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Development of Microcontroller Based Temperature and Lighting Control System in Smart Home

JUNE THARAPHE LWIN[1], AUNG ZE YA[2]

[1]Dept of Electrical Power Engineering, Mandalay Technological University, Mandalay, Myanmar, Email: tharaphelwin@gmail.com.
[2]Dept of Mechanical Engineering, Mandalay Technological University, Mandalay, Myanmar, Email: dr.aungzeya010@gmail.com.

Abstract: Recently, smart home has achieved evident interest due to consideration of an ideal living home with advanced technologies. Smart home technology is a good choice for people not only care about security but energy saving as well. Besides, energy saving is considered as one of the most important issue affects the consumers, power system quality and the global environment. The obvious point of smart home is that it is automatically adjusted to the desired state through interactions between the physical condition and electronic devices. This study is mainly mentioned the microcontroller based temperature and lighting control system for energy saving in one-story building with six room's smart home. The microcontroller is the brain of the system for interfacing and controlling the system. Therefore, in this paper, 40-Pin PIC18F4550 High-Performance, Enhanced Flash USB Microcontroller is applied to maintain the room temperature range of smart home as 25 ° C ± 5 ° C. Then, the temperature and lighting sensors are used to sense the real condition of the room of smart home. This research is a platform to be continued for the future smart control applications.

Keywords: Future Smart Control Applications, PIC18F4550 Microcontroller Based, Smart Home,Temperature And Lighting Control System.

I. INTRODUCTION

Home Energy Management System (HEMS) and residential energy storage system play vital roles in a Smart House. HEMS automatically collect precise real-time data on power usage by room and presents it visually, and the system can help households limit energy consumption while providing a comfortable living environment. Smart home system uses advanced computer technology, network communication technology and automatic control technology, which combines the subsystem into a control system including temperature control and alarm control, main house power supply switching system. The smart house has two interfaces

- Computer interfacing
- Remote control unit interfacing

The home automation system is a key for energy conservation that can be equipped in normal buildings. As there are many benefits of wireless technology over wired, most of the home automation systems are based on the WSN technology. But now this paper study about internal temperature controlling system based on microcontroller to save power and reduce the costs for optimization of smart home system.

II. METHODOLOGY

Microcontroller takes various inputs from connected sensors and processes it according to defined program and then it provides logical output to whole house's power system. Its additional features is that it is having power protection system also, so when any fault occurs inside home the protection system immediately traps the main power source. With its numerous features, the PIC18F4550 can create a multitude of useful applications, such as smart home. Among them, there are many I/O ports, serial and parallel ports, timers, RAM ROM, EEPROM modules and A/D converter. There are two main parts in temperature control systems which are measurement and control. Measurement

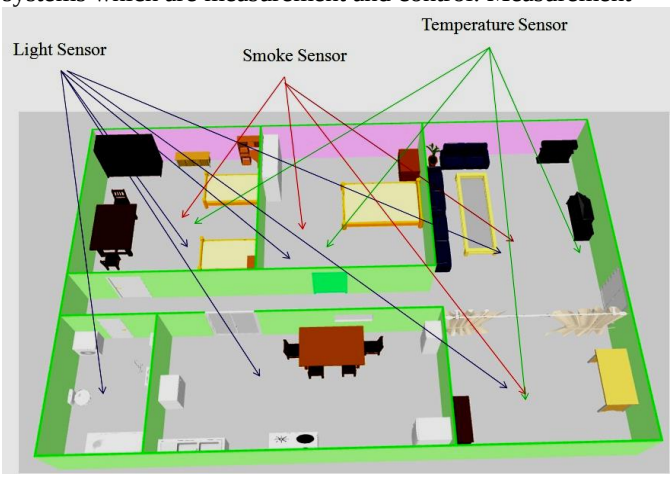

Fig.1. 3D View of Selected Smart Home.

system includes sensing circuit. Temperature cannot be measured directly but must be measured by observing the effect that the temperature variation causes in the measuring

device. A control system is a combination subsystem to maintain output suitably related to input. Temperature control system is essential and practical guide for all engineers involved in the use of microcontroller in measurement and control system as shown in Fig.1.

