



## HOMES APPLIANCES CONTROL USING BLUETOOTH

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### ABSTRACT

New technology applications in managing human living styles, workplaces including residences have led to the discovery of different methods of interacting and controlling both users and the buildings. This piece of research work proposed a simpler system for users' interaction with home appliances, using Bluetooth technology for operation support. As a study for this article, a combination of the Bluetooth and Arduino modules with smartphones is introduced to provide building users with easier access and control through a simple user interface. This designing way showed also great management flexibility compared to using switches. Controlling remotely home users and appliances is more convenient to its residents. Home appliances can be easily monitored using smartphones via Bluetooth connectivity because each one can communicate over nearer cellular networks using some built-in communication capabilities. This paper discussed about a combination of Android software and hardware, with Bluetooth module and smartphones. Then, it explained how these technologies set together have created a system that enables accessing a control unit to turn "ON/OFF" status of the home devices. The concluding sections are about the design and implementation of the proposed model applying these technologies.

**Keywords:** smart home, home control, new technology applications, smartphone, Arduino, Bluetooth, Internet of things, remote-control, home appliance.

### INTRODUCTION

This section is much more about home automation presentation as in related articles and research papers.

The progress made in technology knowledge has enabled new technology applications to come up with some products and problems solution to many of former tasks and responsibilities formerly performed only by human intervention [1]. Smart technology and thus smart devices or machines are nowadays such popular terminologies to point at those new means for carrying out human's traditional ways of doing some works. Much is being done then to lend hands to human monitoring based tasks at all level – home, business enterprises and industry works. They rank from communications (e.g. vending machine, home or workplace surveillance by CCTV) to soft actions (e.g. massaging armchairs/beds), including physical actions (e.g. robots use in manufacturing shops and mines plants). Basically, the cooperative use of various technologies' features is change the ways human world used to evolve from human face to the working objects, work subjects, work performer to what is labelled in [2] article as a change from "Face-to-Face into Face-to-Screen" based works or activities monitoring, as the new method for effective and accountable management of people and things around them.

However, from above introduction, much has been inspired as partially making up a background of this research study about home appliances' control using automation technology applications system. In fact, house's appliances control is among the latest innovations in home, enterprises industry's office's equipment design and managements have enabled/facilitated by the advancement in communications technology [1] [2] [5]. Nowadays, what matter in generally is all about various system designs' options for this purpose to taking advantage of the related technologies to support any of the project's solutions creativity. The remaining of this journal article is organized as follows. First the study background; then the technologies reviews followed by the main concepts and development motivation for the piece of project presented along with this paper, and some further details throughout its different sections. Then, the next is a summarized explanation about the project structure and how operates the proposed control system. And then, another section discusses about the project design important specifications as the guidelines to typical users; such details can help also similar project's developers achieve some desired goals based on these sections' knowledge sharing.



## PROJECT BACKGROUND

An electronic system is an electronic circuit with components de-signed to accomplish either simple or complex functions for in-stance in home automation architecture. Typical examples of such sub-systems used in home automation include items such as a tele-communications system; computer system and some automation systems. Such integrated systems are the fundamental components of the automatic control encountered in other various control systems; their design intends suppressing or minimizing the involvement of human work and thus saving also the energy consumption, since such a control system uses the technique of self-moving processes to do the work.

In fact, home automation is one of the first projects one thinks about when wanting to make the life easier, comfortable, and secure; etc. But, with a hope to financially spend little on the costs bill, therefore, to save the energy consumption at home because it involves as better way [3] [4] [5] the control and manages the home equipment such as lighting, home appliances use, heating/Air-Cond; etc. With the popularity and widespread around the world of the smart-homes, there is high chance for a continuous need for automatic control of home and its appliances. Hence, a new terminology in daily people communications is known as domotics, which is the “technique of technological applications in the control of house appliances by electronically controlled systems” [6] [7]. In fact, switches are set “ON” at least dozens of times a day, and most of the times they are forgotten to be turned “OFF”; and with such happening the lights for instance will consume more energy and this will increase also the electric bill budget. Therefore, with domotics, home’s user can control the equipment connected to a dedicated system for that purpose.

Furthermore, there are very few worldwide accepted industry standards for domotics based devices /systems development. There-fore, the smart home space/field is still heavily fragmented while there are many competing vendors. Bluetooth is one of the popular communication protocols for the products that are used in the home automation [5] [6] [10]. Based for examples various journal articles and technical reports here are some of the most obvious reasons for Bluetooth based products popularity. First, this system has avoided the use of new cables for connections. Secondly, the manufacturers often prevent independent implementations by withholding documentation. Third, wired or wireless technologies can support the communications between the systems to deliver required operation services. Fourth, currently an upgraded Bluetooth that is designed to reduce the power consumption and the comparison of the short-range wireless technology is permitted to evaluate if that Bluetooth version is a good alternative. In fact, the upgraded version offers low power consumption, low cost and its general availability in tablets and smartphones; and also it can be easily used to control and monitor all the systems. In this article, the discussed piece of study on controlling home appliances such as lamps and fans with is mainly to demonstrate how to design a simple, low-cost

system like others for widely use in future. In more details, domotics, enable home’s user to easily control the equipment connected to a smartly designed system. And, this system consists of a smartphone, a tablet or a personal computer, which enable connecting to the home equipment’s switches through Bluetooth or Internet.

## HOME REMOTE CONTROL SYSTEMS AND ISSUES

The function of automation for home appliances control is to help the people to save money they spend for the electric consumption bills; to eliminate the situation of forgetting to switch OFF the lamps and fans if they have remained switched ON for long periods, because of the users being far away to come back and change their status. This application system is a solution model against the problem of wasting energy and especially some money by being overbilled up for what is not usefully consumed. Bluetooth technology makes it possible to handle the problem of controlling (ON & OFF) the appliance in use when there no one at home; this process helps enhance the power efficiency and improve the users’ quality of living.

