An Enhanced Smart Home Control And Monitoring System

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***Abstract*-Home Automation technology is becoming as synonymous with environmental sustainability as it is with convenience and security. Incorporating smart home technology into a new or existing structure makes it easier to reduce energy consumption and carbon footprint (ones impact on the environment) a home creates. This paper proposes an enhanced smart home control and monitoring system which conserves energy by automatically controlling various home installations and appliances. The system also secures the house in real time by opening the door only when the right password is supplied and detects fire in its infancy. At the heart of the control is AT89C51 which is a low power, high performance cmos 8-bit microcontroller. Appropriate sensors were chosen to monitor the processes. The output from the sensors serves as input to the microcontroller which actually controls the entire processes. The system was simulated using proteus ISIS and a working prototype was produced.**

Keywords— AT89C51 Microcontroller, Smart home, environmental sustainability.

INTRODUCTION

Today's culture is filled with horror stories of home break-ins and burglaries, leaving people with the fear that their home may not be protected from the outside world. This desire for security has caused an increase in the demand for sophisticated home alarm systems. This demand for better home security systems has also drifted over to a need for home automation.

A home automation system integrates electrical devices in a house with each other in order for them to be controlled from a central location which results in improved convenience, security and energy efficiency/conservation.

Understanding how energy is spent and knowing how to control it are key prerequisites for residential energy conservation and achieving environmental sustainability and reduction in carbon footprint. One's daily activities affect the environment in many different ways – driving, flying, heating/cooling homes; even the type of food eaten makes a difference. When carbon emissions and carbon footprint is talked about, it usually mean carbon dioxide (CO_2) emissions which is a green house gas – it traps the sun's heat and keeps the earth warm. Too much CO_2 in the air leads to climate change, also known as global warming.

One's carbon footprint is the amount of carbon dioxide that enters the atmosphere because of the electricity and fuel one uses. It is measured in tonnes of carbon dioxide. In 2010, the UK produced 496 million tonnes of carbon dioxide. Some of this is produced by business and industry, but around 30% comes directly from household energy use [3]. Energy use in the home accounts for around 3.2 tonnes per household [3]. Fig 1.1 shows energy consumption for typical home with heating accounting for 29% energy drain while cooling follows suite.

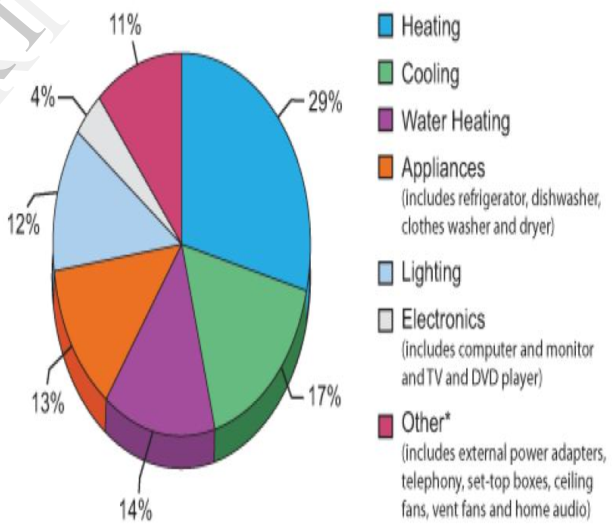


Figure 1: A Plot of typical energy consumption in homes [1]

Therefore, by making the households more energy efficient, energy consumption will be reduced to the barest minimal and big reduction in the carbon dioxide emissions can be achieved.

Active research is moving towards smart homes, home automation and smart meters with demand response integration to shut off loads by the utility when peak demand is high [6]. However, when the user is empowered to make control decisions, the result leads to energy conservation and active environmental sustainability which is accepted and tolerated all over the world.

SYSTEM ANALYSIS AND DESIGN

Every module of a logic system can be represented by a general model called the state machine [2]. The job of a finite state machine is to sequence operations on a data path. The model consists of three elements, viz:

- **The next state function** which in general receives as input the present values of the state variables together with the external inputs. From these it generates the next state which is the next value of the state variables.
- **The state** which consists of memory elements which holds the present values of the state variables (state register).
- **The output function** which receives as input the present values of the state variables together with the current input values and generates the current outputs.

