Home Automation Using Raspberry PI: Design And Implementation

In this emerging world of technology, where home and office automation is a necessity, we are proposing a system that makes use of Raspberry Pi to control those appliances connected to a smart home or office. What more exciting about the proposed system is that all the connected devices can be easily accessed with the help of an android phone and for that, the user will simply need to install our android application in their devices. The working principle of the android application includes sending commands through GUI of the appliances via Bluetooth. Followed by this, the receiver will be forwarding the commands to the Raspberry Pi board for further processing. This will allow a scheduled on and off of the appliances and a complete control over the appliances according to the commands of the users. It is possible as the circuit is relay based that act as switches for a particular AC load. The commands of the users that are received by the receiever enable the raspberry processor in processing the commands accordingly in the circuit. The required supply to the circuit board is supported by a transformer. We further demonstrate a real time home automation system that makes use of raspberry pi.

Technological revolution and evolvement have led to the rise of the need to automate homes and offices. Office and home automation are concepts that has existed for a long time and has been commonly referred to as Intelligent Home or Smart home (Vujovi? & Maksimovi?, 2015). They include centralized security locks, appliances, lighting, among other systems aimed at enhancing security systems, conserve energy, and improve comfort. This technology is growing quickly and is becoming a popular but is limited because other users like the elderly and the disabled tend to reject these systems because of the cost and complexities that they face. Technology advancements in wireless connection has enabled implementation of such systems using WIFI, GSM, or Bluetooth; every connection has its unique applications, specifications, and requirements. This project proposes designing a home and office automation system using Raspberry PI to control office and home appliances that have been connected. It is very convenient to the users because all the devices and appliances can be controlled from an android phone or tablet by downloading the android application that has been developed to control the appliances. The system will utilize Bluetooth connection to facilitate users to issue commands using a graphical user interface (GUI). The receiver will then receive issued commands and forward them to Raspberry PI dashboard to be processed (Bertko & Weber, 2017). This will enable scheduling of switching the appliances on and off and give the users complete control over all the connected appliances. The transformer provides the required power supply to the circuit board. Moreover, real-time home automation system will be demonstrated and simulated. The android application will be able to record and display the status of each appliance. The project presents home automation system design and implementation using Raspberry PI to control and monitor home appliances and device using a tablet or android phone.

Home automation system has improved efficiency, comfort, safety, convenience, and energy saving. The popularity of this technology is increasing because of the flexibility and easiness of controlling, monitoring, and checking the status of the home appliances at the comfort of the user using a mobile phone or tablet (Balasubramanian & Cellatoglu, 2010). However, the cost and complexity increase with the increased number of appliances to be controlled or monitored. In the recent years, the desire to automate home appliance control has risen because of the simplicity and affordability through smartphone and tablet connectivity. The system integrates all the electrical components with each other in the house. Techniques and approaches used in the home automation entails those in controlling home tasks like lighting.

Home appliances may be connected together via a home network to facilitate remote control and access through the internet using a personal computer, smartphone, or a tablet. The appliances and home systems can communicate in an integrated way through information technology integration in order to achieve efficiency and safety benefits (Saini, et al., 2016).

The formation of home automation started physically starting with the formation of mechanization materials. Both the automation and centralization of exercises that are deemed private is usually based on a private structure that is electrically-wired. However, enlightening a room from a switch upgraded people life styles whereby it was more simple and safer to lighten a broader location just by a single click on a switch. This was followed by the evolution of a home TV and a remote control in the 1950s. These two innovations played a vital role considering the point-to-control communication amid gadgets despite lacking a two-route data trade. As a result, X10 was released as an original convention to be used to wire buildings for basically for home automation in the 1970s.

