

# Design and Development of Control and Management Systems for Smart Homes

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## Abstract

The smart home and management system in this study are powered by D.C. batteries. Before running out of power, a fully charged battery can last for two to three days. When you turn on the system, the maximum temperature and the name of the study are shown on the LCD. Additionally, it will demonstrate that no one is in the house. As more individuals enter the house after you click the push button to enter, it will show on the Liquid Crystal Display (LCD) that you are welcome and that there are now more people inside. You get to decide how many people you let inside the residence. If you set the limit to 12, the door won't open again until someone quits the building by pressing the exit button before another person is allowed to enter. You can pick when you want the fan to turn on automatically by setting the maximum temperature. The fan in the house is used to lower the temperature if the weather is hot. The fan won't turn on until the maximum temperature of 30 °C has been reached, for example. Additionally, if everyone leaves the house, the fan and light will turn off automatically because nobody is inside. For safety purposes, there is a light in front of the house. It will automatically turn on if it becomes dark outside at night. The second LDR outside the home is in charge of controlling this light. The exterior light will turn off during the day if the LDR detects light, and it will turn on automatically at night if it detects dark. This is done for security reasons. Within the residence is the first LDR. It will switch on the lights when someone enters the house. No one will be able to exit the house before the light is turned off.

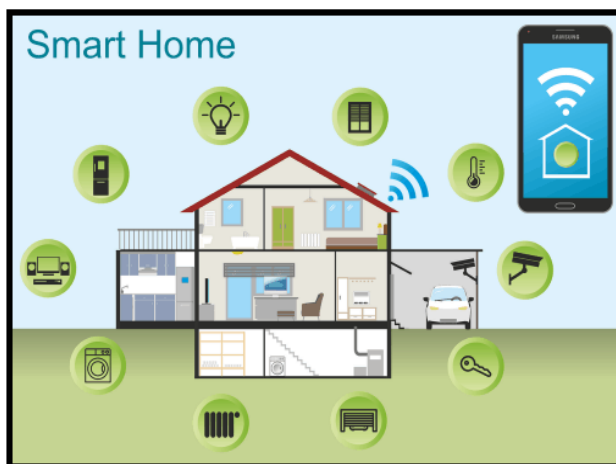
**Keywords**—LDRs, LCD, Smart House, Infrared sensor, Microcontroller, Motor, Lights.

## I. INTRODUCTION

With the development of technology over the past century, the terms "smart house" and "intelligent security system" have come to the attention of researchers. A smart home is one that has the ability to remotely or automatically control its appliances and devices. A range of sensors, modules, shields, and microcontroller boards can be utilized to build smart home systems [1]–[8]. As a result, as depicted in Fig. 1, this technology also has a wide range of additional functions, including smart security, home facility protection,



temperature management, intelligent lighting configurations, and many more. The subsystems for wireless communication, entertainment, security, convenience, and information management are also included in a smart home [9]–[13]. A system of interconnected sensors, actuators, interaction tools, and modules is referred to as a "smart home" and is used to provide homeowners with support and applications such as safety and security, automation, entertainment media, and energy control with little to no human participation. But smart home safety and security systems are highly necessary and constantly needed for a variety of reasons, including people's propensity to feel protected in their own houses and to lower a high rate of criminality [14]–[16]. Numerous sensor types can be used in the construction of smart homes to safeguard them against combustion, as gas infiltration is another unwanted situation. Liquefied petroleum gas (LPG) is a popular cooking fuel in contrast. Since LPG is sold in cylinders, a leak might cause an explosion. A gas infiltration case is usually unknown to the occupants of the residences and other institutions. They might consequently ignite a conflagration that bursts. To avoid this dangerous situation, the gas leakage detection strategy must be installed and used [51–53]. There has been a significant rise in crime recently [54]. As a result, installing protection systems in homes is crucial [17,18]. The use of different types of sensors, such as PIR sensors, water level sensors, soil moisture sensors, light intensity sensors, current sensors, voltage sensors, DC motors, and ultrasonic sensors, has been discussed extensively by many other researchers [55]. To build a complete smart home system, all of the sensors stated above can be incorporated with modules and microcontrollers [10]–[22]. The research's contribution might be summed up as the introduction of a low-cost system for managing applications for smart home gadgets. The suggested system has a few crucial functional components. The first is used for security, and the second is used for the occupants' safety in the residence. The IR sensor, laser beam directed at a Light Dependent Resistance (LDR) sensor, Bluetooth module with programmed smart phone App, and servo motor make up the first component. The gas sensor, flame sensor, temperature and humidity sensors, liquid crystal display, and alarm make up the second component. The Arduino served as the processing engine for the sensor data in both components [56].



