

SMART HOME AUTOMATION SYSTEM USING AVR MICROCONTROLLER

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ABSTRACT

In this study, the design and prototype implementation of Smart Home Automation System is proposed. Home Automation is a budding technology. Modern homes are becoming Smart Homes. These homes are progressively shifting from conventional switches to a centralized control system. At present, conventional wall switches located in different parts of the house make it difficult for the user to go near them to operate. Furthermore, it becomes more difficult for the elderly or physically handicapped people to do so. The system incorporates sensors, microcontroller and Bluetooth module to provide automation capability to various household activities. A microcontroller offers high performance and flexibility. The author has adopted an AVR microcontroller for controlling various appliances. The main objectives of the Smart Home Automation System are to provide a low-cost solution to minimize the energy consumption, provide support and comfort, and make life easier. The system can monitor the changes in temperature, lighting, detect fire and keep a check on the safety of the house.

Keywords: AVR, Bluetooth, Centralization, Microcontroller, Smart Home Automation System

I. INTRODUCTION

Home automation refers to providing the capability to control as well as monitor various household activities. These may include lighting, heating and air conditioning, security locks on the doors, multimedia, and various appliances. A home automation system can have varying degrees of intelligence and complexity. Automation of homes is adopted not merely to provide ease, convenience, and comfort to the user but also to minimize the energy waste and ensure home security. An ideal home automation system has the capability to sense its environment, process and act with minimal supervision. It is reliable, secure, user-friendly and cost effective.

The home automation technology has witnessed remarkable growth and popularity over the past decade. In modern homes, various routine tasks have been automated for the benefit of the user. A simple example would be microwave ovens and automatic washing machines, which were introduced to reduce the manual labor. The home automation systems are not limited to lighting, HVAC and security systems, but have evolved into fire detection systems, entertainment systems and energy management systems as well.

Currently, there exist various home automation technologies [1]. The DTMF (Dual Tone Multiple Frequency) technology uses the DTMF tone generated by pressing a mobile phone keypad button to control devices. The main disadvantage of this approach is that the user will have to remember which key to press for each appliance he wants to control. In the free hand gesture control, a person should be present in front of the appliance he

wishes to control and must gesture to turn on and turn off a device. The disadvantage associated is that normal hand movements may be interpreted as a gesture to control the device.

Home Automation is gaining a lot of attention; however, due to the high cost, there are only a few houses that are smartly automated [2]. As the devices are getting smarter, mobile communication technologies are becoming a part of automation systems. Baraka [2] presented a system that used an Arduino and a hybrid system comprising both wireless Zigbee and wired X10 technologies.

Withanage et al. [3] presented a comparison of popular home automation technologies. The study identified performance and affordability factors of home automation systems. X10 is affordable, but not necessarily reliable. Z-Wave is expensive, but has high performance. Z-Wave is better compared to ZigBee based on price-performance and might be chosen over the latter.

Das et al. [4] developed a system for home appliance control using the SMS service provided by GSM network. The user could send an SMS to control and monitor the home appliances. The system implemented an ATmega8 microcontroller based control module. The drawback of the system can be the running cost; the user will have to incur SMS expenses.

A Home Automation model using X10 protocol was realized by Karatas and Aksoy [5]. The model implementation used a microcontroller for data processing and is easy to use, simple, compact and low cost.

Another Home Automation System using Wi-Fi technology was described by ElShafee and Hamed [6]. The system provided a user friendly control solution that was low-cost, covered a large area, and provided scalability.

A design of a low cost and wireless Home Automation System was presented by Ramlee et al. [7] to provide support to the disabled and the elderly. It incorporated the use of a PIC microcontroller and a Bluetooth module to control the target appliances in the home. The system used two GUIs (Window and Android application) to provide simple control.

Shah et al. [8] focused on the importance of power saving. A smart power saving system was suggested to minimise energy waste and provide comfort at the same time. They developed a system based on the use of a microcontroller and wireless communication.

A module for Home Automation application was developed by Wijetunge et al. [9]. The concept was of a system general purpose to the developer rather than the end user. A set of electrical appliances were controlled with the help of Bluetooth communication.

Bluetooth is the ideal way to use wireless communication between various devices in a home automation system. The Bluetooth technology operates over unlicensed and globally available frequency of 2.4GHz. The range of the Bluetooth technology is application specific and can vary from 10m to 100m, at a speed of up to 3Mbps, depending on class of radio used. This technology provides interoperability to the user. It enables the user to control various devices within the home with his smart devices using wireless communication giving the ability to monitor and control.