Home appliances remote control system consists basically of two broad components or subsystems, which are the Bluetooth installed onto come home devices and the smartphone. And between the two are few subsystems for enabling interaction with the home appliances. The Bluetooth makes use of the called ARDUINO mechanism to directly issue commands of switching (ON/OFF) the operation of the home’s connected appliances according to wireless signal type received from a smartphone; and the smartphone uses a telecommunication service to communicate with Bluetooth interface. In fact, with android application in the Smartphone, its users can switch ON or OFF the home appliances remotely.

Research on the home appliances remotely monitoring has various issue domains of interest. Some of related studies focused on predicting the probability about when people will switch ON/OFF the light [8], or other related items in system design. However, here, the focus in the proposed model is about designing a sample solution that can serve for the purpose of this article’s topic when using the contemporary technologies.

Generally, the combination of software and hardware, has made is possible to control various home appliances such as lamps and fan that connect to Bluetooth module. Arduino is one the popular integrated elements of home remote control systems [7] [9]. The Arduino system is about a series of kits that combines and connects both software and hardware in order to give the ability to turn ON and OFF the home appliances [7] [9]. In the introduced project in this article, Bluetooth is used to control the home appliances and a series of programming ‘codes’ applied to the Arduino boards will make the lamps and fan to turn ON and OFF when there is nobody at home, The coded signals that are programmed to operate appliances get into the electronic devices and they are sent through the home wirings to the appliances switches (ON and OFF) in every part of the house [5] [6] [7] [9]; thus no more need to move up to the any switch location



even when the user is in the house. In fact, Bluetooth technology lets two devices connect to each without a connection wire; and its popular uses include hands-free devices like headsets for mobile phones; wireless link to transfer data between two electronics devices [10].

### ISSUES WITH HOME APPLIANCES MANAGEMENT

One of life living style problems today is about the waste of energy resources in home. Energy is limited for use in great amount in what to make lives easier, comfortable and, productive. It is important to use the energy resources wisely and always try to save the electrical power; for, the recourse is very important for us later. "The earth provides enough to satisfy every man's needs, but not every man is greed" [11]. Otherwise, conserving electricity in homes consumption will create the accumulated savings in energy bills at the end of the year. And, conserving electricity is important beyond the impact on financial budget since it can also cause the depletion of natural energy used to generate electricity. Human attitudes is one of the factors that contribute to the higher electric power consumption due to the habit of wasting electricity and because of the lack of awareness towards energy saving. Most of the people nowadays tend to forget to switch OFF the lamp and fan when leaving their house because it has already become a part of their behavior. Based on observations, there are many cases where the consumers forgot to switched OFF the lamps when they come out from the washroom especially children and teenagers [12]. The use of electricity continuously in the washroom without any occupant could lead to the energy wastage. However, the variation in these observations shows that home occupant's switching behavior is complicated; because depending on other things like the individual personality, on the available daylight, time of the day, type of electric lighting, type of switch and location to users' sight/reach [6] [7] [13].

### HOME REMOTE CONTROL SYSTEM TECHNOLOGY AND FEATURES REVIEW

#### Remote control system technologies

Here are briefly analyzed some commonly applied technologies into home remote control systems (HRCS) with focus on the categories encountered in past and recent product documentation. This section has reviewed about the manual and automated based home remote control systems, and then analyzed a bit their features and some reason of preferences for some and not for others. In general, the developers have to study from several ideas of the development of such a project in discussion in this article. First, a developer must study about the controlling home appliances using Bluetooth that includes similar concepts with the android Bluetooth connectivity, the appliances systems and its applications development tools. And then, the functionality of the hardware systems and the combination of the software application make the project operation complete.

#### Manual lighting control

In this mode, the controller operates like a regular switch. In manual mode, the occupants simply press the main button to turn the lamps ON or OFF [14]. Electrical appliances, such as lights are generally need to be installed with permanent connections rather than using plugs and sockets. The lighting depends on the occupants control to the switch as whether to turn the lamps ON or OFF. This mode can save energy by better reducing and accordingly the amount of time when the light/fan remains ON contrary to automatic mode, which would strictly follow the timing limit. Therefore, home occupants can control the appliances' operation according to their satisfaction and then save the energy, because every appliance is set ON/OFF when respectively required or not, and this for an adjustable period. But, if the users forget to turn the lights and fan OFF, it will cause a waste of electricity and increase the electrical bills.

#### Automated lighting control

Automation plays an increasingly important role in the world economy where many people got their daily life too busy. Hence, automatic systems are preferred over manual cases [6] [7] [15]. The energy consumption is inevitable in providing comfort to the working environment to maintain the quality of life and the production activities. One of the solutions to save energy without decrease in com-fort levels is through lighting control that is nowadays widely used in both indoor and outdoor lighting of commercial, industrial, and residential spaces. This solution lets provide the right amount of the light where and when it is needed [16], and thus save the energy for both lighting requirements and human efforts to control it.

### HOME CONTROL TECHNOLOGIES AND SYSTEMS

Various technologies making up a home remote control systems consist of different components; the major ones are review here with some clarification on their key functionalities or roles.

#### Android based smartphone: Classification and selection

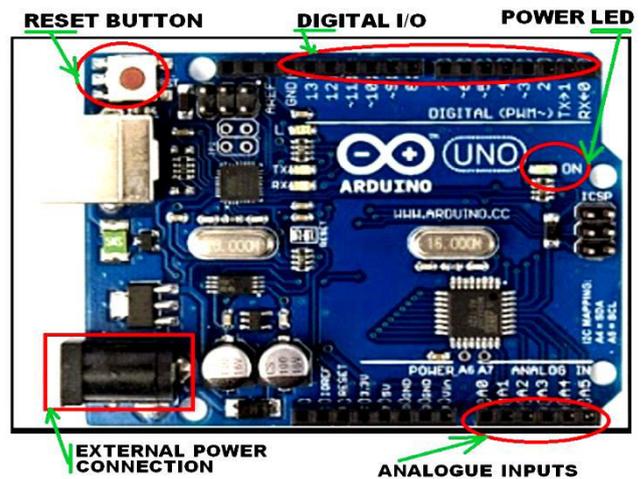
The project's smartphone operating system (OS) is one of the first required elements of choices for this project development and An-droid based phones can be the best model to select from. Such a choice can be because of Android becoming particularly popular everywhere today; including its acceptance and ranked (2017) the first by Google for having Linux Kernel. Upon agreement with Android developers, the Google Android OS got specific name for each major of the Android OS version in alphabetical order with Android 1.0 the earliest and then 1.1 versions, both respectively born in September 2008 and February 2009. However, the first Google based Android (Cupcake /Android 1.5) was released in April 2009; and since then Google has started naming every An-droid new version. Beyond Cupcake, other versions have been gradually named: Donut (1.6) and Éclair (2.0 & 2.1)