**Fig. 1.** A simple smart home

## II. SMART HOME

From fire vaults to warm cells to torches and candles, and finally to the arrival of the most contemporary invention, namely electricity, homes have been created throughout antiquity, which has offered convenience for the home's occupants. After that, it was explored how to use embedded systems and electronic parts in machinery and other appliances. While programming instructions for the CPU of embedded systems can be used to complete a number of functions, such automatic hot and cold washing, turning on/off lights [57], and security employment. Since the 1970s, embedded and integrated systems have gained popularity and started to appear in urban households' domestic operations. In order to find necessary smart home systems, home automation is able to link between electrical and electronic features [23], [24]. Here are a few examples of smart home automation and control applications [25-32].

1. Keeping an eye on the weather and controlling the heating or cooling system.
2. Identifying a leak in the cooking gas and advising the residents of the house via an alarm and an SMS.
3. Keeping an eye on the weather and, in case of rain, closing the windows of the house.



4. The clever control that determines whether to switch on or off the exterior lighting for the house depending on the time of day or night.
5. The intelligent control of turning ON/OFF various home appliances via a mobile phone using Wi-Fi, Bluetooth, or an SMS service.
6. Utilizing RFID [58, 59] technology to unlock and close the front door of the house rather than traditional locks.
7. Utilizing movement detection sensors to protect a house against burglary [60].
8. When the fire first appears, turn on the firefighting pumps.
9. Using intelligent irrigation to water the garden based on the amount of humidity in the soil.
10. Electricity for the home is produced using solar cells [61, 62].

The items previously mentioned all offer residents of homes security and safety. The aforementioned applications can also be used by businesses and other entities. While each of these applications makes use of a variety of electronic sensors, their data may be managed and processed by using a variety of microcontroller boards, including Arduino, Raspberry Pi, PIC microcontroller, and others. Due to its simplicity of use, low cost, and open-source nature for both software and hardware, the Arduino is therefore more frequently used than other varieties. The "Internet of Things" (IoT) [63] concept has been rapidly developing in recent years, and more amateurs and researchers are using this technology to develop smart home applications. The user handles these appliances remotely and sends or receives all necessary data through the system's mainboard through the internet by combining all of the home programmable equipment into a Local Area Network (LAN). Smart home sensors and modules can be wirelessly connected via a number of other technologies, including wireless LAN, ZigBee, Bluetooth, etc. Figure 2 shows an illustration of wireless communication between modules, sensors, and the internet in a home [33, 34].

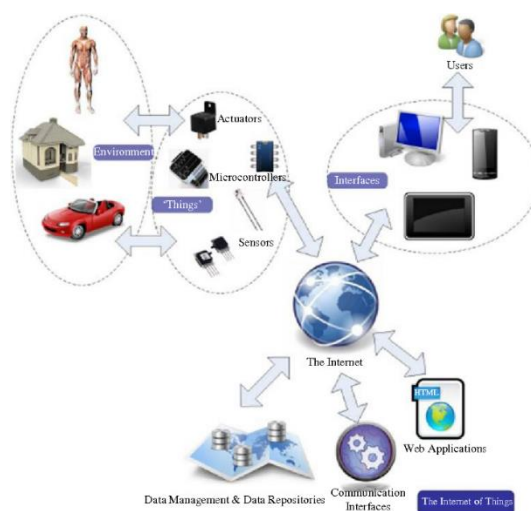


Fig. 2. Wireless communication between the modules and internet

A. Benefit from smart homes.

Smart home adoption has a number of noteworthy benefits that can be realized. Some of these benefits can be combined with the ensuing arguments [35–42].

1. From one location, manage and control all of your home appliances.
2. It gives users the option to add or remove new appliances from the system as needed.
3. Improve the security of the house's defense [64–67].
4. Through the use of a remote control, it offers the homeowners comfort for their house operations.
5. Savings on energy because only real consumption is used.



- 6. Increasing the equipment's usefulness, but smart homes might enable even more effective appliance operation.

B. System for securing a home

Home security is not a recent development; it has been acknowledged since the Stone Age. People then used a variety of rocks, trees, and weapons to ward off predators [68]. The methods for safeguarding one's royalty have been progressively improved in recent years. Nowadays, people utilize considerably more sophisticated, safe, and affordable security measures to guarantee the ideal property's security. To ensure effective protection for homes against burglary, the automatic home security system is built on various electrical components or makes use of microcontroller boards[43, 44].