Bluetooth technology based wireless communication makes Home Automation System flexible since it can be accessed in any geographical location as long as there is a Bluetooth connection between the system and control device (like a mobile phone, a tablet, or a PC), and they are within the Bluetooth network range. Also, Bluetooth based Home Automation System is safe from an internet hack or power failure.

The objective of this study is to design and implement a Smart Home Automation System. The system incorporates the use of a microcontroller as a control module and uses Bluetooth technology for wireless communication between the smartphone and the control module.

II. MATERIALS AND METHOD

This study presents a low-cost, reliable and user friendly microcontroller based Smart Home Automation System. The system allows the user to monitor and control connected devices inside the home. The smart home automation system integrates different automation systems to provide a better standard of living. The Fig. 1 shows a block diagram representation of the proposed system.

This section of the study is divided into two sub-sections. The first sub-section describes in detail the hardware components used and the software to program the microcontroller. The second sub-section explains the methodology used. The smart home automation system automates the house in order to provide well-being, accessibility, energy efficiency, and security. The main hardware components of the smart home automation system are listed below along with detailed explanation.

2.1 Hardware Peripherals

The main hardware components of the smart home automation system are listed below along with detailed explanation.

2.1.1 Supply Unit

To build a power supply unit, a 9V battery and a voltage regulator IC (integrated circuit) L7805 is used. The IC L7805 belongs to the 78xx series of fixed linear voltage regulator ICs. The voltage regulator IC steps down the voltage from 9V to 5V for the MCU and provides a regulated output voltage of 5V to the microcontroller.

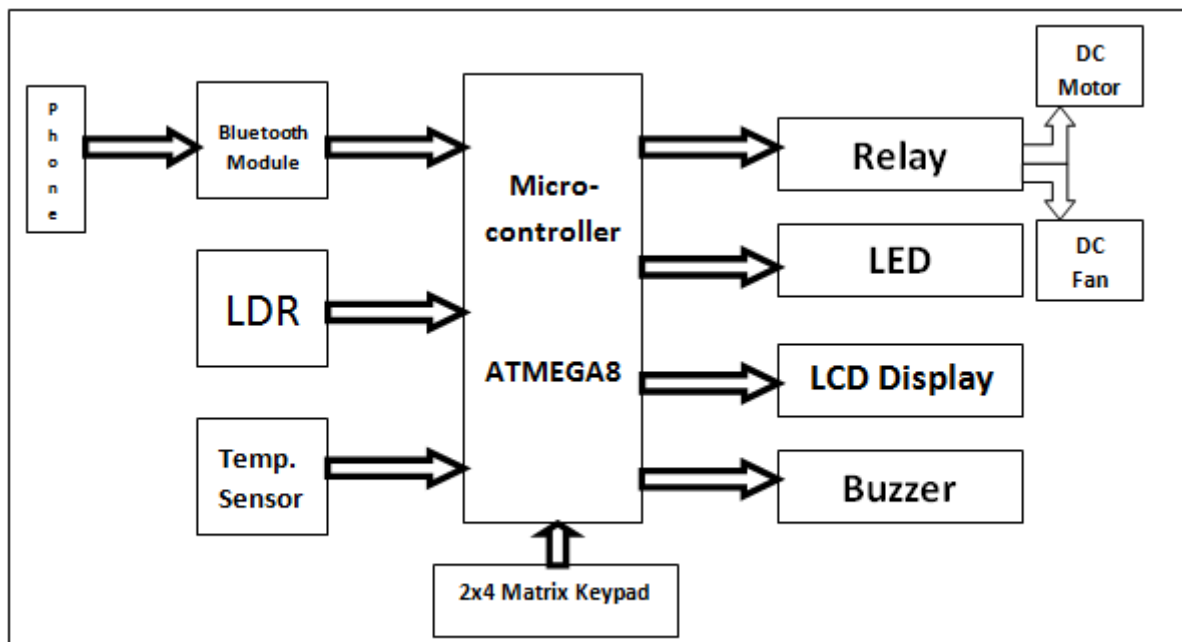


Fig.1 Block Diagram of the proposed Smart Home Automation System

2.1.2 Input Peripherals

2.1.2.1 Light Sensor

A LDR (light dependent resistor) is used as a light sensor to measure the ambient light levels and input them to the MCU. An LDR is a light-controlled variable resistor. It exhibits photoconductivity. The resistance value of

the LDR increases with decreasing incident light intensity levels and vice-versa. This photo-detector is ideal for lighting automation.

2.1.2.3 Temperature Sensor

The IC LM35 is used as a precision temperature sensor. It has an output voltage linearly proportional to the ambient temperature in Celsius and low output impedance. The LM35 is rated to operate over a -55°C to $+150^{\circ}\text{C}$ temperature range.