Later on, in between 1966-1967, there was what many termed an outstanding invention of an excellent device which was called the ECHO IV. It had capabilities to register shopping records, regulate the switching on and off of apparatus, and even control the temperature of a home in spite of not being industrially sold. This therefore means, the Kitchen Computer was designed based on the current technology. Due to poor advertising of the apparatus, it was difficult to design more models despite being furnished for putting away formulations. The evolution of the internet came as the cutting edge followed by the Wi-Fi revolving into a distinctive contraption in people's homes. Consecutively, there were further home innovations ranging from home system administration and local tech among others. This created a mesh network in the home of a user while sending 900 MHz signals (Aldrich, 2017). This was popularly termed as the Z-Wave technology that was capable of linking numerous devices while controlling door locks, appliances, food monitors among others.

As a result of what many terms as the Internet of Things, innovations have become part of our daily lives. Smart home innovations are seen to be part of almost everything in our homes ranging from apparatuses, refrigerators, and even home security can now be easily controlled by smart innovations at home. Having said so, it is true that all the controlling activities of home devices are indispensable institutes of the Internet of Things. Presently, smart homes are designed based on the security of our homes and the fact that many people have a high desire to live a greener life. For instance, when talking of remote multipurpose control, lights that are computerized, booking machines, observation sensors among other technologies, are what people currently depend on as their ears and eyes as far as home systems are concerned. However, these sensors are designed for various uses like measuring temperature, gas, light, fluid, and even recognizing commotion.

Block Diagram

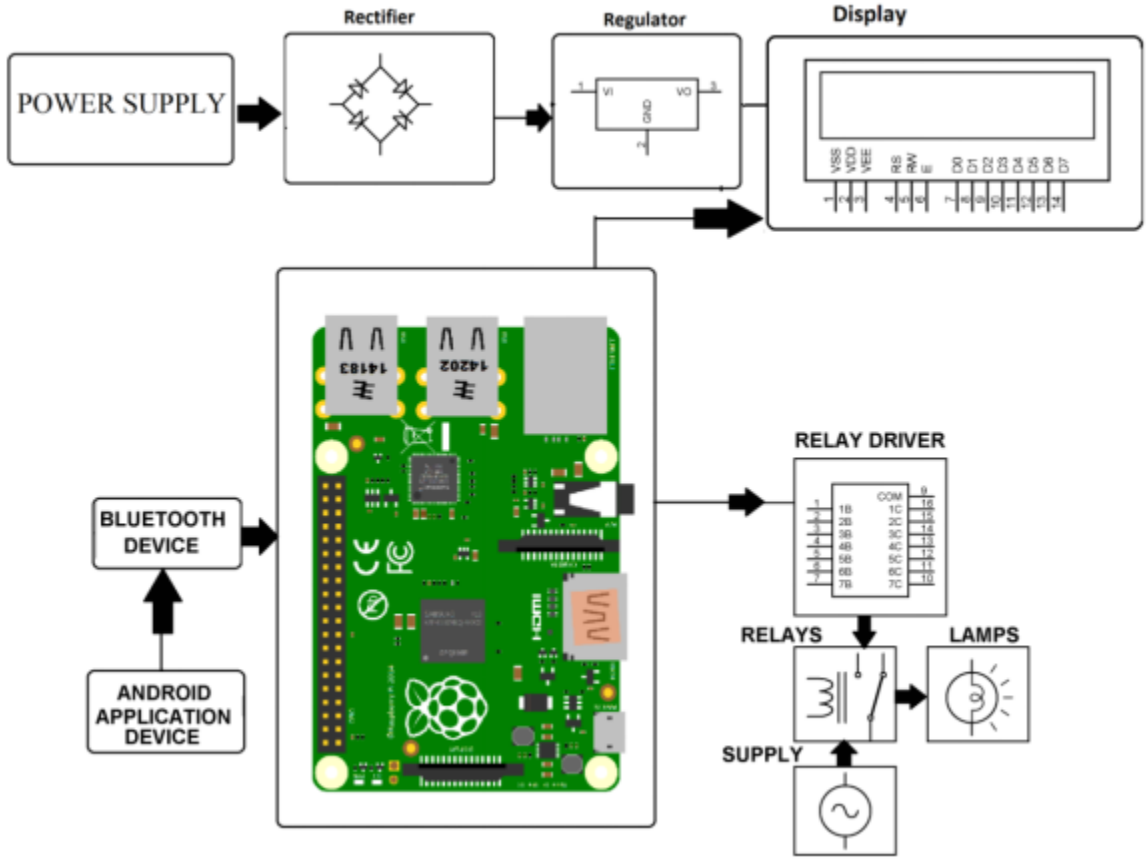


Figure : Block Diagram

The following hardware is required in order to successfully complete the development of the home automation system: Android device (tablet or smartphone), Bluetooth module, relay driver, power supply, Lamps, rectifier and regulator, Resistors, LCD, capacitors, and diodes.