This paper describes the use of microcontroller in temperature control application. In order to reduce costs and optimize production, in many applications it is necessary to control the change. In this paper, integrated-circuit temperature sensors is used as the input sensor, analog signal is used as the type of output, ON/OFF control as the control algorithm and heating and cooling system as two outputs are selected to control the temperature condition.

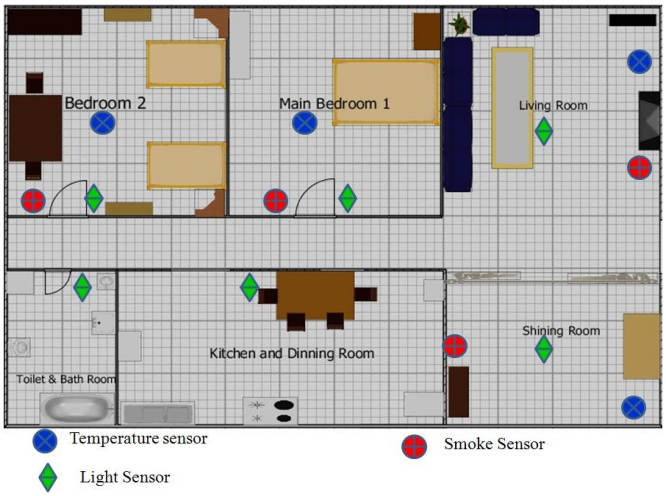

Fig.2. Top View of Locations of Sensors in Selected Smart Home.

Temperature control system (Fig.2) relies upon a controller, which sends many signals from the temperature sensor such as a thermocouple or Resistive Temperature Detector (RTD), thermistor and integrated circuit sensor for precisely control the process temperature without extensive operator involvement [1]. It compares the actual temperature with the desired control temperature, or set point, and provides the output to a control element. As the heart of the system, PIC microcontroller is used to control the environment in which the heating and cooling system operate and to monitor the temperature data inside and outside a building and to drive the external (heating and cooling system).

A. Household

The material properties of buildings influence the thermal performance and their energy consumption patterns. The walls, floor, roof and windows have central thermal conductivity, and allow circulation of warm/cold air in the house. The energy consumption depends on the house characteristics, specifically on its geometry. Therefore, the house geometry is defined by the size and the numbers of rooms, which are assumed to be from 1 to 4, modelled using the average of length, width and height of walls and windows. The sensors are assumed to be placed in master bed room, secondary bed room, living room and kitchen room.

B. Lighting System

Smart home lighting system has many advantages:

- Lights in the house turn on automatically with one touch control.
- Turn off all the lights with a single touch.
- Free from shock hazards.
- Brightness can be controlled according to surrounding conditions.

C. Temperature System

The main object in temperature system is the reading of temperature value from LM35 temperature sensor. The main use of LM35 temperature sensor is that it is the easiest of all the temperature sensors because it is an integrated circuit that outputs a voltage proportional to the temperature in degree Celsius and the sensor itself takes care of non-linear effects. LM35 sensor is connected directly with microcontroller. PIC18F4550 reads the signal from LM35 sensor as variable analog value. After processing, microcontroller will send a cooling or heating signal to the system.

D. Alarm System

The Proteus software based home alarm system which act as a security guard of the home. The basic purpose of a home alarm system is to keep us and our family safe, and keep our home safe from crime. When the alarm is triggered, it emits a loud sound design to frighten away intruders. To protect home from unauthorized entities, consider an entry from front door only where keypad is connected. The home alarm system is created in this program by setting a suitable code for alarm to work. The code for actual alarm is fixed.

III. MAIN FEATURES OF PIC 18F4550

Microcontroller is a computer on a chip that is programmed to perform almost any control, sequencing, monitoring and display function. The Peripheral Interface Controller (PIC) microcontroller solution features a powerful architecture, flexible memory technologies, comprehensive easy-to-use development tools, complete of technical documentation and post design-in support through a worldwide sales and distribution network

A. Nano-Watt Technology

PIC18F4550 can significantly reduce power consumption during operation. Pin diagram of PIC18F4550 is shown in Fig.3. Key items include [1]:

- Alternate Run Modes: By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.
- Multiple Idle Modes: The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4% of normal operation requirements.
- On-the-Fly Mode Switching: The power-managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their applications software design.