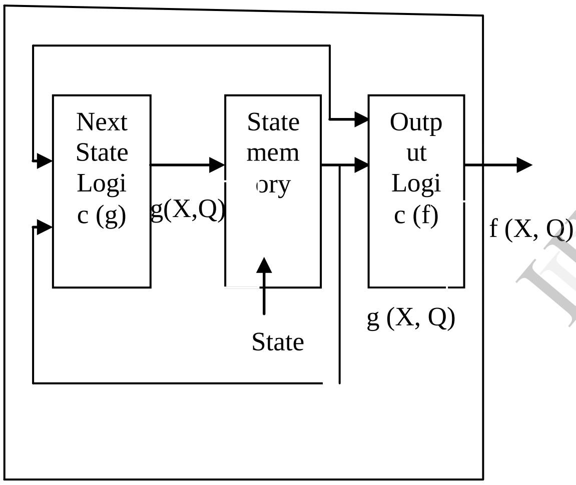


Fig 2: The general model of finite state machine [2].

From the general model of a finite state machine, the model for the enhanced smart home control and monitoring system was realized as shown in fig. 3 below.

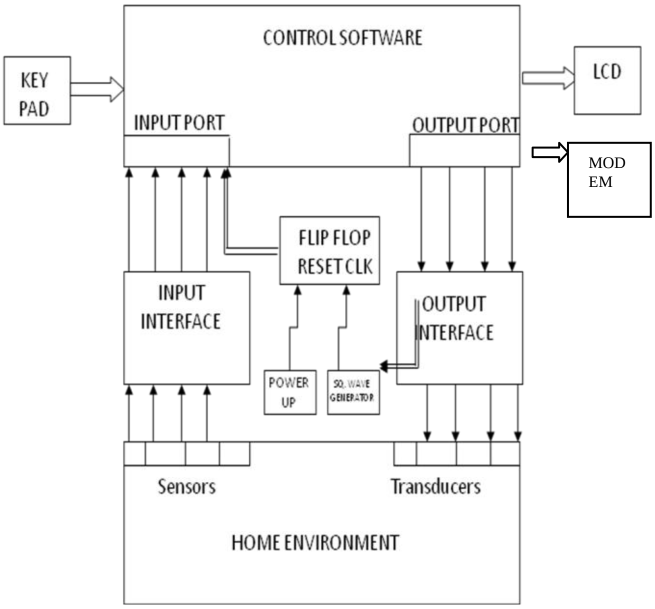


FIG 3: THE MODEL FOR THE SMART HOME AUTOMATION AND MONITORING SYSTEM

Here, the State is the memory element which consists of flip flops that holds the present values of the state variables.

The next State logic consists of AT89C51, a low power consumption microcontroller with programmable memory which receives as input the present values of the state variables together with the external inputs.

The output function receives as input the present values of the state variables together with the current input values and generates the current outputs which is displayed on an LCD or sent as an sms message to a dedicated number through the GSM modem.

The Input Interface comprises of the over head tank water level monitoring sensor sub circuit, the smoke sensor sub circuit, temperature control sensor sub circuit, the motion controlled light sensor sub circuit and the keypad.

Each of these with the exception of the keypad comprises of the following:

THE SIGNAL CONDITIONING CIRCUIT

Analog signal conditioning provides the operations necessary to transform a sensor output into a form necessary to interface with other elements of the process control loop. In these cases, it is necessary to provide a circuit to convert this resistance change either to a voltage or a current signal. This is generally accomplished by divider circuit:

$$VD = \frac{R2Vs}{R1 + R2} \qquad (1)$$

Where Vs = Supply voltage
R1, R2 = divider resistors

THE COMPARATOR

A digital Comparator is an interface device between analog and digital circuits. The input section is similar to an op-amp, while the output section can be connected directly to TTL or CMOS.