2.1.2.4 Matrix Keypad

A 2x4 matrix keypad is used to input the password. If the password is correct, the door opens and the user can enter the house. Thus, the home automation system ensures safety of the home.

2.1.2.5 Bluetooth Module

HC Bluetooth serial interface module HC-06 is used as to provide Bluetooth connectivity to provide wireless communication between a mobile phone device and home automation system. Default communication baud rate: 9600, and 1200-1.3M are settable.

2.1.3 Output Peripherals

2.1.3.1 LED

An LED is a p-n junction light emitting semiconductor diode. It emits light when current is passed through the two leads. It works on the principle of electro luminescence. An advantage of using an LED is high luminous efficacy.

2.1.3.2 DC Motor and DC Fan

A small DC motor is used for operating the opening of the door when the user enters the correct password. Since the current requirement for driving a DC motor is more than the current available at the I/O pins of the microcontroller, a motor driver IC L293D is used. A small DC fan is used for demonstration of the system's ability to provide air conditioning.

2.1.3.3 LCD Display

A 16x2 LCD (liquid crystal display) is used as a basic electronic display screen. A 16x2 LCD means simply means that it can display 16 characters per line and there exist 2 such lines.

2.1.3.4 Buzzer

A small buzzer is used to alert the user in case of a possible fire hazard.

2.1.4 Controller

A microcontroller is used to act as a brain to the home automation system. A microcontroller is a highly integrated chip where all the peripherals like CPU, timers, counters, RAM, ROM, registers, I/O pins, clock circuit, etc. are built in. Therefore, is a microcontroller is a combination of a microprocessor and peripherals. Microcontrollers are small, powerful and are used in embedded applications for specific tasks. In the smart home automation system, one ATmega8A microcontroller is used. It belongs to the Atmel's family of microcontrollers.

Atmel AVR microcontrollers provide flexibility in terms of design and no other microcontroller offers better power efficiency than the AVR family. The megaAVR device family offers a good amount of memory and inbuilt peripherals and is suitable for general purpose applications.

Some of the features of the 8-bit AVR microcontroller ATmega8A are listed below:

- 8K Bytes In-System Self-programmable Flash memory

- 512 Bytes EEPROM
- 1K Byte internal SRAM
- 23 programmable I/O lines
- Advanced RISC Architecture

2.2 Software Introduction

Code-Vision-AVR software has been used to program the AVR MCU. It is the ideal IDE (Integrated Development Environment) for the 8-bit Atmel AVR and XMEGA microcontrollers for the programming of Atmel AVR family of microcontrollers. It is a C cross-compiler and has an Automatic Program Generator. This software offers an editor with auto indentation, and syntax highlighting for both C and AVR assembler. It allows easy access to EEPROM and Flash memory without the need for special functions like in other compilers for AVR. It offers a very efficient use of RAM. The program is written in C language. It is then build and the .c file is converted into .hex file before transferring the program to microcontroller's Flash memory.

2.3 Methodology

In today's scenario, most homeowners already have at least one smartphone having Bluetooth compatibility (or even a tablet, or PC for that matter). This makes the incorporation of a Bluetooth based Smart Home Automation system highly convenient. The proposed Smart Home Automation System incorporates the use of Bluetooth technology for wireless communication. The user can monitor and control their lighting, fan, and door lock and security system with the help of a user-friendly application. The author has made use of Bluetooth terminal application available on Google Play Store. A connection is established between the mobile Bluetooth and Bluetooth module, using a 4 digit pass code. Next, the user inputs a character in the Bluetooth Terminal application. The character is then received by the Bluetooth Module in the HAS. The microcontroller reads the input character and performs the corresponding function. Fig. 2 gives a snapshot of the Bluetooth application.



Fig. 2 Snapshot of the Bluetooth application

The proposed smart home automation system is designed to increase user friendliness, flexibility, and security through a single embedded system. It consists of a standard Bluetooth module, temperature sensor, light sensor, matrix keypad, relay, DC motor, DC fan, LEDs, LCD display and a buzzer. The smart home automation integrates four modes of home automation: lighting, heating and air conditioning, security and fire detection.

2.3.1 Lighting System

The smart home automation system is an intelligent device that senses the amount of ambient light in a room and qualitatively alters the brightness of the LED. The system incorporates a light sensor, an LED, and the

microcontroller for this purpose. The light sensor is connected as an input to the ADC pin 24 of the microcontroller and, the LED is connected as an output on pin 17. The light sensor senses the light levels and inputs them to the microcontroller. The microcontroller, that is the brain of the system, reads the values and varies the output current values to the LED, altering the brightness levels and thereby providing lighting automation. Therefore, as a result, this mode of automation offers significant power savings.