- Low Consumption in Key Modules: The power requirements for both Timer1 and the Watchdog Timer are minimized.

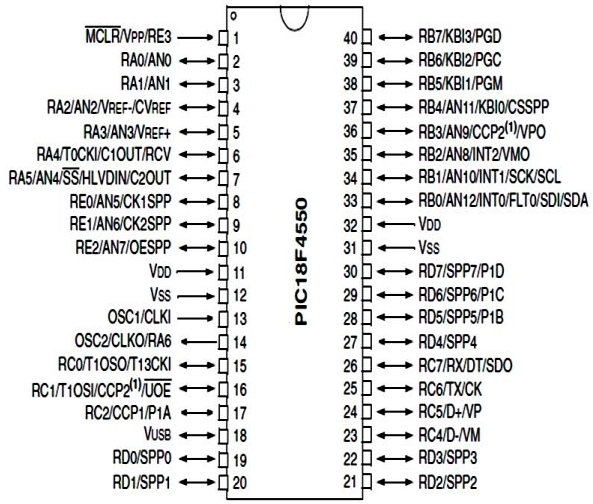

Fig.3. Pin Diagram of PIC 18F4550 [1].

B. Universal Serial Bus(USB)

PIC18F4550 has fully featured Universal Serial Bus communications module that is compliant with the USB Specification. The module supports both low-speed and full-speed communication for all supported data transfer types. It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators [1].

C. Multiple Oscillator Options and Features

PIC18F4550 offers twelve different oscillator options, allowing users a wide range of choices in developing application hardware. These include [1]:

- Four Crystal modes using crystals or ceramic resonators.
- Four External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O).
- An internal oscillator block which provides an 8 MHz clock (±2% accuracy) and an INTRC source (approximately 31 kHz, stable over temperature and VDD), as well as a range of 6 user-selectable clock frequencies, between 125 kHz to 4 MHz, for a total of 8 clock frequencies. This option frees an oscillator pin for use as an additional general purpose I/O.
- A Phase Lock Loop (PLL) frequency multiplier, available to both the High-Speed Crystal and External Oscillator modes, which allows a wide range of clock speeds from 4 MHz to 48 MHz.
- Asynchronous dual clock operation, allowing the USB module to run from a high-frequency oscillator while the rest of the microcontroller is clocked from an internal low-power oscillator.

D. Memory Endurance

The Enhanced Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles – up to 100,000 for program memory and 1,000,000 for EEPROM. Data retention with outré fresh is conservatively estimated to be greater than 40 years.

E. Self-Programmability

These devices can write to their own program memory spaces under internal software control. By using a boot loader routine, located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field.

F. Extended Instruction Set

The PIC18F4550 family introduces an optional extension to the PIC18 instruction set, which adds 8 new instructions and an Indexed Literal Offset Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages such as C [1].

G. Enhanced PPC Module

In PWM mode, this module provides 1, 2 or 4 modulated outputs for controlling half-bridge and full-bridge drivers. Other features include auto-shutdown for disabling PWM outputs on interrupt or other select conditions and auto-restart to reactivate outputs once the condition has cleared [1].

H.10-Bit A/D Converter

This module incorporates programmable acquisition time, allowing for a channel to be selected and a conversion to be initiated, without waiting for a sampling period and thus, reducing code overhead. Proposed a system is for advanced temperature control and monitor system, which is implemented on software using PIC18F4550. Firmware is designed to adjust and monitor each room of a smart home and management the power energy. This temperature management system is about a new smart home control system based on intelligent sensor network to make home network more intelligent and automatic. The system contains multiple smart sensors which sense the presence of consumer, sense the body temperature and humidity. Proteus simulation are used to implement a novel real-time, error control, low energy utilization scheme in selected smart home.