in 2009, Froyo (2.2 to 2.2.3) and Gingerbread (2.3 to 2.3.7) in 2010, Honeycomb (3.0 to 3.2.6) and Ice Cream Sandwich (4.0 to 4.9.4) in 2011..., Nougat (7.0 to 7.1.2) and Creo (8.0) respectively in 2016 and 2017.

Arduino is an important component for home remote control systems project for being the main component of all involved systems that commands and manages all other components participation to the operation of the whole remote control system. For, the interface inside the smartphone can make communicate with the appliances through the capability of the Arduino that use the Bluetooth module's connectivity. The selection of a model from the different Arduino types is also important to assure that it can fit with the required behaviors from the command inputs as analyzed and decided in advance to the project start. Here are some basic details about Android based hand-phones that can be in home control systems.

- Arduino Yun is a board that is used when designing connected devices or generally for the Internet of Things (IOT) projects. It combines the power of Linux with the ease of use with Arduino systems.
- The connection from Arduino: Ethernet and Wi-Fi support, a USB-A port, micro-SD card slot, 20 digital input and output pins, with 3 reset buttons included on the Arduino board [17]. It is a microcontroller board based on the ATmega32u4 and the Atheros AR9331, which is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture [18]. And it also distinguishes itself from other Arduino boards in that it can communicate with the Linux distribution on board, offering a powerful networked computer with the ease of Arduino.
- The Arduino Mega is a microcontroller board based on the ATmega1280. It has 54 digital input/output pins, 16 analogue inputs, 4 UARTs a reset button, etc.; [19], and its power source is selected automatically [19].
- Arduino Uno possesses (Figure-1) a microcontroller as the brain, which is ATmega328 IC. It consists of six analogue inputs and also 14 digital input/output, a USB connection, an external power supply, a power LED, and a reset button; etc. It is also known as the first in the series of USB based Arduino boards; and based on Android 1.0 (the Arduino software /IDE) it has become the reference model for the Arduino platform (e.g. Figure-1). Arduino Uno is viewed also by others as suitable model for beginners.



**Figure-1.** Arduino Uno components board layout (E.g. Arduino-Uno-VS-ESP8266) [20].

### HOME REMOTE CONTROL SYSTEMS SENOR'S CATEGORIES OVERVIEW

Sensors elements like in else automation system, is a very important part of a home remote control system. Common elements of a sensor system are the magnetic contacts, infrared (IR) and the passive infrared (PIR) sensors; etc.

- Magnetic Contacts

The earliest electronic home security system was entirely made up of door sensor (Figure-2), when someone opened a door and it triggered a big vibrating bell in a central part of the home. Today it is available for almost any appliances and more used on the doors /windows. The magnetic contacts are not expensive and safe to be used because the tools are trustworthy. The magnetic contacts are mounted in parallel or end to end in the door/window's frames to monitor the opening movements.



**Figure-2.** Magnetic based door - a door sensor with power sleep mode model: example [10].



### ▪ Infrared sensor (IR)

The development of IR sensors was initially linked to astronomical observations; but since World War II and for many years they have been fostered essentially by defence applications, particularly thermo-vision and, later on, smart vision and detection, for surveillance and warning. Only in the last few decades, the impact of silicon technology has changed the development of IR detectors dramatically, with the advent of integrated signal read-outs and the opening of civilian markets such as environmental, transport and energy applications [21][22]. Infrared technology addresses a wide variety of wireless applications with the sensing and remote controls as the main areas.

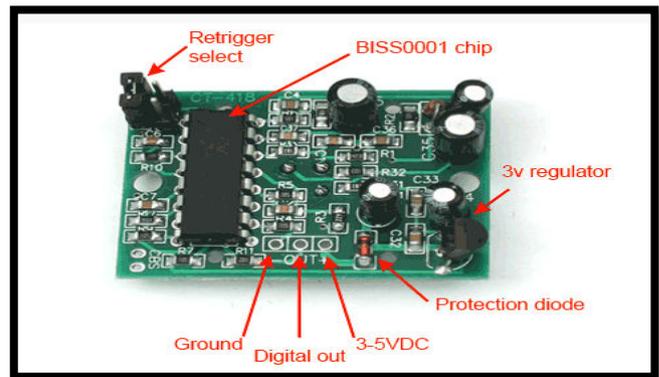
An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. Infrared (IR) break-beam sensors are a simple way to detect motion. These types of active IR sensor have emitter and receiver (Figure-3), placed in such a way that the IR emitted by the emitter falls directly in to the receiver. If the IR is transmitted but altered, then the receiver generates output based on the change in radiation. However, compared to PIR sensors (Figure-3.1 & Figure-3.2), break beams (i.e. "IR") are faster and allow better control to detect the motion [22].



