

Hardware Implementation of Smart Home Automation System Using Aurdino UNO



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Abstract Home automation system is one of the developing systems nowadays. This project is concentrating on automatically controlling the devices or appliances working at home based on the comfort of the person living there. Arduino technology is used as the control system. This system designed to enhances the comfort and safety of the user and to the effective usage of the power. Bluetooth peering between client and server act as a wireless communication system. In this work, mobile station is the client and HC6 Bluetooth module is the server that is connected directly with Arduino Uno. It is an automatic system that can work sensing the movement of the human in the confined space and Bluetooth is attached to observe the working devices.

Keywords Arduino UNO · Home automation · DHT11 humidity and temperature sensor · HC-SR501 PIR motion sensor · MG811 CO₂ sensor · ACS712 current sensor

1 Introduction

Home automation system can be developed using a single controller, which has the ability to observe and control different inter-connected appliances such as power plugs, lights, temperature sensors, motion sensors, humidity sensors, smoke detectors, gas detectors and fire detectors. It must have the ability to control emergency and security systems also. One of the advantage of home automation system is, it can be controlled and managed easily by an array of devices such as smart phone, tablet,

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desktop or laptop. It's because the system mainly focuses in digitalizing the distribution system. An automated device has the ability to work with adaptability, persistence, lowest error rate and high accuracy [1]. The automation system not only helps to reduce the human effort but also saves time and energy [2, 3]. Home appliances are interconnected and controlled by microcontroller. They communicate with each other, so that intelligent power management and safety could be obtained efficiently. Most of the current home automation systems are not available for general public due to their high initial cost and difficulty in maintenance. Some systems provide solutions that are not very useful for household applications. Sriskanthan et. al. suggested an automation system based on Bluetooth instead of internet [4]. Further, studies [5, 6] have some examples for web-built automation which are not possible to be executed at low-cost. The developed system not only controls the devices but also prevent the devices from the risk of short circuit. There are few comparable systems that have already been established and some are still in testing stage. A Voice Operated Home Automation System works based on the voice input of the user [7]. It can properly work in isolated areas but not suitable for poor acoustic areas such as living room, visitors' hall or kitchen. For example, when considering light control system in a living room, it works according to the input of the sensors and process with the preset default value without any user interference. In the research work done by Christian Reinisch et al. XBee based home automation system was presented. XBee transceivers module was used for wireless communication between the user control panel and the remote-controlled device. Home automation and monitoring system fully controlled by human is presented in research work [8]. It was implemented using Arduino Uno and XBee as the main components. Though it is mentioned that the system is of low cost, it is much expensive than Bluetooth based home automation system. Also, the frequency-based control system is not very secure because the frequency can be hacked by anyone. There are several researches conducted on IoT (Internet of Things) based smart security and home automation. According to this method, all components are controlled by smart devices through internet. The microcontroller used here is raspberry pi, because high functional microcontroller is needed to the data transmission [9]. But raspberry pi is expensive than Arduino. Integration of intrusion detection and web service alarm system will improve the home security [10]. But this research focuses only on the intrusion detection. Also the cameras used in this work are not suitable for dark conditions such as night time. Bluetooth based home automation systems is preferred in this research work for many reasons. Since it is very hard to hack the blue tooth based system, it is more secure than IoT based system [11]. Compared to other home automation system, the cost of this system is low. Resetting of desired range of temperature or humidity is another advantage of bluetooth based home automation system. At the same time, it is essential to mention the disadvantages of IOT-based home automation system. It has paved path for several security challenges. Cyber attacks targetted not only on someone's privacy but also on organized crime, mental suffering, and the probability of jeopardizing human lives [12]. Forgetting the passwords, using untrustworthy devices, using public wifi and later get in to troubles are few other problems [13].