IV. COMPONENTS OF THE SYSTEM

Smart energy controlling system is intended for saving the energy systematically. This system is needed to sense the light conditions, temperature and motion. In this system, many sensors are used to operate the whole system. There are four components in the smart energy storing system.

- Temperature sensor (LM35DZ)
- Light dependent resistor (LDR)
- Smoke sensor
- PIC microcontroller

1. Light dependent resistor (LDR): LDR is made from a chemical compound called cadmium sulfide (CdS).This

compound changes resistance depending on how bright the light is that shines on its collecting surface. Bright light causes low resistance values between the two leads while dim light causes higher resistance values. The sensitivity of a photo detector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance at the cell. The sensor is jointed with the PIC pin RB1-7. Microcontroller is sensed the LDR resistance value to know the light intensity.

2. Temperature sensor (LM35DZ): LM35DZ is a precision IC temperature sensor with its output proportional to the temperature (in °C). It can be measured more accurately than with a thermistor. It also possesses low self heating and does not cause more than 0.1°C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise and fall in ambient temperature. Its scale factor is 0.01V/°C. The output pin of the sensor is jointed to the PIC16F887 pin (RA0-7). Microcontroller is sensed its analog output voltage and then changed to digital output.

3. Smoke sensor: There are two main types of smoke sensors: ionization detectors and photoelectric detectors. A smoke alarm uses one or both methods, sometimes plus a heat detector, to warn of a fire. The devices may be powered by a 9-V battery, lithium battery, or 120-V house wiring.

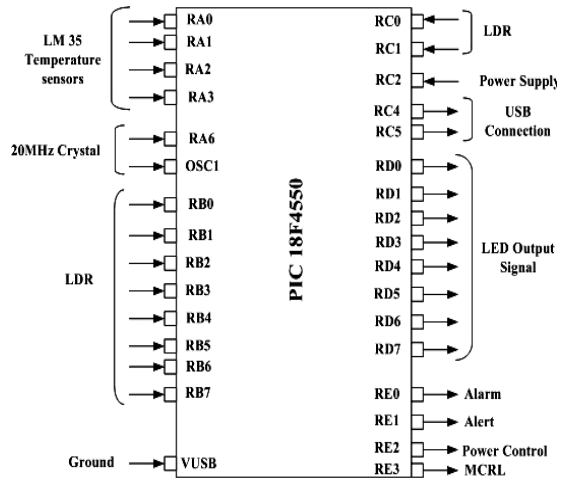

Fig.4. Pin Diagram of PIC 18F4550.

PIC Microcontroller: Microcontroller is a computer on a chip that is programmed to perform almost any control, sequencing, monitoring and display the function. In this paper PIC18F4550 is used to transmit and receive the serial data. The transmitter circuit and receiver circuit is controlled by two PIC18F4550. Pin diagram is shown in Fig.4.

V. SYSTEM FLOWCHART FOR PROPOSED CONTROL SYSTEM

The flow for controlling system will begin read temperature and LDR sensor. After implementing the program, the operation of the overall system can be seen in this flow chart (Fig.5). When the consumer is sensed, the operation will start to turn ON detecting process according to the consumer's body temperature with the help of humidity sensor, and the whole program would be ready to read the temperature from the sensor immediately. After the microcontroller senses the analog signal, the internal ADC of microcontroller is used to convert the analog signal into digital output. For the first stage, if the temperature is between 20 degree Celsius and 30 degree Celsius, the microcontroller will remain at normal operation and the system will keep getting the temperature reading constantly. When the temperature is less than 20 degree Celsius, the heating system will be turned ON.