**Figure-3.** IR Break beams sensor design: receivers and transmitters have respectively three wires and two wires [22].

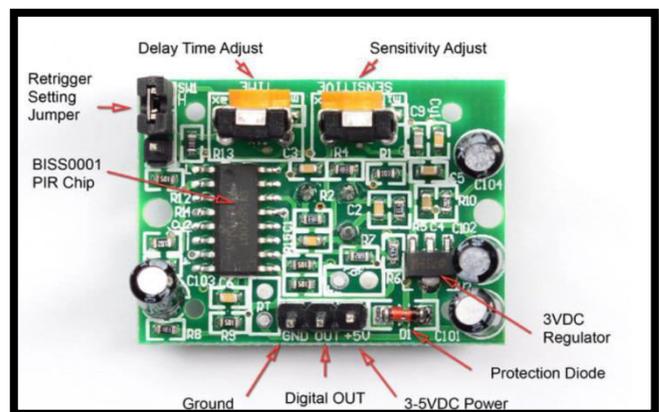
### ▪ Passive Infrared Sensor

Passive Infrared (PIR) sensors and the pyro electric effect have been known for more than 24 centuries. The principle of operation is that it detects movement and there is a very strong correlation between movements in a room and human in the room, so this choice is bound to be one of the most reliable. PIR sensors also allow sensing a motion and almost always used to detect whether a human has moved in or out of the sensors range. [21] [22].



**Figure-3.1.** PIR former designs [23].

Along with the Pyro electric sensor is a bunch of supporting circuitry, resistors, capacitors and inexpensive chip. This chip takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analogue sensor. They have a wide lens range, and are easy to interface [21] [23].



**Figure-3.2.** PIR recent designs [23].

With knowledge and technology advancement, new/recent PIRs have more adjustable settings compared to its former designs (Figure-3.1).

### BLUETOOTH MODULE OVERVIEW

Bluetooth module (Figure-4) is a small wireless system designed for communication technologies that can fit for some applications than other.

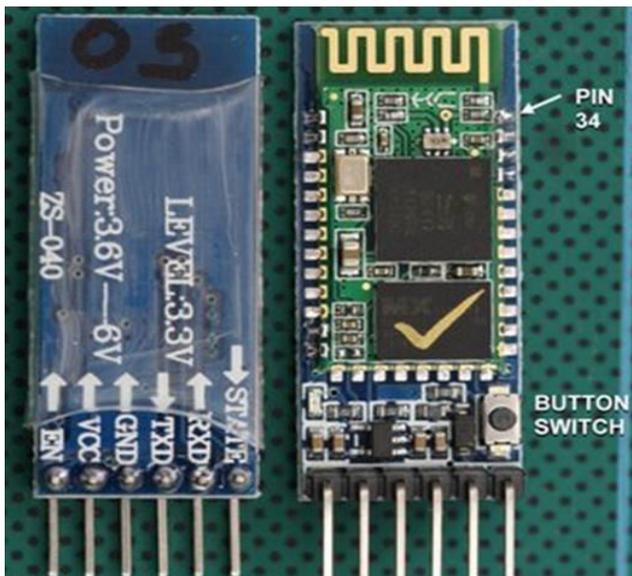


Figure-4. Bluetooth module H-05: front and back side views [24].

The good networking can be some primary factors that can decide the efficient range for the Bluetooth communications, which can upgrade the Bluetooth connection. To transfer data at the close range in continuous way, the Bluetooth system is used for streaming the data applications in a wireless technology, which acknowledges exchanging the information in visible form over short distance area. Besides that, in Android smartphone, the Bluetooth application can send the data to the Arduino Bluetooth module. The serial monitor in the Arduino IDE displays then the received data while connecting the devices capable to send and receive the data at the same time.

▪ **Note:**

Other important gadgets or kits supporting Bluetooth technology in home remote control building include HC-05 and HC-06 Bluetooth modules. In fact, HC-05 and HC-06 Bluetooth modules are also popular and very simple to set up with an Arduino board. They are suitable where wireless data transmission is needed in slave mode because for instance, HC-06 module is firmware on the other hand and only can be a slave device with very limited AT commands.

### SMART HOME CONTROL SYSTEM DESIGN OVERVIEW

An experiment involving two stages work is discussed under this section regarding the points to achieve during the development of this application. The prototype has been tested to ensure the circuit well-functioning and its connections correctness. The circuit containing Bluetooth module and PIR sensor was prepared and inter-connected using Arduino, and then tested in simulations method. An example of this design work can apply a simple algorithm like the following:

- Project definition and model choice >> Material selection >> Product requirements preparation/gathering >> Actual design work.
- A flowchart associated with (a)'s steps (e.g. Figure-5).

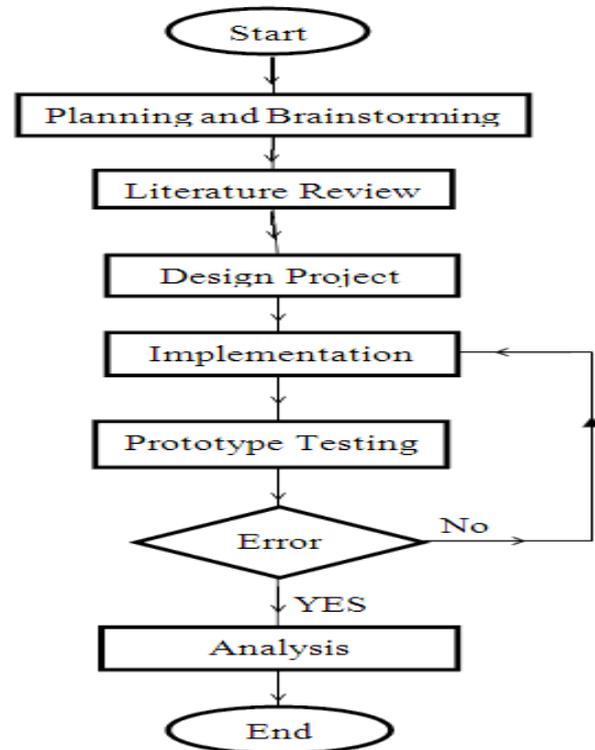


Figure-5. Project design simplified flowchart.

The overall steps for the project realization stages can be summarized into six sequences (Figure-5), namely: planning/ideas brain-storming, literature review; project design, prototype implementation; modeled solutions testing and validation.