III. SYSTEM DESIGN AND CONSTRUCTION

The newly launched system typically consists of two major components. The first section relates to the safety of the house, while the second is reserved for automatic control (i.e., automation). The Arduino IDE is used to program both components, which are based on Arduino microcontrollers [45]. The infrared (IR) sensor and the laser beam that is pointed directly at the LDR serve as the foundation for the home's security system. The IR sensor immediately sends logic "1" to the Arduino Nano kit to turn ON the warning siren the instant the thief walks in front of it. Additionally, the thief will be facing the laser beam if it tries to avoid the IR sensor. When the ray is broken, the LDR resistance value increases, and the Arduino Nano then follows the previously described procedure. The ATmega328P of the Arduino Nano and Arduino Leonardo microcontrollers with multiple sensors, such as the MQ-02 gas sensor, KY-026 fire detection sensor, as well as soil wetness sensor, are the foundation for the automation and controlling process for the introduced configuration. Table I describes the functions of the aforementioned sensors that are used in this work.

Sensor	Task
Flame sensor	It serves as a tool for configuration detection. Arduino will activate the buzzer, the sprinkler represented by LED 1, and print a warning message on the LCD in the event of a fire.
Gas sensor	It is used in the home kitchen for LPG detection purposes. The Arduino will activate the buzzer and print warning messages on the LCD in the event of a gas leak.
DHT-11 sensor	Used to measure weather conditions such as temperature and moisture. The LCD will display the temperature and humidity values, and the LED-2-designated air conditioner will be turned on by the Arduino.
Soil moisture sensor	Used to measure the moisture content of soil. The Arduino will turn on the water pump, which is symbolized by LED-3, and print a message on the LCD if the soil is dry.



The system is also developed using the Arduino Leonardo, 2x16 LCD, and DHT-11 sensors; the LCD's purpose is to display the weather's temperature and humidity. Additionally, the LCD will display warning messages for the LPG leak and fire detection situations. Finally, the HC-05 module, which enables Bluetooth-based wireless communication with a unique Android app and a small servo motor, is also used to remotely control the garage door [69]. The employed Android application was created in the "MIT App Inventor" online environment, which was established by Google and is run by the Massachusetts Institute of Technology. This platform relies on the development of a graphical user interface based on a visual programming language (i.e., block arrangement), which enables users to drag and drop visual blocks to create the necessary software [46–50].

#### **IV. MATERIAL AND METHODS**

##### 4.1. Materials

Table II: Below are the materials used in this research

S/N	Names of components	Number used
1	LDRs	2
2	Lights	2
3	Liquid crystal display	1
4	Microcontroller	1
5	Buzzer	1
6	IR Sensor	1
7	Switch Button	1
8	Light Emitting Diode	1
9	Battery	3
10	Connections	29
11	Fan	1

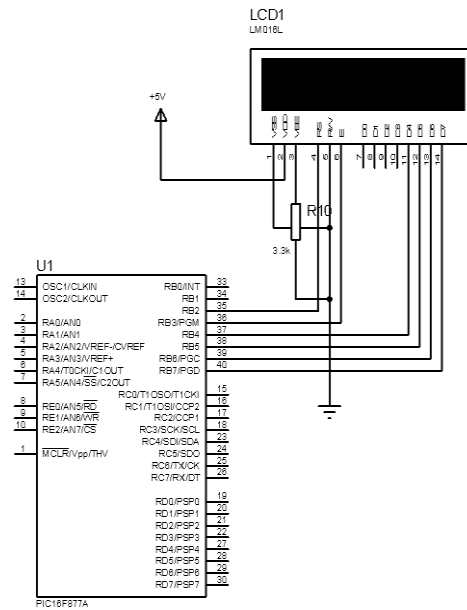
##### 4.2. Methods

The microcontroller PIC16F8877A serves as the brain of the research, which offers relay with necessary information when the temperature is very high above the setting point to activate the DC fan in order to prevent the battery from unnecessary discharge. In cooperation with the DHT11 temperature/humidity sensor, it is used to monitor the temperature level in the premises while the LCD is used to display the corresponding temperature inside the room and also the number of people inside the house. Also, DC 12v bulbs are controlled by an LDR sensor during the day and night periods in order to control the waste of power consumption. The outside light is used at night for security reasons. However, the major components mentioned work in cooperation to form the system with the microcontroller. The automatic door, which is controlled or operated by the push buttons, is used to control the number of people who will enter and exit the house with the help of an IR sensor, which is used in the system.

##### 4.2.1. Connection of the Microcontroller to LCD

The liquid crystal display pins are connected to the microcontroller, which is the brain of the whole research.