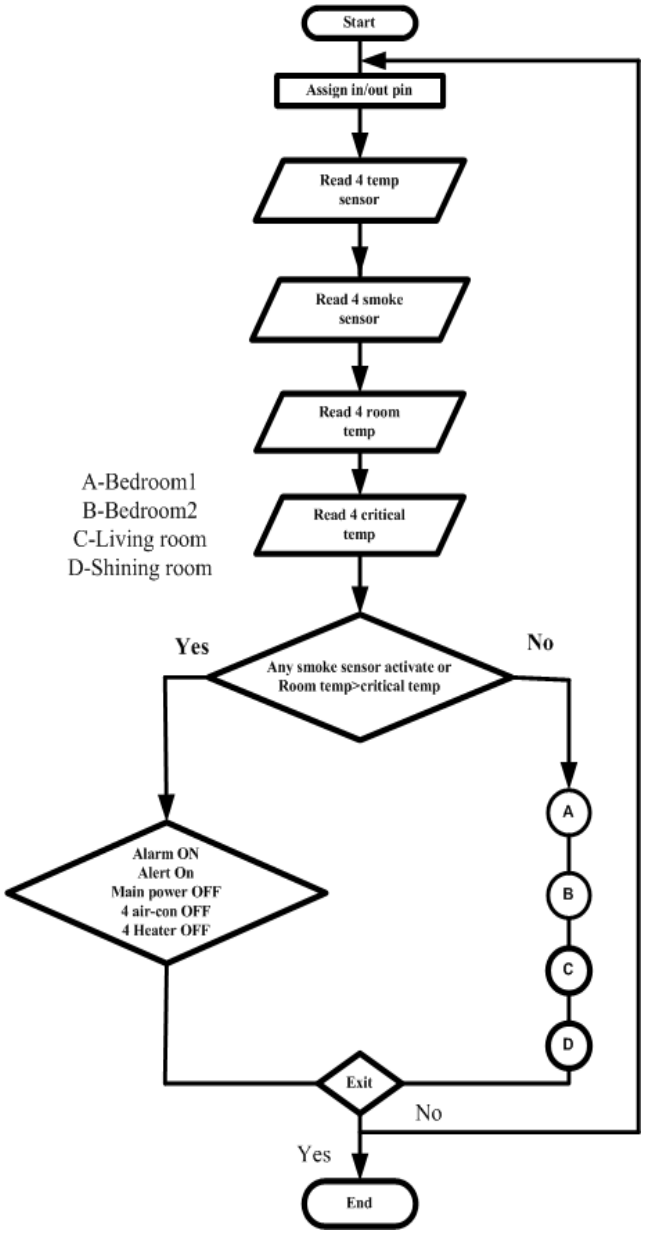

Fig.5. System Flow Chart for Temperature control system for smart home.

Same goes if the temperature is more than 30 degree Celsius, the microcontroller will advance to the cooling system ON and the heating system OFF automatically.

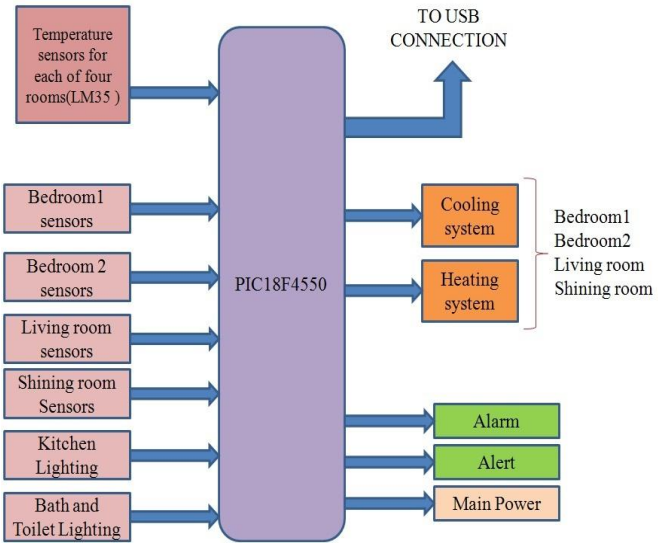

Fig.6. Block Diagram of Temperature Control System for Smart Home.

In this paper, the control circuit and software packages are proposed for monitoring and control functions in temperature control system as shown in Fig.6. This combination of hardware and software serves as the temperature control system that has the ability to perform full responsibilities. To get the performance, the software set up for PIC is coded in microcontroller assembly language.