People often forget their passwords or the places where they have saved the passwords due to their careless nature. Most of the times, they write complex passwords and save it in unusual places. People use same user names and passwords for many applications, accounts forums and websites. Sometimes if they reset the passwords again and again, these websites may ask for a new password which has never been used before. At that time, the user would be clueless and tend to set an immediate password which is appearing in his mind for no reason. After few days they forget it naturally. There are possibilities a home owner may log in to his home from different networks like from the office, from a friend's house or from public Wi-Fi networks. The network chosen by the user may be insecure. This could result in the user being exposed to variety of phishing attacks. Also, if the phone doesn't have enough charge or data, one can log in to his home from untrustworthy devices like a friend's phone or laptop or from an office laptop or from a net cafe. There are chances the user may forget to log out from these devices. So, when accessing the home from such devices, legitimate user credentials could be stolen by simple software tools like key logger.

The main drawbacks observed in the previous works are, insecurity of the home automation system, high cost of installation of the system and disturbing nature of sound and light in the operating environment. Adding night vision cameras and control the home by automation (not by voice command) can improve the efficiency and it is suggested in this research work. Development of the system with Arduino Uno, rather than XBee or raspberry pi reduce the cost of installation.

The organization of this paper is as follows: Sect. 1 depicts the introduction, and literature review, Sect. 2 depicts the individual systems namely light control, temperature control, current control, fire protection and ventilation (CO₂) control and their working principle. The results are presented and discussed in Sect. 3 followed by conclusion in Sect. 4 and future scopes in Sect. 5.

2 Architecture of Smart Home Automation System

The developed system consists of five sub-systems namely light control, temperature control, current control, fire protection and ventilation (CO₂) control. The system is powered by 12-V D/C from converted A/C source from national grid cum battery. The system consumes less power, but in case if there is power cut in national grid, none of the above-mentioned systems will work. Therefore, small solar.

panel is used here to recharge the battery and ensure those systems work continuously. The battery powers the circuit when A/C supply is not available. Figure 1 shows the overall structure of the design.