Basically the work under each goes this way:

- The preparation includes planning what project to be developed.
- The reviews to finding more details about the project component, function and etc.,
- The design is to produce the project layout and related work to its appearance;
- The prototype is done using the material selected based on the characteristics that are correlated to each other;
- The assembled prototype is implemented according to the design model (e.g. plan/diagram and dimensioning. fit);
- Finally, the prototype testing upon execution allows seeing what can be the first performance result. This is repeated as many as possible to ensure all potential errors are resolved. Lastly, when the resolved problems are analyzed, the details can be written to make sure that the project functions well.



## REQUIREMENTS ANALYSIS AND CATEGORIES

The requirement analysis of the Controlling home appliances using Bluetooth is studied and presented next, using the most of accessible related work in open literatures. The system's function descriptions are also discussed to show how the product can meet its specification according to the requirement of controlling home appliances using Bluetooth. The requirement analysis is considered here as being of two kinds, which are the functional and non-functional requirements.

### Functional requirements

The functional requirements refer to what has to be done by identifying the task that must be accomplished; and this analysis will be used as the top level functions for the overall functional analysis. These details explain in what way the system respond to the input and how the system will function in particular place of its activity. Under the functional requirements, the system allows the user switching on and off the lamp and/or fan in the house by using the interface that has been created in the application. The main menu of the application displays the configuration button for reconfiguring the system. It gives some instructions to the user to control the home appliances.

### Non - functional requirements

These are the requirements that specify the criteria used to judge the operation of a system, rather than any specific behavior and the functions that being offered by the system services. By these requirements, the system must be easy to use, allowing users to understand and learn the system, so that they know how managing the system without any need of referring to the manual when wanting to use the system. Besides that, the user is given the decision to determine every component to be in the system whether it is part of the software or hardware of the system.

## SYSTEM MATERIALS SELECTION

### Arduino Uno

It is selected for controlling home appliances using Bluetooth due to particular of its characteristics, which is that it can simply connect to a computer using a USB cable or powering it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The programming libraries and the available online materials also make it a great platform for the beginners to work on. In addition, the drawbacks of micro-controller like 8051 and 8052 can be cured with this Arduino Uno controller. Other advantages of Arduino Uno include: programming in C++ language; a 32KB memory and a clock speed of the Arduino for 16 MHz that allows it performing a particular task faster than the other processors or controllers; use of USB for connectivity and thus can operate through a PC, making easier data

communication between them. Another important thing is the no-need for a physical reset pressing button because this can be done by the soft-ware running on a connected computer. Additionally, Arduino Uno is the most suitable controller in automation industries because of its simple yet effective features.

### HC- 05 Bluetooth module

The hardware part of the controlling systems that supplies a wire-less device to work with the computer is the Bluetooth module. It can be peripheral, accessory, or other added product such as smart phone that also may be used. Bluetooth sensor is a circuitry or de-vice system enabling to detect the data sent from the smart phone to the microcontroller. The Bluetooth device wirelessly then connect to a phone or computer. In this study, the proposed system application allows controlling the lamps and fan by switching it ON and OFF using a smartphone through the Bluetooth connectivity. HC- 05 Bluetooth module in this system operates as master and it is connected the slave Bluetooth module as a slave board to make a wire-less connection with a PC and it can be set as Master to enable making a communication between two separate Arduino Boards.

### Passive Infrared sensor

The Passive Infrared (PIR) sensor or passive infrared motion sensor is able to detect the infrared sources with the temperature likes human warm body or animal passing in front the sensor (Figure-6). Such crossing motion will intercept one half of the PIR sensor, which causes a positive differential change between the two halves, but a reverse process happens when the human leaves the detection area.

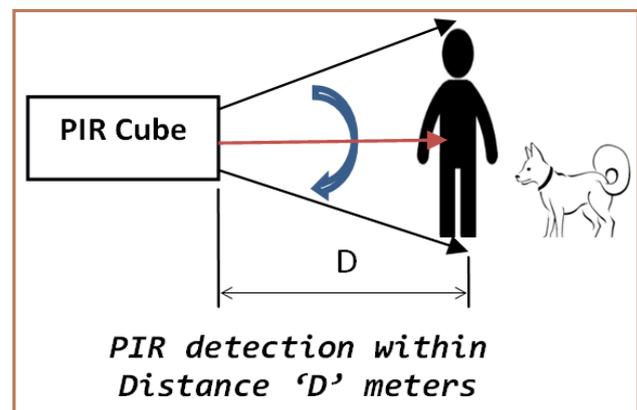


Figure-6. Passive Infra-red (PIR) sensor systems.

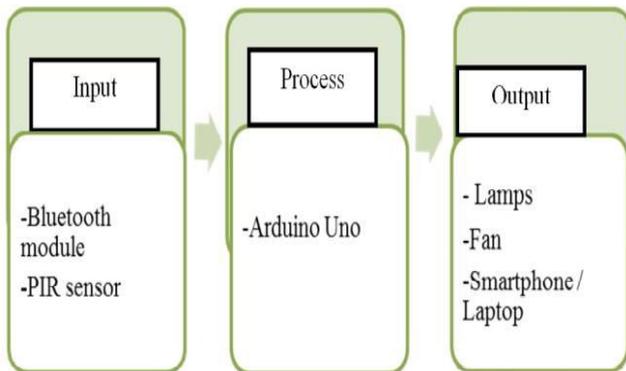
## PRODUCT PREPARATION

This activity here has involved the use of Bluetooth module and Arduino Uno for the control of home appliances like lamps and fans in this study case, the Bluetooth and the Arduino module are connected together in order to act as the drive for the home appliances circuit of lamps and fans. And after fully completing this preparation, has followed testing the functionality of the product system.



▪ **Product coding and designation**

Arduino Integrated Development Environment (IDE) Java platform has been used to make an IDE application; that is the workspace for uploading and debugging the coding from the software into the board. Arduino uses C or C++ language and based on the wiring. Arduino IDE consists of the wiring library to make the input or output operation user-friendly; and the program runs using two functions, namely setup() and loop(). Here are some details about the physical appearance /look of this product system.