It compares two voltages or currents and outputs a digital signal which acts as an input to a TTL or CMOS device. It has two analog input terminals $V_+$and $V_-$and one binary digital output V_o. The output is ideally

$$V_o = \begin{cases} 1, & \text{if } V_+ > V_- \\ 0, & \text{if } V_+ < V_- \end{cases}$$

That is, Vo = Vref – V (2)

The output signal remains constant as the differential input voltage changes. When described that way, the comparator resembles a 1-bit ADC.

DESIGN SPECIFICATIONS

Following the model of the enhanced smart home control system shown in figure 3, the design will focus on these three layers: the input interface layer, the control software and the output interface layer.
The model specifications are as follows:

The enhanced smart home control system was designed to have five process variables at the input interface layer which are called (*WLS = Water Level Signal, TCS = Temperature Control Signal SKS = Smoke Signal, MDS = Motion Detection Signal, KPS* = Keypad Signal).

The control voltage used is +5volt and a maximum current of 200mA.

THE ASM CHART OF THE SYSTEM

The design of a finite state machine starts with an abstract graphic description such as a state diagram or an ASM chart. Both show the interaction and transitions between the internal states in graphical formats. A state diagram or an ASM chart can capture all the needed information (that is, state, input, output, next state function and output function) in a single graph.
For the purpose of this work, an ASM chart was used for the design of the finite state machine, “an enhanced smart home control and monitoring system”. The acronym used in both the ASM chart and the State Transition Table is defined below:

WLS = Water Level Signal

TCS = Temperature Control Signal

SKS = Smoke Signal

MDS = Motion Detection Signal

KPS = Keypad Signal

PSN = Present State Name; PSC = Present State Code (the memory location); NSN = Next State Name

NSC = Next State Code (The memory Location)