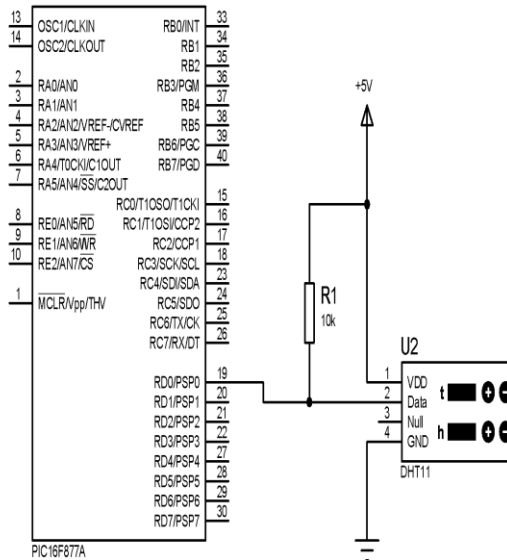




**Fig. 3.** LCD interfaced to PIC16F877A

#### 4.2.2. DHT11 temperature/humidity sensor unit

The DHT11 acts as a temperature and humidity sensor. It gives an output of 10mV/C and is capable of producing a voltage from 10mV to 1.5V that corresponds to temperatures from 0 C to 50 C and 0-80%.



**Fig. 4.** Connection of DHT11 to microcontroller

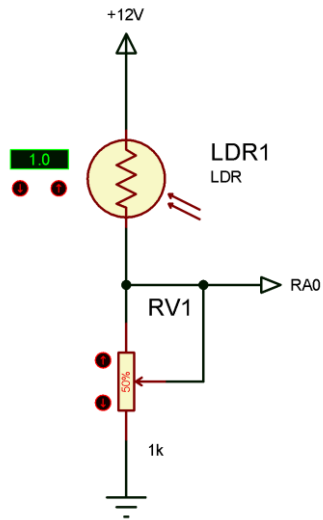


Fig. 5. Infrared Sensing Unit

#### 4.2.3. DC FAN/LIGHT Control Unit

The unit serves to control the DC fan and light system using a BD139 transistor. The circuit of this unit is shown in the figure below.

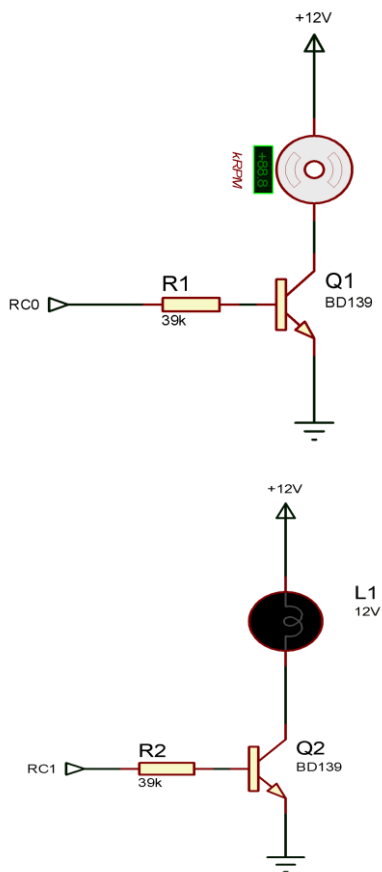


Fig. 6. DC fan/light transistor



4.2.4. Door control unit

The arrangement of the circuit as below is the actuator part, which uses the BC547 transistors to enable the actual door control to open and close due to movement of the motor clockwise and anticlockwise when a visitor arrives.

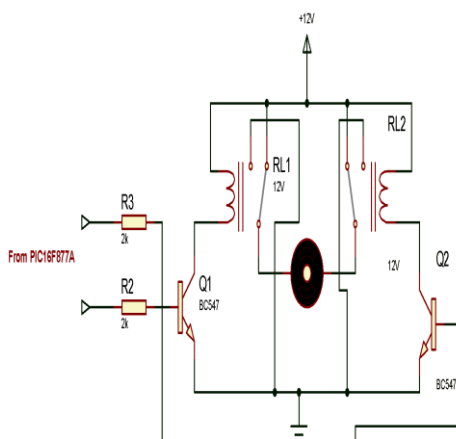


Fig. 7. Door control circuit

4.4.5. Alarming unit

This unit is used for alarming. When the limit is exceeded, it will sound an alarm showing that the number of people that are required to enter the house has reached its limit.