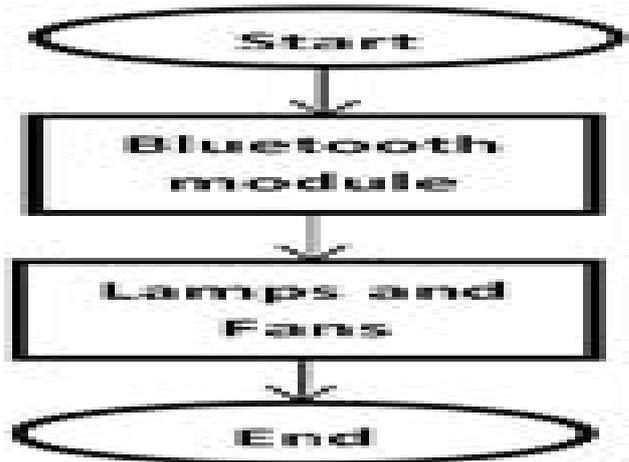
**Figure-7.** Products blocks (I/O & Process) labelling.

Figure-7 shows the different home appliance control system individual block's contents (Input/Output, and Process) in design.

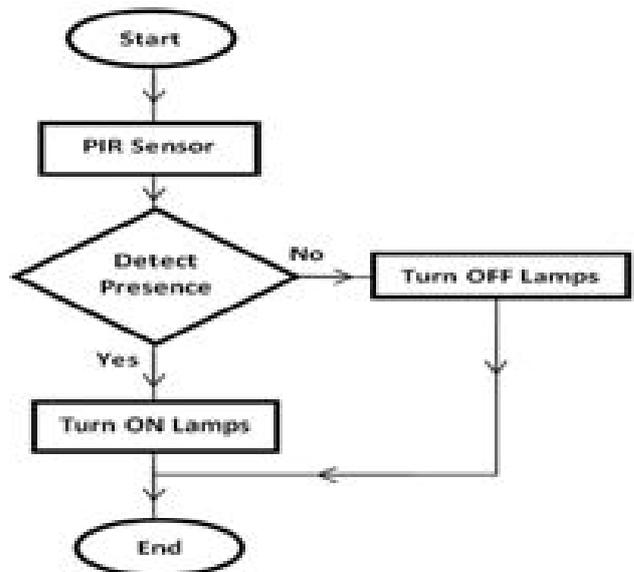
▪ **Product layout example**

Here are some basic details about how the Bluetooth module connects with the Arduino Uno (Figure-7). And, after connecting Blue-tooth module onto Arduino board, the application from the smartphone can be now used to test their interaction to controlling the lamps and fans by manually turning them "ON and OFF". Other features enabled in this product model include the following possibilities.

- a) The first feature is about changing the brightness of the lamps using an application created in the smartphone.
- b) The second possibility is making use of the PIR sensor interaction with the Arduino (Figure-9). This is to leave the sensor lighting up the lamps when there is a "presence or motion" detected by the PIR sensor in one case; or the light is turning off when no motion is detected.

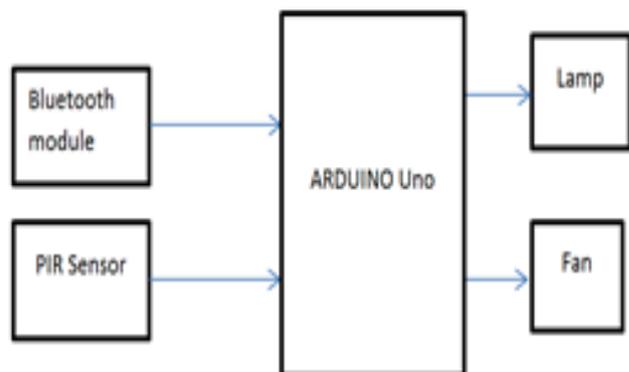


**Figure-8.** Bluetooth module system and connectivity check.



**Figure-9.** PIR sensor system motion detection process.

However, the required program codes to enable these behaviors are shortly discussed in introduction of the above paragraph (i.e. Product coding & Designation).



**Figure-10.** System blocks for home appliances control using Bluetooth design.



### ▪ Sample of the systems coding

Partially applied programming codes are displayed on the next page. And the complete programming codes can be obtained from the first author's email address as indicated under the article/s title.

```
//part 1
int lamp1=11;
int lamp2=12;
int fan=10;
int dimLamp1 = 4;
int dimLamp2 = 7;
//variables
int Received=0;
int fan_state = 0;
int lamp_state = 0;
```

Figure-10.1. Data definition and initialization.

```
//part2
void setup(){
  Serial.begin(9600);
  pinMode(lamp1,OUTPUT);
  pinMode(lamp2,OUTPUT);
  pinMode(fan,OUTPUT);
  pinMode(dimLamp1, OUTPUT);
  pinMode(dimLamp2,OUTPUT);
}
void loop(){
  if(Serial.available()>0)
  {
    Received = Serial.read();
  }
}
```

Figure-10.2. Appliances control and methods coding.

```
//part3
// FAN cases
if (fan_state == 0 && Received == 'a')
{
  digitalWrite(fan,HIGH);
  fan_state=1;
  Received=0;
}
if (fan_state ==1 && Received == 'a')
{
  digitalWrite(fan,LOW);
  fan_state=0;
  Received=0;
}
```

Figure-10.3. Fans control case coding.

```
//part4
// Lamps cases
// LAMP 1 case
if (lamp_state == 0 && Received == '1')
{
  digitalWrite(lamp1,HIGH);
  lamp_state=1;
  Received=0;
}
if (lamp_state ==1 && Received == '1')
{
  digitalWrite(lamp1,LOW);
  lamp_state=0;
  Received=0;
}
```

Figure-10.4. Lamps control case coding.