In this project, Saleh and Hussam use HC-05 Bluetooth module to facilitate connection between the application and the Raspberry Pi. The reason why we chose this type HC-05 is because it is capable of operating both in slave and master mode and HC-06 can only operate in slave mode making HC-05 our best choice. The diagram below shows the HC-05 Bluetooth circuit:

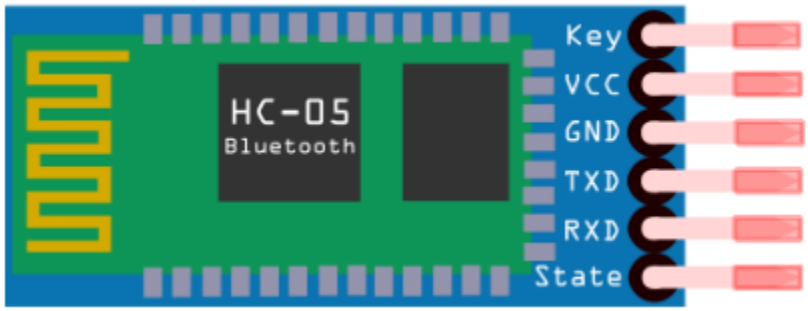


Figure : HC-05 Bluetooth circuit

(Source: Pang & Jia, 2016)

Saleh and Hussam acquired two teensy boards and combined it with a compatible Raspberry PI board. They did this in order to allow processing of the serial information to be done in the library rather that connecting to a UART port in a hardware. Each board was connected to the module while focusing on the power requirements for the module and board. Teensy boards require 3.3v and will integrate well with HC-05 because it has an onboard 3.3v regulator. Additionally, it has small buttons that is used to issue AT commands and pin 34 which is commonly referred to as (KEY) (NORRIS, 2018). The pin should be powered up in order to put the Bluetooth module into AT command mode. The HC-05 Bluetooth module has a button and thus lack the KEY header pin; therefore, Saleh and Hussam did not need to connect it to anything. They soldered a wired so as to connect it directly and allow us to enable the AT command mode in our code.

The transformer is required to facilitate conversion of AC electricity to the desired voltage with minimal power loss. Two type of transformers will be required, step-down transformer to reduce the voltage and step-up transformer to increase the voltage when needed (Miramontes, et al., 2013). The importance of the transformer is to ensure that the voltage is a safe and acceptable voltage.

The output coil is referred to as secondary coil while the input coil is referred to as the primary coil. The two coils are connected together via alternating magnetic field and has no electrical connection. The core is represented by the two lines in the middle. Power in and power output in the transformer because power leakage is very minimal. The current is stepped up while the voltage is stepped down (Navdeti, Parte & Talashilkar, 2016). Voltage ratio is determined by the turn's ratio which is the ratio of the number of turns of every coil. The number of turns on the input coil is large in the step-down transformer because it is connected to the main supply which is of high voltage while in the output coil, the number of turns is less because it is connected to low voltage (Cicolani, 2018). The formula below is used to determine the turn's ratio:

Np/Ns=Vp/Vs=Turn ratio (where Np denotes number of turns of the primary coil, Ns- number of turns on the secondary coils, and Vs- input voltage.

The transformer is a very important component while developing the system because it ensures smooth flow of safe and acceptable current and voltage in all the appliances.

