication, and software engineering. When the PIR finds intruders (in form of variation in temperature, gas leakage, pressure, etc), the relevant sensing device(s) respond and the microcontroller sends encoded alarm signal to the wireless sensor network established in home. The moment the alarm signal is received, it will send alarm short message to the users (owners of the building) through GSM network immediately. The design analysis and calculations were carried out and finally, a positive result was achieved.

4.2 Recommendation

In view of the limitations of this design, the following improvements are suggested as recommendations for future work in this area of study.

- An embedded system seems to be the direction in which electronics technology is headed. We recommend smart systems should be incorporated in the design.

- Better microcontrollers are being produced all the time. We recommend the use of the latest microcontrollers and embedded microcontroller technology.

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