## SYSTEMS IMPLEMENTATION AND TESTING

### ▪ Hardware system implementation

The necessary equipment/components for developing this home appliances control systems have a hardware section. Under that section the selection of Bluetooth module and the sensor system was done as to ensure a high quality image and good connectivity to the controlled appliances. And a particular aspect considered for the sensor system's camera and Bluetooth module in the selection has been the sensitivity. Then, other characteristics included the accuracy, range, stability and response time and the cost. And for this article's demo project, HC-05 Bluetooth module and PIR sensor have been used.



### Software implementation

The software part consists of the computer programs and the application to complete the android application into home appliances controlling through Bluetooth connectivity. The system and application choices have considered much more their level of being user-friendly and to be understood by others.

### Systems testing

This activity generally takes/took place as the final process before declaring the project deliverable.

## RESULTS AND DISCUSSIONS

Here is a sample result for this illustrative project. Some discussions are added up as an example of real feedback from design and testing activities.

### RESULTS

The system has been tested to demonstrate the project delivery's functionality as in presented design. The combination of the soft-ware applications and hardware components has enabled the application operating as planned or labelled on the designed interface to work and control the command given by android application. That application has an interfaced screen that allows the users to send some control's commends towards the lamps and the fans located in the living room and the bed room. Arduino Uno has been able to process the input from the users and produce the planned output on the pins set. The projects have been successfully created including the operation along with explanations of the different functions used for the application software and hardware systems work.

### APPLICATION INTERFACE

The designed application for controlling home appliances using Bluetooth system gave the functionalities that make the user control-ling the lamps brightness including the condition for the fans by sending the "ON and OFF" commends according to their operation's code /required input. Firstly, the user must open the Blue-tooth mode to connect the Bluetooth module with the smartphone. Then at the home control configuration screen, the user can control the lamps that being place at the living room and the bed room. So, from that, when the user presses the living room button, the lamps inside the living room will turn ON and it will turn OFF if the button is pressed again. Same goes with the lamps for the bed room button and the fan condition. In additional, the user also is able to control the brightness of the lamps by moving the slider inside the application of the smartphone to the right and left position. If the slider moves to the left, the lamps become dimmer; and if the slider moves to the right, the lamps become brighter. The Bluetooth symbol was used to connect the smartphone with the Bluetooth module when we press the Bluetooth symbol and the screen will display "connected" if the smartphone and the Bluetooth have connected to each other and will display

"disconnected" if the smartphone and the Bluetooth were not connected.



Figure-11. Configuration screen of the application.

## HARDWARE SETUP

### Hardware circuit connection

For the hardware setup connection, each of the LEDs will be connected to the pin number 4, 7, 11, 12 and 13 on the Arduino Uno properly. The fan will be connected to the pin number 10 and the ground (GND). The PIR sensor will be connected to the pin number 3, GND and 5V.

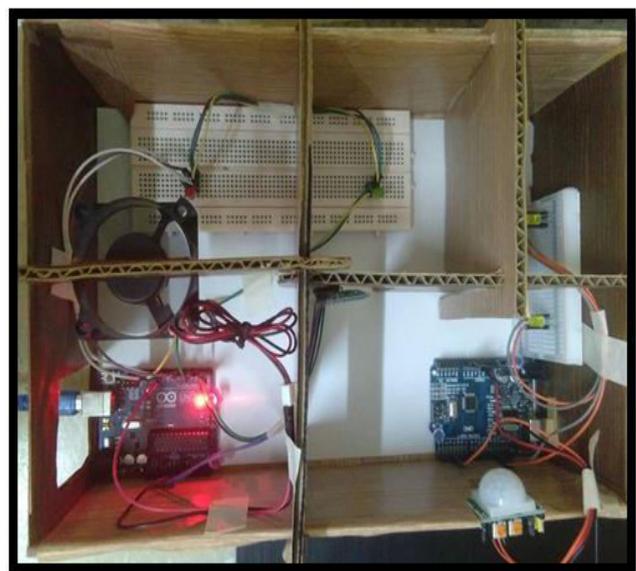
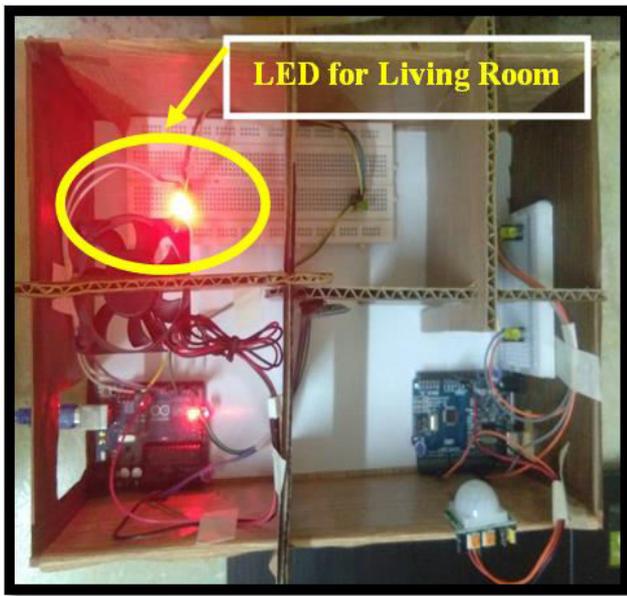


Figure-12. LEDs, PIR sensor and fan connections on the Arduino Uno board.