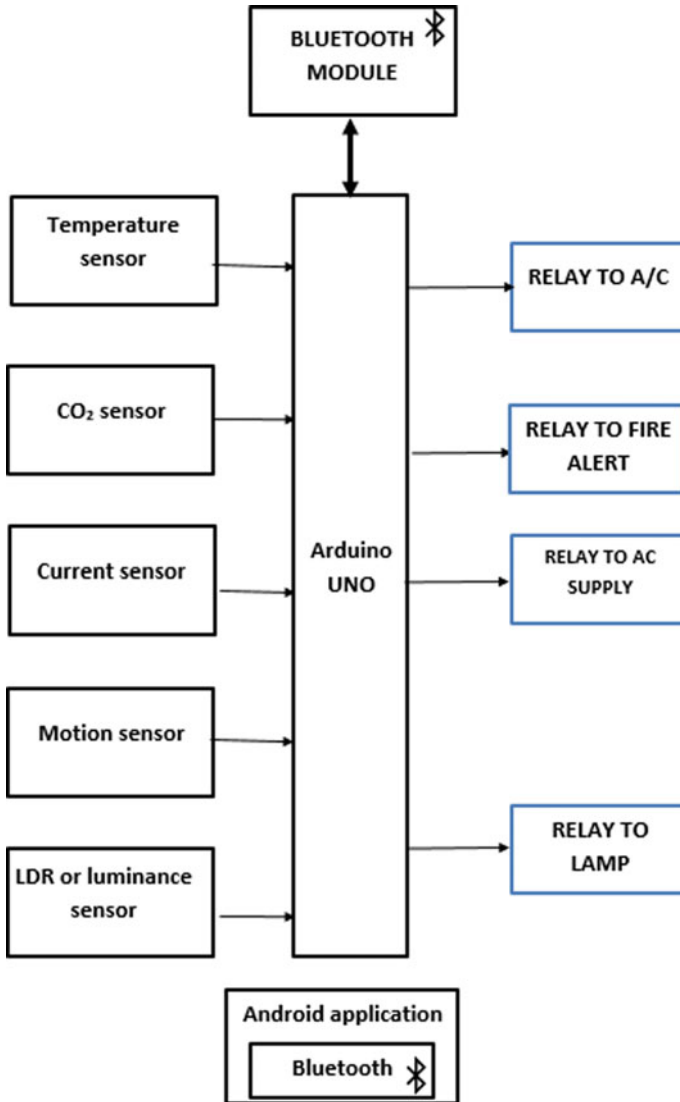


Fig. 1 Block diagram of basic structure

2.1 Use of Bluetooth Connection

Bluetooth module is connected with the mobile phone of each member of the family because the user needs to know whether the system is working properly and comfortable to the user. For this purpose, LCD display shield application is used to display the details of temperature, humidity, level of carbon dioxide, level of light and usage

of total power consumption in KWh. C language programming is used to make the system fully automated. When the system detects motion in the defined space, automatically all the other functions such as temperature, light, carbon dioxide, fire and current control start to occur. The application shown in Fig. 2 is available in Google play store. The commands connect, command string, and text-to-display are used to connect the designed device, to set the parameters base on the user's requirement and to view the fixed parameters, respectively. Arduino UNO based home automation system gives complete control over the domestic devices at home, and the user can observe it in his device as like observing a CCTV footage in the TV display. The Bluetooth system uses a computer or smart phone as receiver. It has high communication rate, high security and we can install it with low cost. It is a radio standard and communications protocol device designed for low power consumption and to a

Fig. 2 Application that use for monitor the system (Source–Google play store)

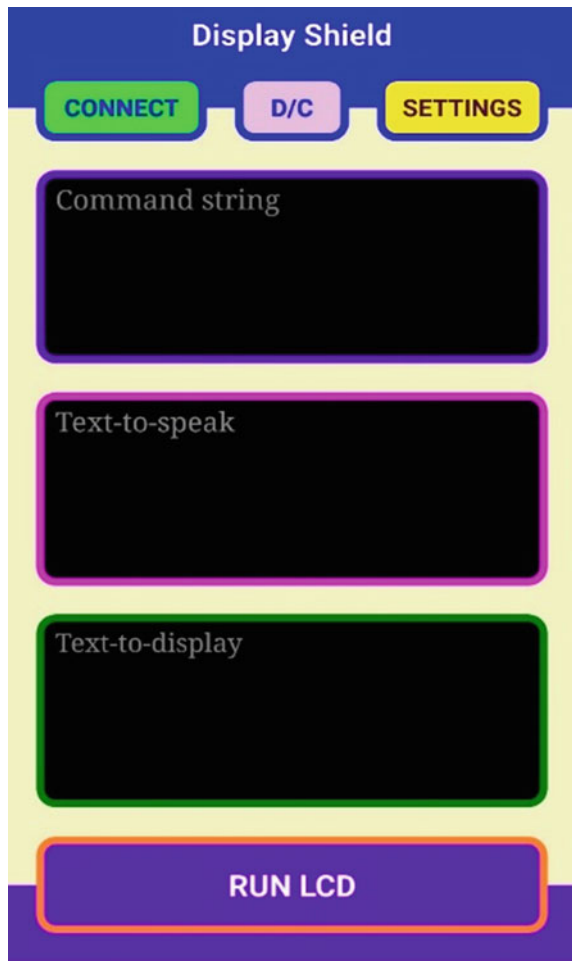
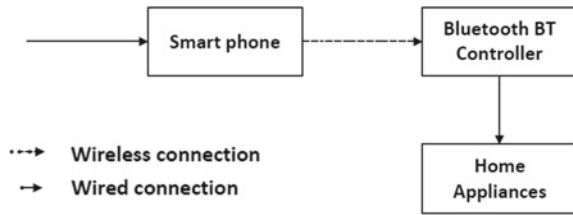


Fig. 3 Data flow diagram of bluetooth



short-range communication. In-built low-cost transceiver microchips is the salient feature here. It allows communicating with the system when the controller is in specified distance range. Bluetooth network has the range of 50 m. The data flow diagram of Bluetooth is shown in Fig. 3.