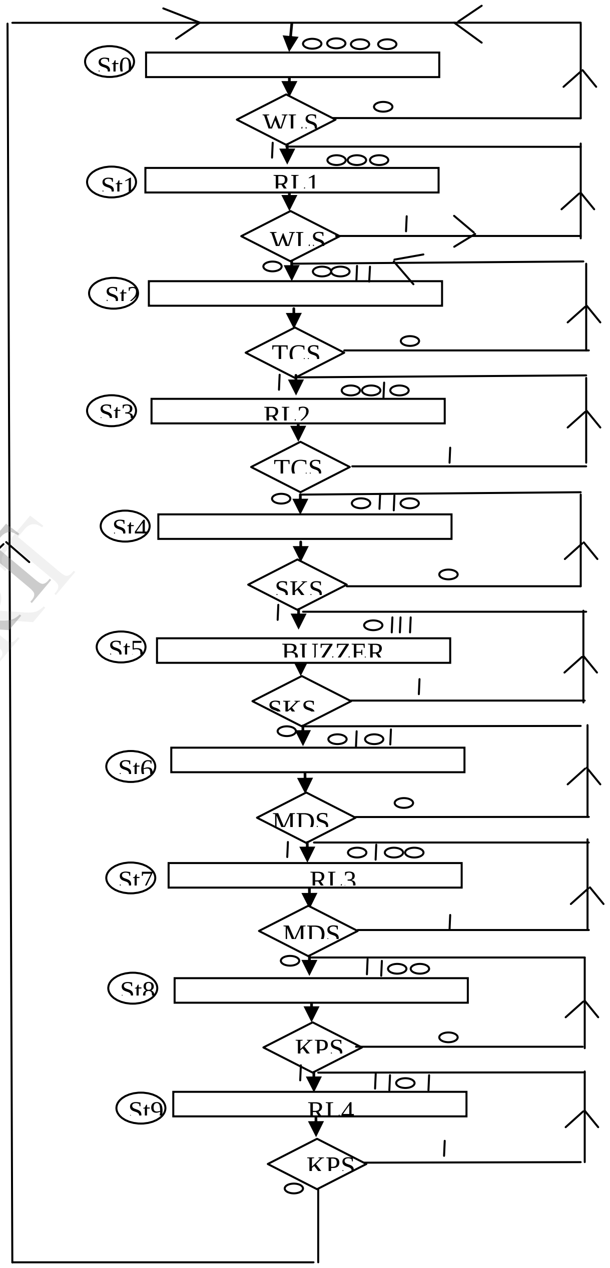


Fig.4: ASM Chart of the System

Table 1: The State Transition Table of the System

LINKPATH	Input Qualifiers WLS TCS SKS MDS KPS					PSNDCBA	PSC	NSNDCBA	NSC	Output RL1 RL2 BUZ RL3 RL4				
L1	0	-	-	-	-	ST0	0000	ST0	0000					
L2	1	-	-	-	-	STO	0000	ST1	0001	1				
L3	1	-	-	-	-	ST1	0001	ST1	0001					
L4	0	-	-	-	-	ST1	0001	ST2	0011	0				
L5	-	0	-	-	-	ST2	0011	ST2	0011					
L6	-	1	-	-	-	ST2	0011	ST3	0010		1			
L7	-	1	-	-	-	ST3	0010	ST3	0010					
L8	-	0	-	-	-	ST3	0010	ST4	0110		0			
L9	-	-	0	-	-	ST4	0110	ST4	0110					
L10	-	-	1	-	-	ST4	0110	ST5	0111			1		
L11	-	-	1	-	-	ST5	0111	ST5	0111					
L12	-	-	0	-	-	ST5	0111	ST6	0101			0		
L13	-	-	-	0	-	ST6	0101	ST6	0101					
L14	-	-	-	1	-	ST6	0101	ST7	0100				1	
L15	-	-	-	1	-	ST7	0100	ST7	0100					
L16	-	-	-	0	-	ST7	0100	ST8	1100				0	
L17	-	-	-	-	0	ST8	1100	ST8	1100					
L18	-	-	-	-	1	ST8	1100	ST9	1101					1
L19	-	-	-	-	1	ST9	1101	ST9	1101					
L20	-	-	-	-	0	ST9	1101	ST0	0000					0

Whenever the comparator output changes from 1 to 0 or vice versa, the present state and next state is executed and an output is generated. The present state code and the next state code are sub routines stored in those memory locations.

THE INPUT INTERFACE DESIGN (INPUT QUALIFIERS)

Overhead tank sensor sub circuit

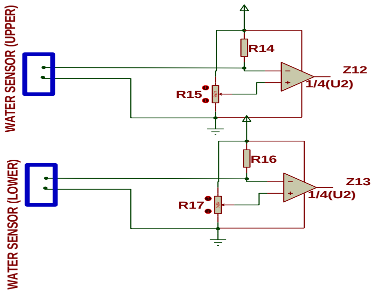


Fig 5: Overhead tank sensor sub circuit

Since the comparator compares two analog voltages and outputs a digital signal, one of the voltages on the comparator inputs will be the variable input and the other a fixed value called the threshold or the trigger voltage. To determine the threshold voltages, appropriate resistors have to be chosen.

Experiment shows that the resistance of water is 100KΩ.

Therefore taking Rw= 100k

Let Vw = ½ Vcc = ½ × 5 = 2.5 V

Where Vw forms a voltage divider between Rw and R14

From (1), we have that

$$VD = \frac{R2Vs}{R1 + R2}$$

Hence $Vw = \frac{100 \times Vcc}{Rw + R14}$

$$Vw = \frac{100 \times Vcc}{100 + R14}$$

$$2.5V = \frac{100 \times 5V}{100 + R14}$$

$$2.5V = \frac{1 \times 5}{1 + R14}$$

$$2.5 + 2.5R14 = 5$$

Therefore, R14 = 1K

Allowing current of 2MA to flow through R15 (so that the voltage will be high enough) and then applying ohm's law, we have that

$$V = IR \qquad (3)$$

where V = Vcc = 5V

R15 × 2MA = Vcc = 5V

$R15 = \frac{5}{2\times10^{-3}}$ = 2.5KΩ Approx. 2.7KΩ for tolerance consideration

Therefore, R14 = R16 = 1K and R15 = R17 = 2.7K.