The needed voltage regulator should have an output current of up to 1A, thermal overload protection, 5,6,8,9,10,12,15,18, and 24 output voltages, output transistor, short circuit protection, and operating area protection (Lakshminarayana & Rajasekaran, 2017). The diagram below illustrates the how 7805 voltage regulator operates.

This is the recommended voltage regulator because it has TO-220/D-PAK package which supports output voltages that are fixed. It employs thermal shutdown, internal current limiting, and safe operating area protection rendering it indestructible. It also has the capability to deliver output current more than 1A when needed if enough sinking it is provided (Kumar, at al., 2018). It can also be use with external components to get adjustable currents and voltages even though it is primarily designed for fixed voltage regulators. The diagram below shows the internal block diagram for the voltage regulator.

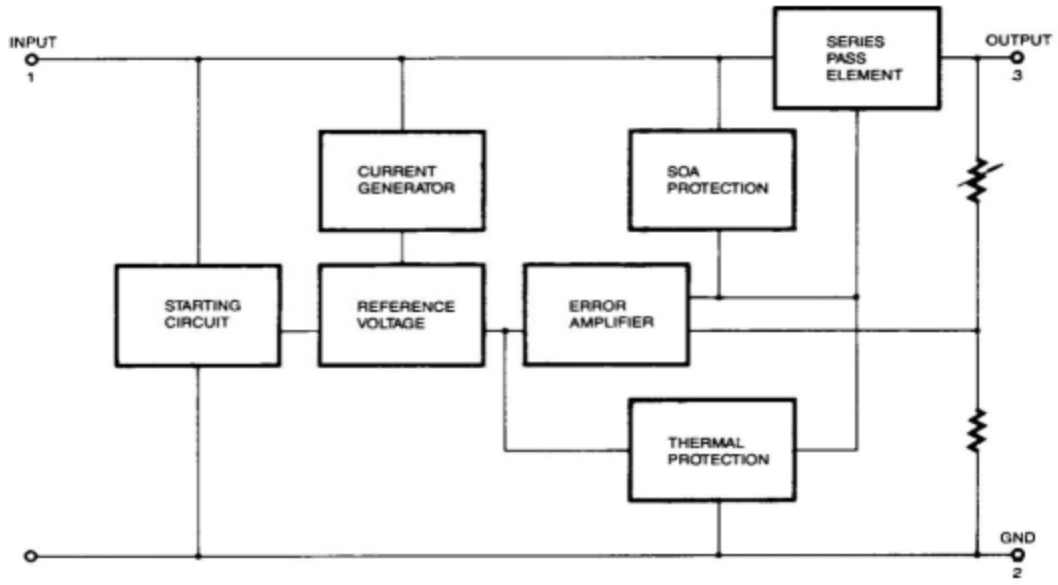


Figure : Voltage Regulator internal Block Diagram

The table below represent absolute maximum ratings expected form the voltage regulator

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range (KA78XX/A/R)	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Table 1: voltage Regulator Ratings

A rectifier is required to facilitate conversion of AC to DC current in a process called rectification. Other important uses of the rectifier in this project include detection of radio signals and as components of power supply. Rectifiers can also be converted into mercury arch valves, vacuum tube diodes, or solid-state diodes (Donat, 2014). The rectifier receives the output from the transformer and converts the alternating current to pulsating direct current. Bridge rectifier has been used in this project because of its full wave rectification and good stability. The diagram below shows how a rectifier works.