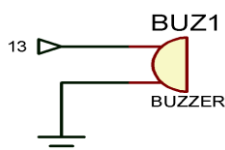


Fig. 8. Alarming unit

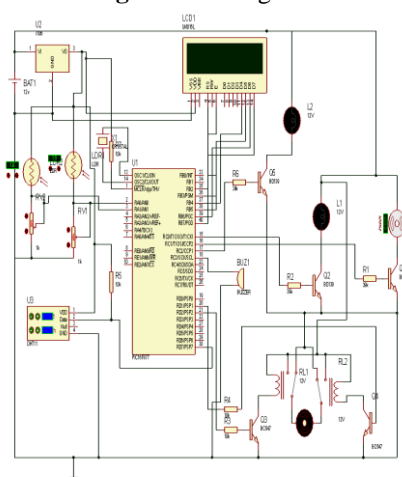


Fig. 9(a). Complete circuit diagram







**Fig. 9(b):** Implementation of the System

## V. RESULTS

The images below are the pictures of the results obtained from the implemented system.



**Fig. 10.** Implementation of the Circuit Display the Title of the research

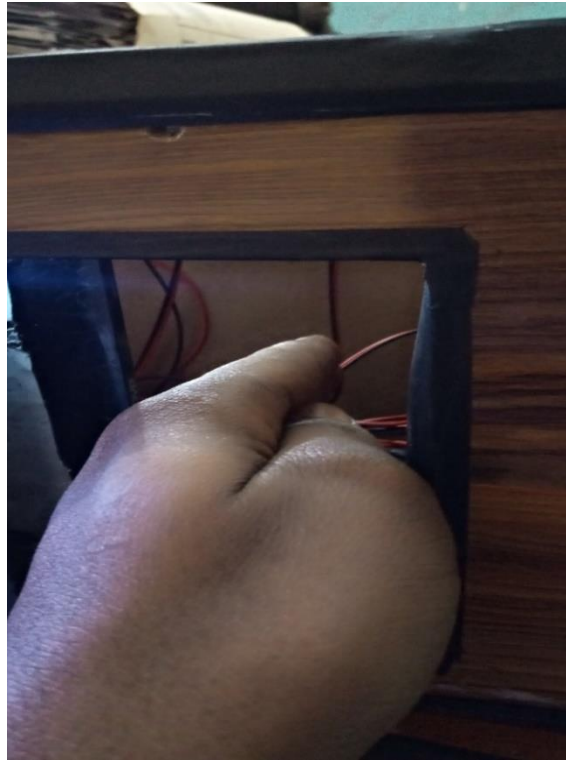


**Fig. 11.** The whole system implementation



**Fig. 12.** Implemented Circuit Displaying the Process of Pressing the Entrance Door





**Fig. 13.** The Process of entering the door



**Fig. 14.** System displaying one person is inside the house



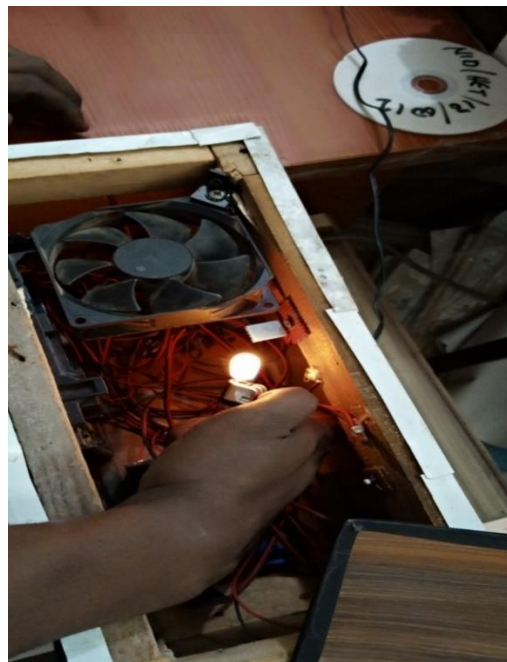
**Fig. 15.** The process of pressing exit button from the house



**Fig. 16.** The process of leaving the house through the door



**Fig. 17.** The outside LDR that is used to control the front light of the house will go off during day light. That is, if the research is exposed to light, the front light will not come on until it sees dark the LDR



**Fig. 18.** The DHT-11 sensor is used to monitor the temperature and humidity of the house. If the temperature exceeds the maximum temperature set, the fan will turn on by itself with the help of the DHT-11 sensor.

## VI. CONCLUSION

The underlying premise behind the smart house is that it improves comfort, security, and energy efficiency for residents. This study looked at the planning and building of a low-cost smart home automation framework. The Arduino Nano and Arduino Leonardo

microcontroller boards are used in the low-cost smart house concepts that have been the subject of our analysis in this study. A smart gate door controller is intended to keep an eye on the home's appliances in order to cut down on energy waste [70], offer security, and manage who has entrance to the home.

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