The Smart Home Automation System also provides the feature of switching on and off the LED. The user friendly application installed in the user's smartphone enables the user to control the LED. The user turns on the Bluetooth in his smartphone, and sends a certain character to the Bluetooth module using the application. The character is then read by the microcontroller and it performs the corresponding action. The user must send the character 'a' if he wishes to turn on the LED and 'b' if he wishes to turn off the LED.

2.3.2 Heating and Air-conditioning System

The smart home automation system provides a temperature control solution that serves to provide the switching on/off of the fan in accordance to the room temperature. This system makes use of a temperature sensor. The sensor is connected as an input to the ADC pin 23 of the microcontroller. A DC fan is connected as an output to pin 6 of the microcontroller via a relay. This mode is similar to the lighting mode of automation. The sensor senses the value of the ambient room temperature and inputs the value to the microcontroller. The LCD screen displays the ambient room temperature in Celsius. The microcontroller switches on/off the DC fan in accordance to the temperature range set by the user at the programming stage. This mode of home automation is employed to minimize energy waste, and provide efficient energy consumption.

The Smart Home Automation System also gives the provision of switching on/off the fan using the smartphone. The user must input a character in his Bluetooth enabled smartphone. The user must input the character 'c' if he wishes to switch on the fan and character 'd' if he wishes to turn it off.

2.3.3 Security System

The smart home automation system employs home security system to restrict the entry of any intruder into the house. A flowchart for the security system is given in the Fig. 3. A 2x4 matrix keypad is connected to the microcontroller as an input to pins 9, 18 and 27 and a DC motor is connected as an output via a motor driver IC L293D. The user must enter a password into the matrix keypad to enter the house. If the password entered is correct, the DC motor rotates and the door opens. If the password entered is incorrect, the DC motor will not rotate and the door will not open. The password is set by the home owner during the programming stage. Therefore, any outsider cannot enter the house unless he knows the correct password. Thus, the security system ensures home security and prevents possible burglary and/or entrance of suspicious persons. Also since the Smart Home Automation System uses Bluetooth, the user can open the door with his smartphone. For the user to open or close the door, he must send the character 'e' and 'f', respectively, through his Bluetooth enabled smartphone using the Bluetooth terminal application.