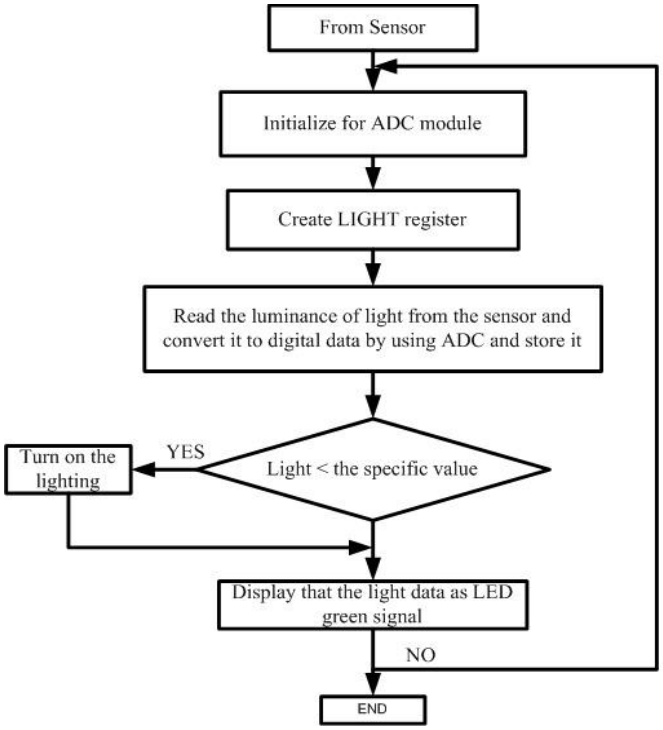

Fig.7. System Flow Chart for Lighting control system for smart home.

Fig.7 shows system flowchart describing how the temperature control system of smart home is monitored. In this process, PIC 18F4550 decides to turn ON/OFF the temperature controlled sensors in each of four rooms based on information adjusted by comparing sensor values. In this project, the critical temperature is selected as 60**°C;** the desired room temperature is assumed 25**°C±5°**C. When consumer comes into one of each of four rooms, sensors will detect or sense the body temperature of consumers. If the detected room temperature is less than or equal to the limited temperature of the system, the sensor will activated to turn ON heating system. At the reversely condition, the room temperature is more than the desired temperature, the air-conditioning system will automatically start to ON state in which the limited temperature can tolerate ±5 °C.

A. Operating Condition for the Normal Room Temperature (Under 60° C)

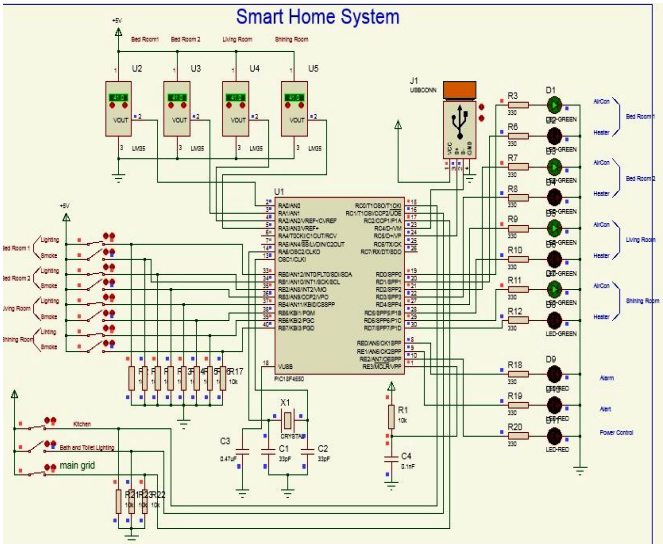

Fig.8. Screenshot of Simulated circuit for Smart home temperature control (Normal condition).