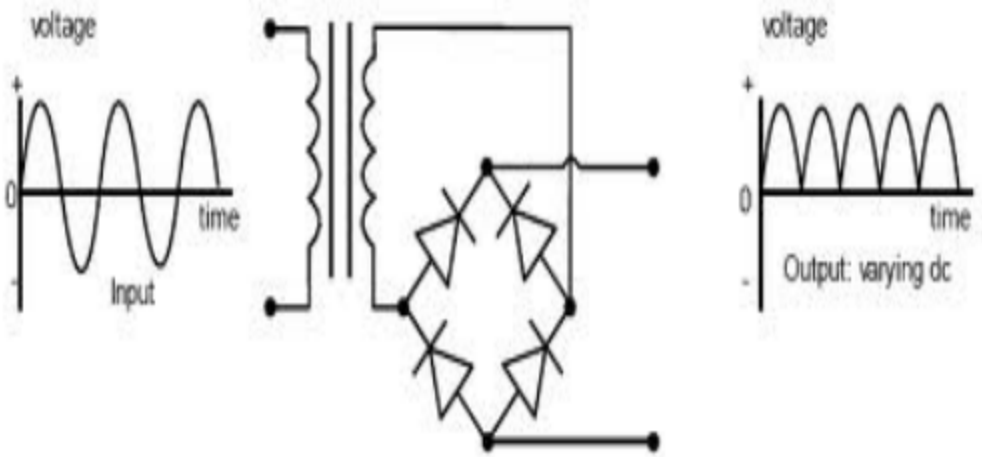
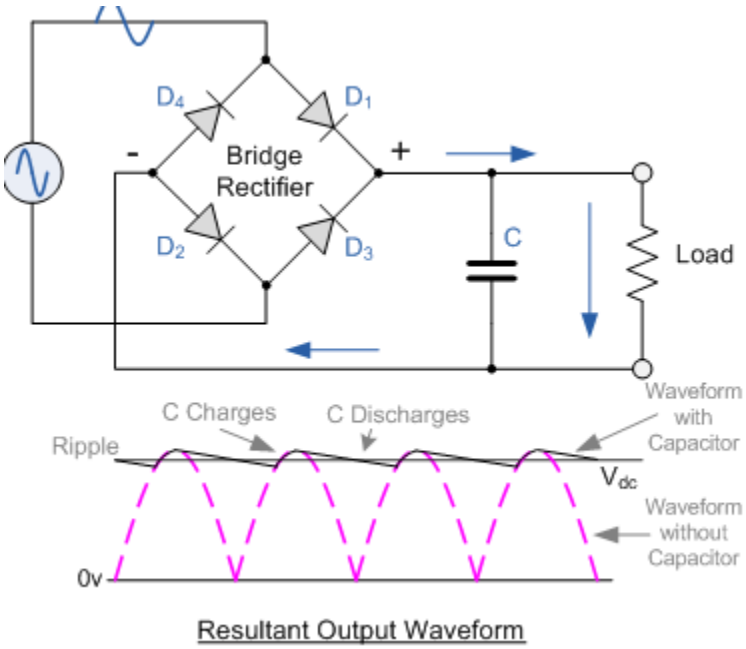


Figure : Rectifier

Capacitor filter is needed to remove the ripples and smoothen the direct current from the rectifier. The output from the filter is kept constant until the load and the mains voltage is maintained constant. The direct current received will change if the mains voltage of the load is varied necessitating the need to have the regulator at the output stage (Kumar & Sharma, 2017). The use of capacitor is limited and can only be used in low-current power supplies, or extremely high-voltage for electron tubes and cathode-ray tubes that need power supply of low load current. The figure below demonstrates how the capacitor discharges and charges



Resultant Output Waveform

Figure : How Capacitor Charges and Discharges

The LCD is required to display information. In this project Hitachi LCD has been used because it is easy to use, inexpensive, and has the ability to give readout using 8 x 80 display pixels.

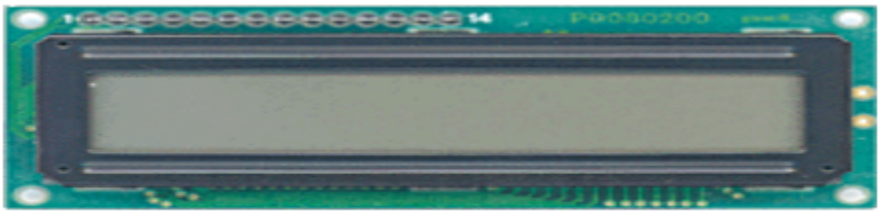


Figure : LCD Display

(Source: Gay, 2014)

Hitachi LCD have Greek, Japanese, and mathematical symbols in addition to the standard ASCII set of characters.