To get V_{TH}, from (1)

$$VD = \frac{R2Vs}{R1 + R2}$$

Therefore,

$$V_{TH} = V_w = \frac{2.7 \times 5}{100 + 2.7}$$

$$V_{TH} = \frac{13.5}{102.7}$$

Therefore $V_{TH} = 0.13V$

From equation (2), Vo = Vref – V, any voltage above 0.13V will result in a negative value which is equal to zero. But once a voltage of o.13V is received, the comparator output will turn to one.

THE NEXT STATE LOGIC DESIGN

Below is the control algorithm from where the control software was generated from.

```
Begin (): Initialize Process variables
Do forever
        If (WLS) then
        Process (Water);
        Else if (TCS) then
        Process (Temperature);
        Else if (SKS) then
        Process (Smoke);
        Else if (MDS) then
        Process (Room light);
        Else if (KPS) then
        Process (Keypad);
        End

Water: Check water level
        If level is minimum then
        Switch on pump
        Check for maximum level
        If level is maximum then
        Display tank full
        Switch off pump
        End

Temperature: Check Temperature
        If (temperature) too high then
        Switch on "AC"
        Else switch off "AC"
        End.

Smoke: Check for smoke
        If (smoke sensed) then
        Sound an alarm
        Display message (LCD)
        End

Room Light: Check entrance
        If (entrance) then
        Check room light intensity
        If room dark then
        Switch on light
        Increment count
        Else switch off light
        Else if exit then
        Check if count is "zero"
        If not zero then
        Decrement count
        Switch off light
        End

Keypad: Check for code
        If code correct then
        Grant access
        Else if allow "3" time check
        If code incorrect then
        Deny access
        Send message
        Sound an alarm
        Display error (LCD)
        End

End
```

THE OUTPUT INTERFACE DESIGN
THE GSM MODEM

Text message may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller i.e., TxD, RxD and GND. The following is the AT Command for sending text message to a mobile phone through the GSM Modem interfaced with a microcontroller:

- AT + CMGW = "phone number, text message", 26. With this command, the Controller now sends the message to the dedicated phone number.

The AT commands is activated once the controller receives a signal from the hazard detector (smoke detector) or when the wrong keypad is supplied three times. On the activation of the AT command, the binary streams are passed through a Gaussian filter (to filter out sidebands extending from the carrier) and then applied to an I- Q modulator where the modulation index is 0.5. To keep the modulation index at 0.5, an I- Q carrier generator was used, that is, two carriers, one in-phase and another one quadrature to it. This is then summed and transmitted into the channel. At the receiving end, a local oscillator generates a signal at the channel's carrier frequency. The incoming signal and the local oscillator signal are applied to a demodulator circuit. This translates the data signal in the sidebands back to its original baseband frequency. An electronic filter removes the carrier frequency, and the data signal is output for use.