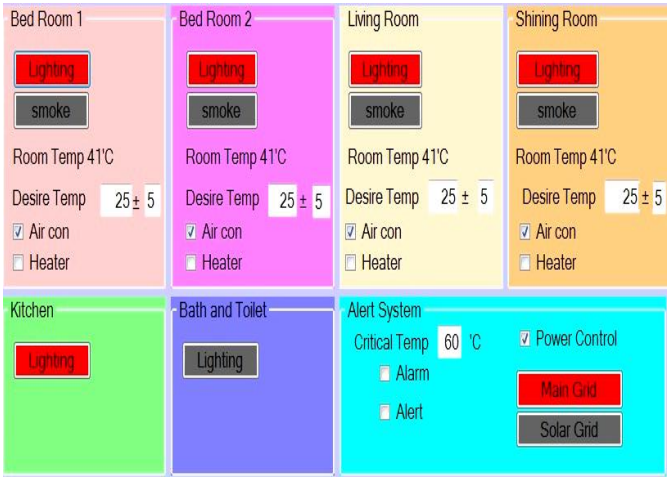

Fig.9 .Screenshot of Graphical interface of Smart home temperature control (Normal State).

Above figs. 8 and 9 states the implemented results of all four rooms which are at normal conditions. In this state sensors are regularly operated according the detected

information.

B. Operating Condition for the Abnormal Room Temperature (Over 60° C)

In some cases, such as extremely power usage (warming or smoking) conditions, both of humidity and smoke sensors will activate to turn ON alert, alarm system and turn OFF main power supply intelligently. So, it can reduce the dangerous and unsecure situations for consumers and also can manage energy efficiency of smart living home. In this process way, the system operates automatically with the help of microcontroller in designed smart home. Figs. 10 and 11 describes abnormal operating situation such as the room temperature of kitchen room is exceeded to the limited temperature. At this time, alert and alarm system activate and main power consumption is automatically turn OFF for safety .So, cooling and heating system from each room will stop their sensing functions respectively.

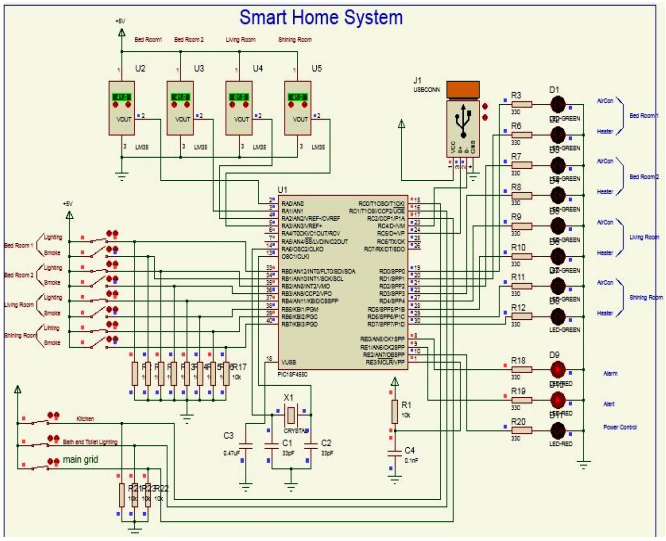

Fig.10. Screenshot of Simulated circuit for Smart home temperature control (Abnormal State).

Fig.11. Screenshot of Graphical interface of Smart home temperature control (Abnormal State).

Therefore, it can reduce hazard and save undesired power usage from every room in which consumers are in or out. And then, it can also less energy consumptions even though it is at peak-hours. The real time monitoring of power consumption is important for future intelligent home where intelligent home is dedicated to the seamless infusion of technology with day to day living to create a lifestyle unique for each individual.

VI. CONCLUSION

The main objective of this paper is to control the lighting system, temperature system and security system. Smart home provides fully automatic, secured and energy efficient system. The smart home technology provides totally different flexibility and functionality than the conventional installations and environmental control systems. Also, the smart house system can be supported by remote control system as a sub controlling system. The system can also be connected to the internet to monitor and control the house equipment's from anywhere in the world using Proteus software. The main purpose of this study is to develop the room temperature controller with PIC. This equipment uses four temperature sensors, drives external equipment, and keeps the temperature of the room at preset temperature. Electric cost will become high if an air-conditioner is always operated. Therefore, heating system is used to adjust the temperature of the room automatically. The result indicates this control development can provide energy saving for home appliances in the smart home environment. It works effectively in term of energy saving compared to the existing ordinary home system. Energy saving is an important issue nowadays. The microcontroller program determines the lights to switch on/off and the cooling/heating setting. The prototype with the simple automation can save the energy cost in all most cases.

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