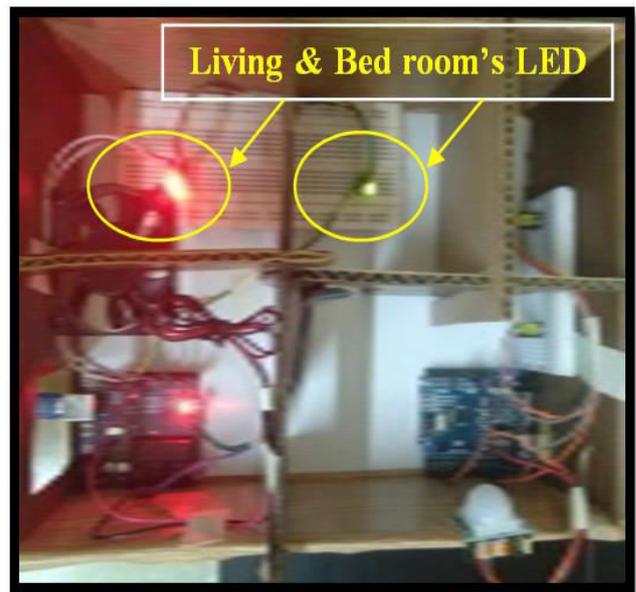


**PERFORMANCE ANALYSIS**

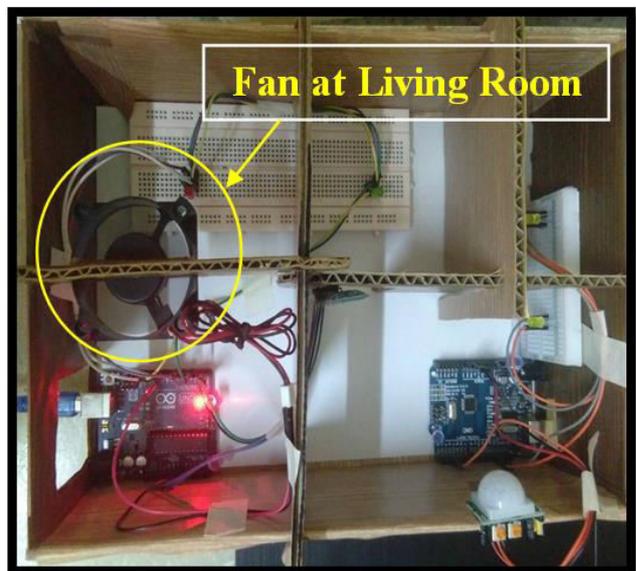
For verification on the functionality correctness of the developed product, a series of testing operation took place as the final step of the project work. The tests showed successful results for the different appliances when switched ON and OFF using the apps that has been developed. Some of the functionality testing details are given in pictures by next paragraphs.



**Figure-13.** Red LED turned 'ON' when the living room button is pressed.



**Figure-15.** Living /bed room control.



**Figure-16.** Fan: hardware & software systems testing.



**Figure-14.** Living/Bed room appliances' control when their command Buttons are turned ON/OFF.

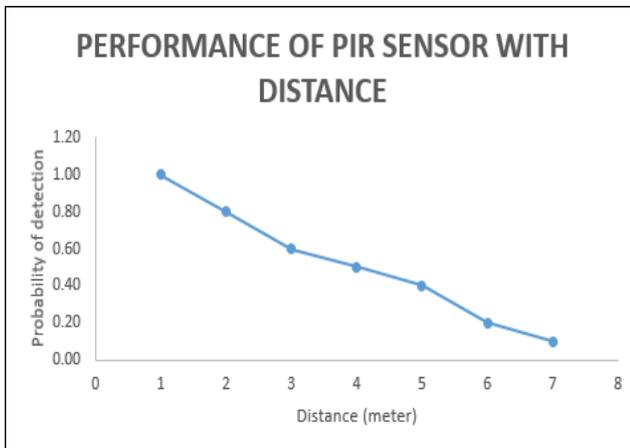
**Table-1.** Performance probability of PIR sensor detection.

'IR' Sensing Distance (meter)	Detection Probability
< 1	1.00
2	0.80
3	0.60
4	0.50
5	0.40
6	0.20
7	0.10

The PIR sensor could/can detect the motion of a room's occupant within its detection range. Thus, Figure-



18 shows that the probability for PIR sensor to detect a human /animal (Figure-6) passing through the sensor depends on the distance "D" to the "IR" source location (Figures 6 & 18). Therefore, the factor 'D' is an important parameter when choosing both a PIR sensor and its implement areas in a house's environment for this purpose.



**Figure-17.** Probability's graph of the PIR sensor performance.

Both, Table-1 and Figure-17 explain about the system control accuracy based on the IR sensing distance. The graph (Downward on the distance-axe) shows clearly that IR sensing has highest chances (Probability: 1.0 or 100% success guaranteed) of detecting object (See Figure-6) passing nearby PIR cube (i.e. at  $D \leq 1m$ ). And on average it performs also well for ( $2m \leq D \leq 4m$ ); and then a low sensing influence from ( $D > 5m$ ). Therefore, the system is good enough since only any target reaching 6 to 4m closer to PIR is intended to get into its control environment and must be detected.

## CONCLUSIONS

The project's objectives for controlling home appliances using Bluetooth presentation have been successfully developed. Particularly to the case of this journal article, most of the relevant details to the general theory of design and implementation have been also introduced throughout this article. These attempts include various technical details from the theory to practical realization of this category of home appliances control.

As to the testing and result analysis, the designed system allows its users to control the lamps and fan conditions if switched ON and OFF when being around or remotely. The use of the Bluetooth technology has then made easier connecting to the home appliances through a smartphone Android application. And, since every Android phone's equipment is supported by an application that has already been developed, thus the need of using another desktop tool to run all the applications is not needed anymore; that is because the microcontroller can handle the process.

One of the limitations with this illustrative project is that it did /does not support functioning properly. The current finding to this limitation problem can be because of the provided interface that is not consistent and thus make the system unstable when being used. Through this early finding, an important conclusion remark has been drawn up about the development of the home appliances control system using Bluetooth. That remark is about the need for using other modern technologies applicable with home appliances control development in order to overcome this above stated problem. An-other important learning is about the PIR sensor's distance 'D' (Figure-6) as a critical parameter when choosing both PIR sensor and its implementation areas.

The most important recommendation out of this project is about a future development using a better programming method to support the interface coding. For example, Eclipse is such a development tools package to make a strong database for the project development. Other improvements of the product could include either of the following. To add a camera to often check the house's conditions from inside for whether the appliances are still switching ON or OFF; and this can be further used for home security purposes like a control on burglar's intrusion. Finally, there is a need to plan for the current control systems upgrading in order to be able to control future appliances installed at home.

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