MODEL SIMULATION

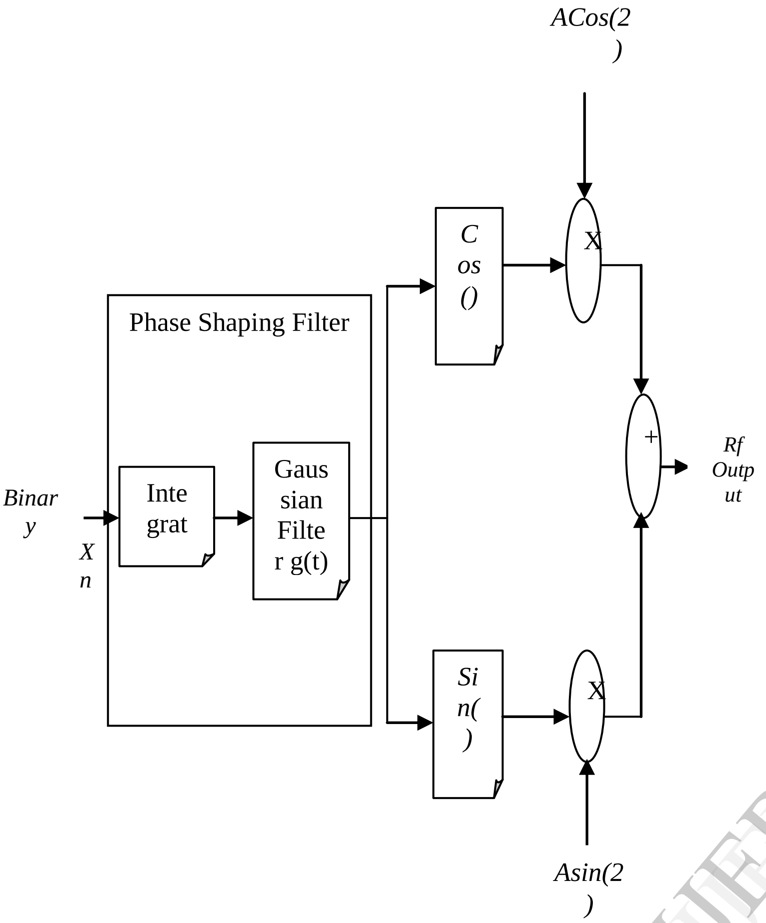


Figure 6: GSM GMSK Modulator

SYSTEM SIMULATION

Proteus Isis was used to simulate and validate the system first before a prototype was developed.

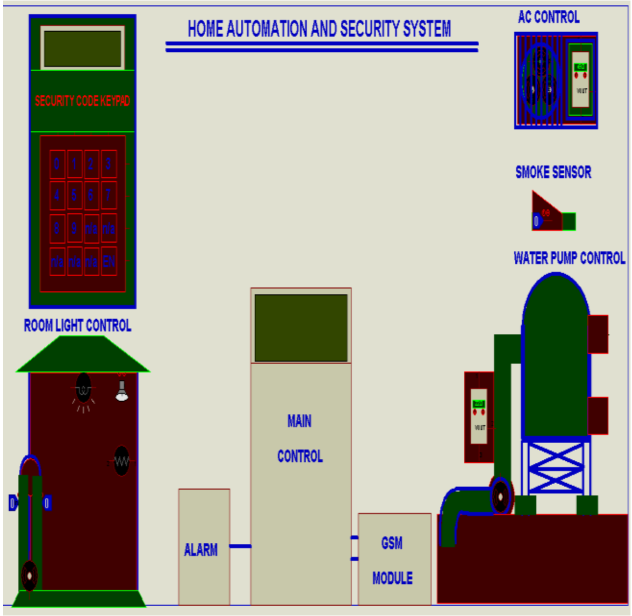
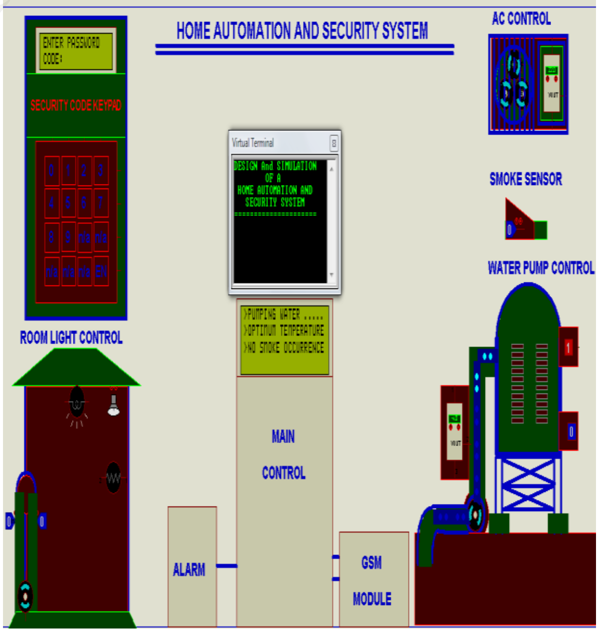