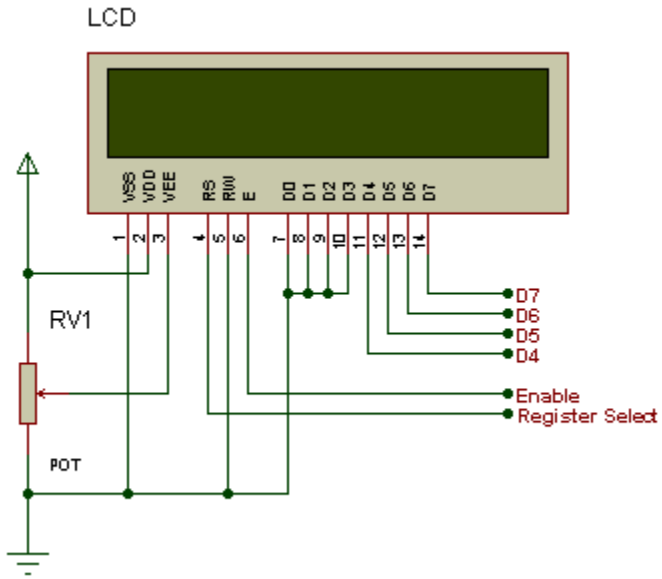


Figure : LCD Controller

Enable (E) enables access to the display via RS and RW lines. Read/Write (RW) determines data direction between the microcontroller and the LCD. Register Select (RS) aids the LCD to interpret the data type on the data lines.

The diode is needed in this project to convert alternating current to direct current and can be used as full or half wave rectifier. While using this diode it is necessary to have the following adhere to maximum reverse voltage capacity, maximum forward current capacity, and maximum forward voltage capacity (Ghosh, et al., 2015).

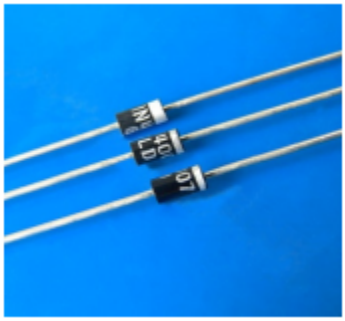


Figure : 1N4007 Diode

This particular type of diode has a maximum forward current capacity of 1A and maximum reverse bias voltage capacity of 50V. Another diode required in this project include light emitting diodes (LED).

Raspberry Pi board is required in this project to facilitate connection of the home appliances on the network. This device was developed by Raspberry Pi foundation is a credit-card-size single board computer. In this project, Bluetooth connection will be used and can be configured from Raspbian GUI (Goodwin, 2010.