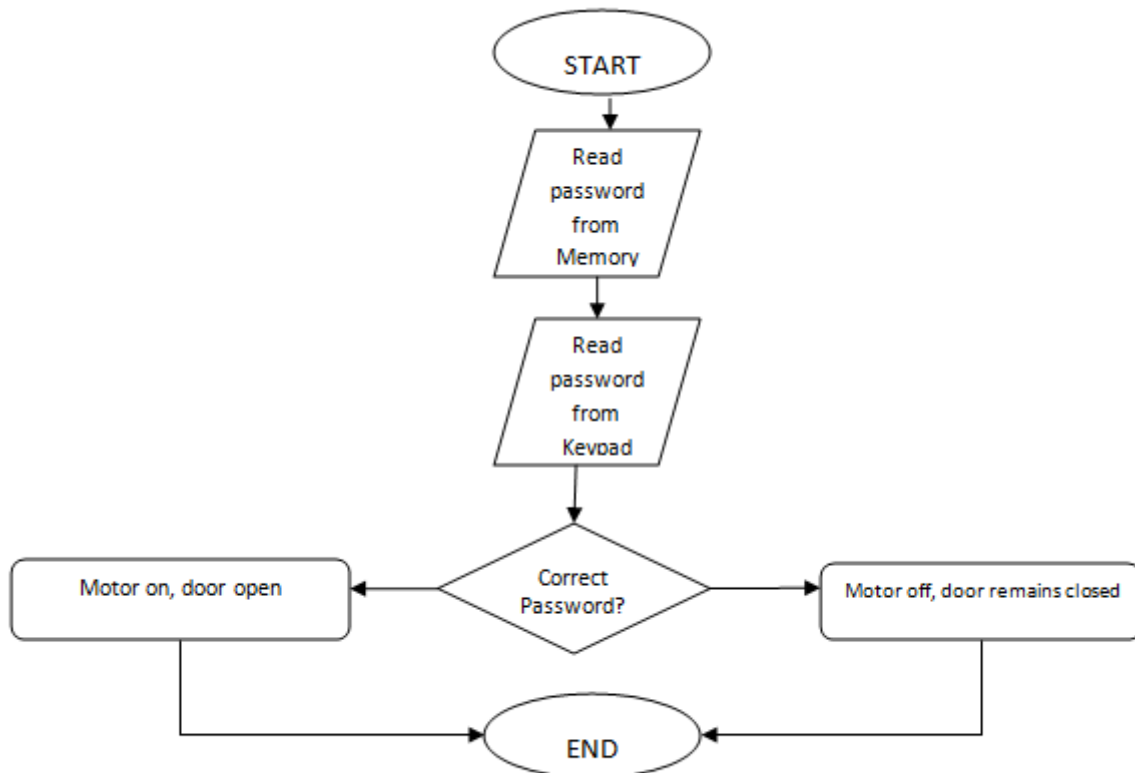


Fig. 3 Flowchart for the Security System

2.3.4 Fire Detection System

The smart home automation system also incorporates a fire detection system to alarm the user of a possible fire hazard. This mode uses the same temperature sensor from the heating and air-conditioning mode of automation. A buzzer is connected as an output to the microcontroller. The microcontroller will set the alarm (buzzer) as soon as the ambient temperature increases to dangerously high level. This mode of home automation ensures the safety of the occupants of the house.

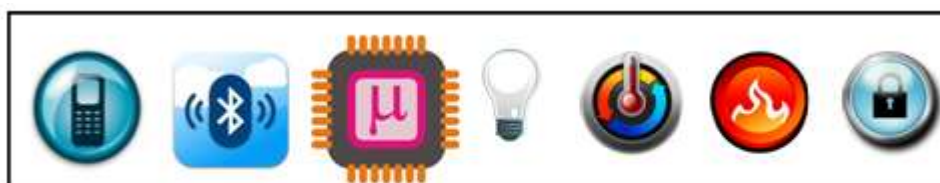


Fig. 4 Smart Home Automation System representation

III. RESULTS AND DISCUSSION

Home automation is a developing technology. Automation of homes makes life easier and also alleviates the problem of energy waste, thereby reducing expenses. There are various home automation technologies each with their own pros and cons. In today's world, there is a developing trend of incorporating smartphone and other such devices into Home Automation Systems. Since, most of these smart devices are Bluetooth compatible, it makes good sense to use Bluetooth technology for wireless communication. The proposed smart home automation system facilitates assistance services such as the monitoring of environmental parameters, and offers a manageable control of home automation devices. The proposed Smart Home Automation System is designed to provide lighting and temperature control, security and fire detection. The LDR senses the change in

the light intensity level with a tolerance of $\pm 5\%$ and the temperature sensor senses the change in temperature within a tolerance of about $\pm 3\%$ of the given threshold temperature [10]. The Bluetooth module range is limited to up to 30feet. Overall, the system provides the user with a centralized control through his mobile device via a Bluetooth connection.

Kaur [11] presented a Home Automation System that incorporated two control units, one for internal system and one for external system. The system offered password based locking system, light saving system and fire detection similar to the security system, lighting system and fire detection system presented in this study. The system also offered a counter dependent automatic switching system for lighting and temperature of the room and smoke detection not presented in this study.

Similar to the proposed Smart Home Automation System in this study, Panth and Jivani [12] designed a Home Automation System to control home appliances using Bluetooth technology. The system used an Android application to exchange ASCII data wirelessly with the control circuit through the Bluetooth facility of mobile phone. Unlike this study, Panth and Jivani [12] developed their own interactive Home Automation System application using Android platform.

Ramlee et al. [7] presented the design of a Home automation System that provides three types of physical control methods to the Main Control Board. Similar to this study, two of the control methods provided wireless remote control of appliances to the PC/laptop user and the smartphone user. Unlike this study, the third control method provided low voltage switches that exclude the electrical shock hazard by use of a wet hand.

Similar to this study, Narayan and Gayathri [13] introduced an intelligent home automation system based on wireless communication technology. However, unlike this study, which incorporates the use of Bluetooth technology for control of client units, the system made use of a voice recognition module along with ZigBee technology to control electrical appliances. Also, the system could alert the user through an SMS in case of a fire hazard with the use of a smoke detector.

IV. CONCLUSION

The proposed Smart Home automation System performs several tasks with minimal supervision. The system intelligently alters the brightness of the room in accordance with the outside daylight. The system offers temperature control with the help of the temperature sensor. Also, the system alerts the user as soon as the ambient temperature falls above the normal temperature range, suggesting the case of a possible fire hazard. The system ensures security of the home and prevents the entry of any intruders into the house. The system also provides control of devices via a smart device through the use of Bluetooth technology.

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