2.2 Light Control with PIR Motion Sensor

The automatic lighting system works using Arduino and Pyro-electric Infra-Red (PIR) motion sensor. It checks for the motion in the room. If the motion is detected, the microcontroller switches on the lights through relay circuit. But the light turns ON during day time is not necessary at all incidents. The Light-Dependent Resister (LDR) is installed in order to identify light and darkness and solve this issue. In case if the user needs light during day time, he can control the lights by Bluetooth mobile device. It means he can ON and OFF the lights according to his necessity by Bluetooth control mobile phone. The main purpose of this set up is to prevent the loss of electric energy unnecessarily during the day time and make the system more efficient. HC-SR501 type pyroelectric infra red motion sensor is used here and the specifications of it are shown in Table 1. The Data flow diagram of light control system is shown in Fig. 4.

Table 1 Specifications of HC-SR501 PIR motion sensor

Parameters	Range
Angle sensor	< 110 degree cone angle
Operation temperature	-15- + 70 degrees
Operating voltage range	5-20 VDC
Power consumption	65 mA
Delay time	5-300S (adjustable) Range (approximately 0.3 Sec-5Min)

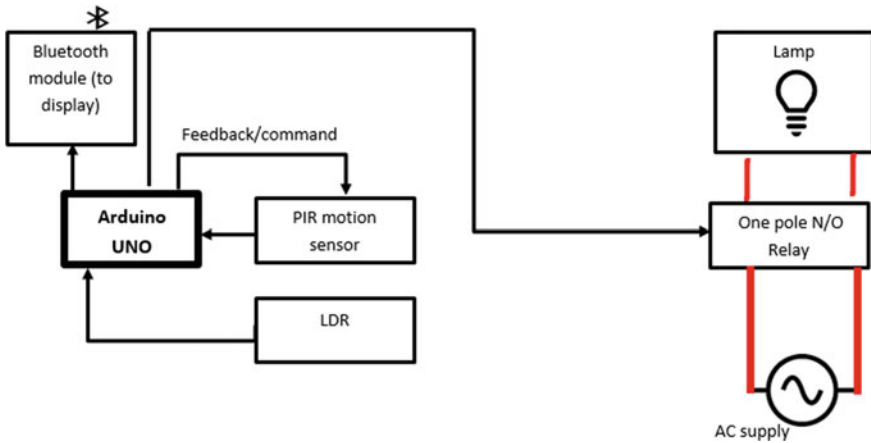


Fig. 4 Data flow diagram of light control system

2.3 Combined Temperature Control, CO₂ Control and Fire Safety Subsystems

2.3.1 Temperature Control

At present, large amount of electrical energy is spent on maintaining the temperature of the living space. It can either be an air conditioner or a thermostat. Also it is true that most of this energy is wasted due to poor management of the devices which control the temperature. The developed system senses the room temperature and controls it automatically. If the temperature reaches 30 °C, the relay is activated and the room starts to cool until the temperature drops to 25 °C. Once the temperature dropped to 25 °C, the air conditioner turns off until the temperature rises again up to 30 °C. These temperature values can be pre-set according to the comfort of the user. Further, if there is no motion detected for 15 min, the air conditioner or thermostat turns off automatically. The default time set as 15 min may be modified by the user according to his need. DHT11 Humidity and temperature sensor is used in this set up and the specifications of it is shown in Table 2. The data flow diagram of the combined control system is shown in Fig. 5.

Table 2 Specifications of DHT11 humidity and temperature sensor

Parameters	Range
Measurement range	20–90% RH 0–50 °C
Humidity accuracy	± 5%RH
Temperature accuracy	± 2 °C
Response time (Seconds)	1/e (63%)25 °C, 1 m/s Air