Fig 7: System in off mode

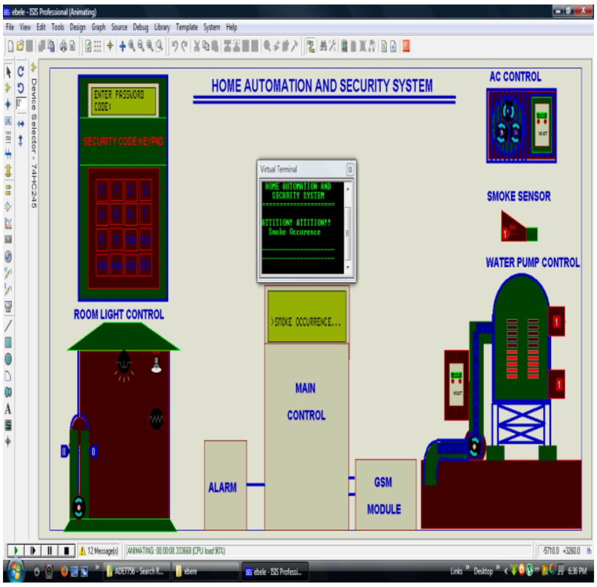


```
ENTER PASSWORD
CODE:
```

```
DESIGN And SIMULATION
        OF A
 HOME AUTOMATION AND
   SECURITY SYSTEM
=====================
```

```
>PUMPING WATER .....
>OPTIMUM TEMPERATURE
>NO SMOKE OCCURRENCE
```

FIG. 8: SYSTEM IN ON MODE



```
HOME AUTOMATION AND
  SECURITY SYSTEM
====================

ATTITION! ATTITION!!
  Smoke Occurence

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```
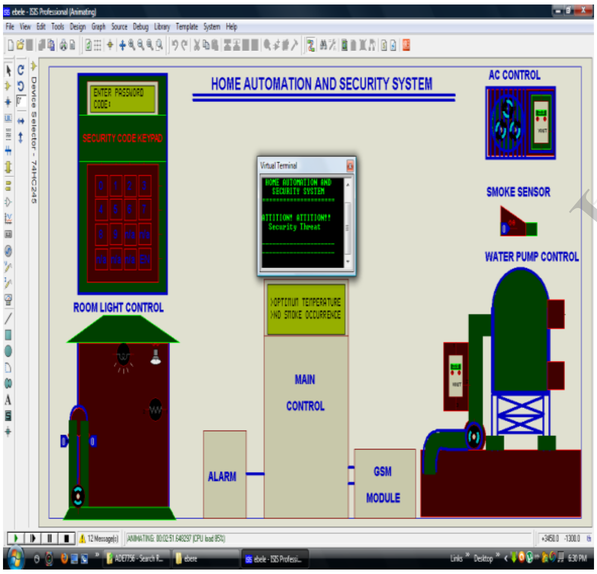

```
>SMOKE OCCURRENCE...
```

Fig. 9: The Smoke Occurrence Scenario



```
HOME AUTOMATION AND
  SECURITY SYSTEM
====================

ATTITION! ATTITION!!
  Security Threat

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```

```
>OPTIMUM TEMPERATURE
>NO SMOKE OCCURRENCE
```

Fig. 10: Scenario for Security threat

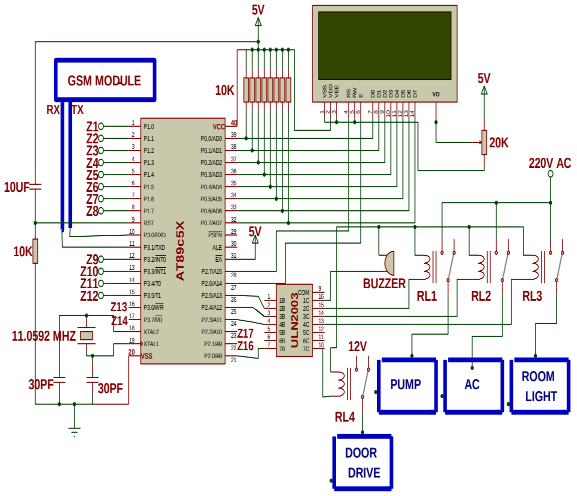

Fig. 11: The Complete Circuit Diagram

Fig 12: The Prototype

CONCLUSION

This paper have proposed and implemented an enhanced smart home control and monitoring system that is adaptive, cost effective, energy efficient and complies with smart planet initiatives. The model took care of the numerous limitations of the traditional automation system such as high infrastructure economy, dead lock states and efficiency in energy conservation. Proteus ISIS was used for model validations.

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