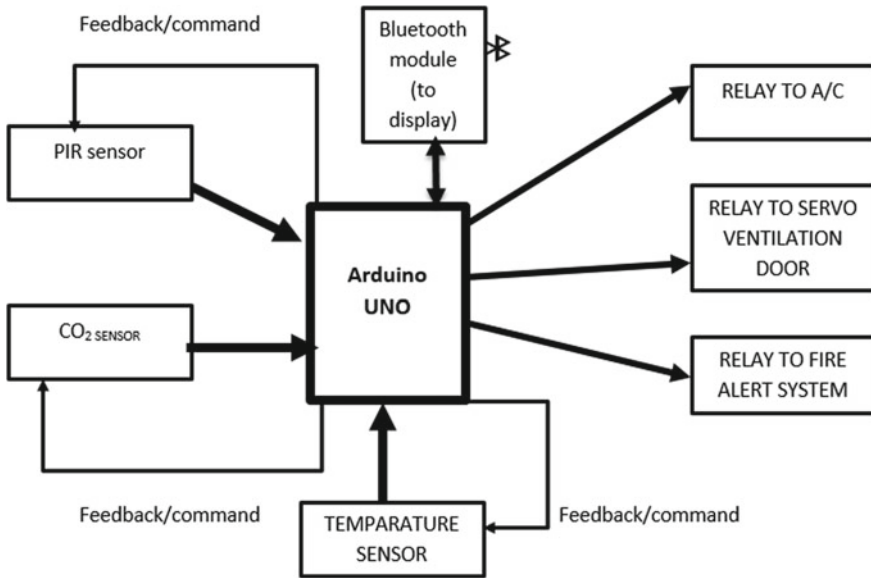


Fig. 5 Data flow diagram of combined control systems

2.3.2 Carbon Dioxide Control

The carbon dioxide monitoring system monitors the amount of CO₂ within the house. MG 811 carbon dioxide monitoring sensor is used here and the specifications of it is shown in Table 3. The increase in the level of CO₂ than the prescribed limit, is harmful for the human life. The CO₂ control unit directs the ventilation system to open until the CO₂ level decreases back to normal. But this system functions only under normal room temperature. If there is any fire situation, the CO₂ level increase drastically and at that time the ventilation door will not open. The reason is to prevent the air flow into the house since it will increase the fire damage. Under such circumstances, fire safety system will take charge of the safety of the house.

Table 3 Specifications of MG811 CO₂ sensor

Parameter	Range	Measuring condition
Inductance	2.39 mH ± 6% Variable	10 kHz
Unloaded Qu Operating frequency:	60 min 500 kHz Max	70 kHz

Table 4 Specifications of ACS712 current sensor

Parameter	Range
Bandwith	50 kHz
Total output error	1.5% at TA = 25 °C, and 4% at
internal conductor resistance	-40 °C to 85 °C
minimum isolation voltage	1.2 mΩ
magnetic hysteresis	2.1 kVRMS
output sensitivity	Nearly zero
	66 to 185 mV/A

2.3.3 Fire Safety

The temperature control system works as fire protection system also. If the temperature rises above 45 °C, the microcontroller detects the situation as fire hazard and the system alerts the surrounding through the fire alarm, and the microcontroller cuts down the power supply to that particular area to protect the house from any electrical leakage and extra risk. At this time, CO₂ cylinders can be used to stop the fire. In this situation CO₂ level will automatically increase. This is the reason why the CO₂ control system is designed to work only under room temperature.

2.4 Current Control System

The Digital auto distribution system is also introduced in our system. This system works with very less, or sometimes with no human effort at all. Usually the distribution system trips off the circuit breaker when high current passes through it, and the circuit breaker needs to be turned on manually once the error is fixed.

But in this system, the circuit breaker turns on automatically. The current sensor measures the current flow through main circuit and sends it to Aurdino. If the current is higher than the rated value, the micro controller cut off the circuit for couple of seconds, and then it switches on and provides the supply current again. If the amount of current is lower than the rated value; the system remains stable and supplies the power continuously. If increased current is detected again, the power supply will turn off. When the error is fixed, the system must be turned on manually. ACS712 Current Sensor is used here and the specifications of it is shown in Table 4. Data flow diagram of current control system is shown in Fig. 6.

3 Results and Discussion

There are many projects available in the market which are operated by Bluetooth control; but in this research work, Bluetooth connectivity is used for monitoring purpose and not for control purpose. Because this system is fully automated and

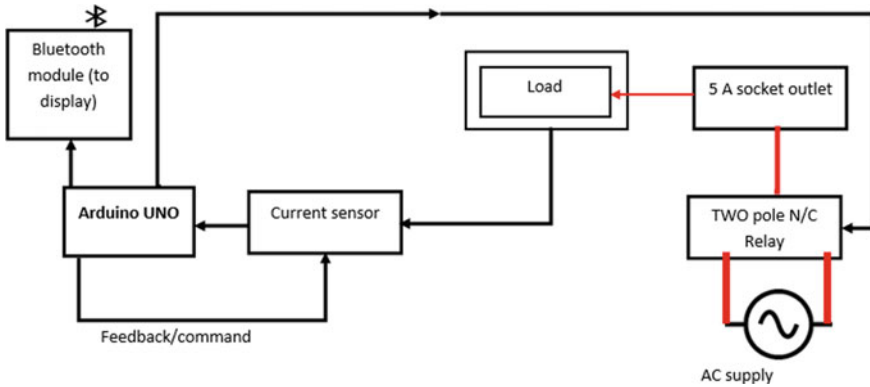


Fig. 6 Data flow diagram of current control system

operated based on Artificial Intelligent. The developed system senses the home environment and make it comfortable to the user based on pre-stated commands. User need not to touch any switches in this system; but if the user feels discomfort he can change the default values according to his desire. The Bluetooth use radio communication method. So the receiver and sender need not to be in line of sight of each other; they can even be in different rooms, as long as the received transmission is in the range. Bluetooth is implemented in variety of smart devices such as phones, TV’s, iPod, and tablets. It is advisable for situations where two or more devices are in proximity to each other and doesn’t require high bandwidth. Comparatively, it is safer than RF control since the Bluetooth device has the in-built password. This method prevents it from the entry of unknown people. The main purpose of Bluetooth in this system is to monitor and display the whole system. Default values of different systems can also be changed by it. Various functions of different systems are shown in Table 5.

4 Conclusion

Different home automation systems are surveyed in this paper. Their pros and cons are discussed and compared with this newly designed system. Arduino UNO is used to make the system fully automated. When the system detects motion in the defined space, all the functions such as temperature, light, carbon dioxide, fire and current control start to occur automatically and LCD display shield application display these details. Usage of total power consumption will also be displayed in it. The main focuses of this new design are minimizing the level of power consumption, reduce human effort, and maintain the maximum safety level. Two new platforms are introduced as the output of this research work. The temperature control system and fire safety system combined together, which reduces the complexity of the system. Digital

Table. 5 The results of the smart home automation system

System	Results
Light control	Works on night time. Based on requirement, it can work on day time also
Temperature control	If the temperature reaches 30 °C, the air conditioner works until the temperature drops to 25 °C and once the temperature dropped to 25 °C, the air conditioner turns off until the temperature rises again
Current control	If the current is higher than the rated value, the power supply will be cut off and after few seconds supply current will be provided again. If the amount of current is lower than the rated value, the system remains stable. If increased current is detected again, the power supply will turn off. When the error is fixed, the system must be turned on manually
Fire protection	If the temperature rises above 45 °C, the fire alarm sounds, and the electric power supply to that particular line will be disconnected
Ventilation control	If the CO ₂ content is higher than the prescribed limit, the ventilation system will be open until the CO ₂ level decreases back to normal

distribution system is another improvement. It helps the people to prevent their home form electrical hazard and make their home a safer place.

5 Future Scope

This system can be made as voice recognition based home automation system, for it will be useful for handicapped and elderly people, who want to control home appliances by voice commands. Voice of every human is unique; so this system may be assumed to have high security. An application in Android smart phone has built-in voice recognition feature, which can be used as voice recognition tool for home automation system. The main drawback of this system is the interruption of other noises. If the voice signal is interrupted with such noise, the communication will be affected and the system will fail in accuracy. Proper attention should be paid in this regards to make it more efficient.

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