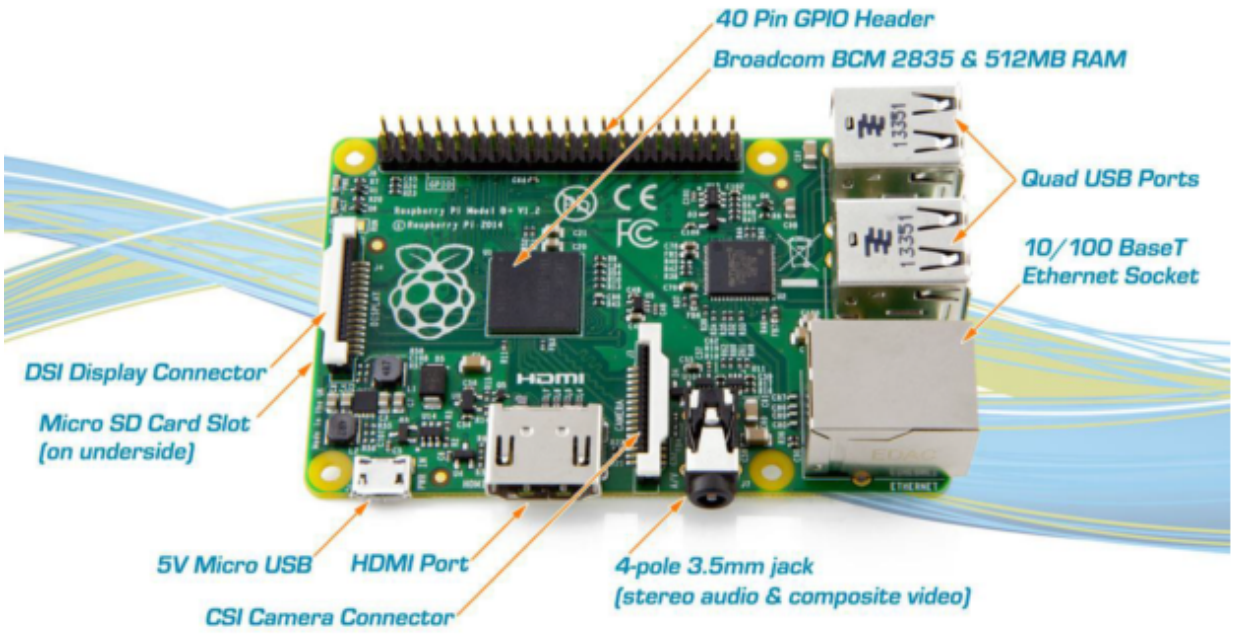


Figure : Raspberry Pi Board

(Source: Narender & Vijayalakshmi, 2014)

The relay circuit is important in the accomplishment of the home automation system because it facilitates switching on/off od low power circuits to relatively high current or voltage. Relay coils often operate on specific voltage of 5v to 12v (Kotilevets & Skvortsova, 2015). The relay circuit gives the needed current to power the relay coil. Logic 1 turns on the relay while Logic 0 turns it off. Four relay circuits have been used in the system to control the appliances and devices at home.

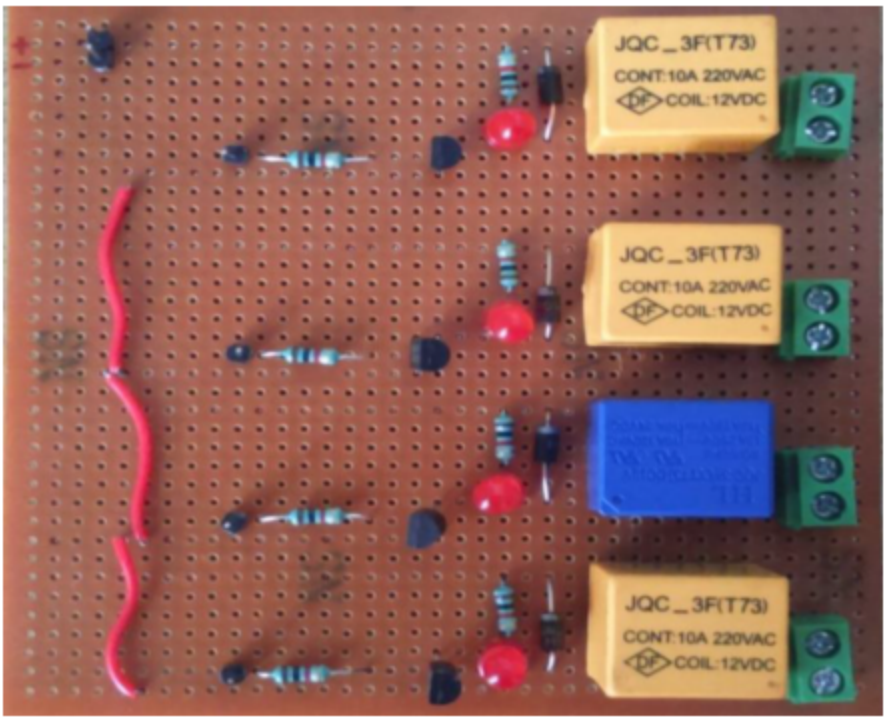


Figure : Relay Circuit

(Source: Goodwin, 2013)

P- and N- components can be combined to create a diode. Saleh and Hussam first considered the current flowing in the materials before getting to know how a PN junction works. The diagram below represents a PN junction:

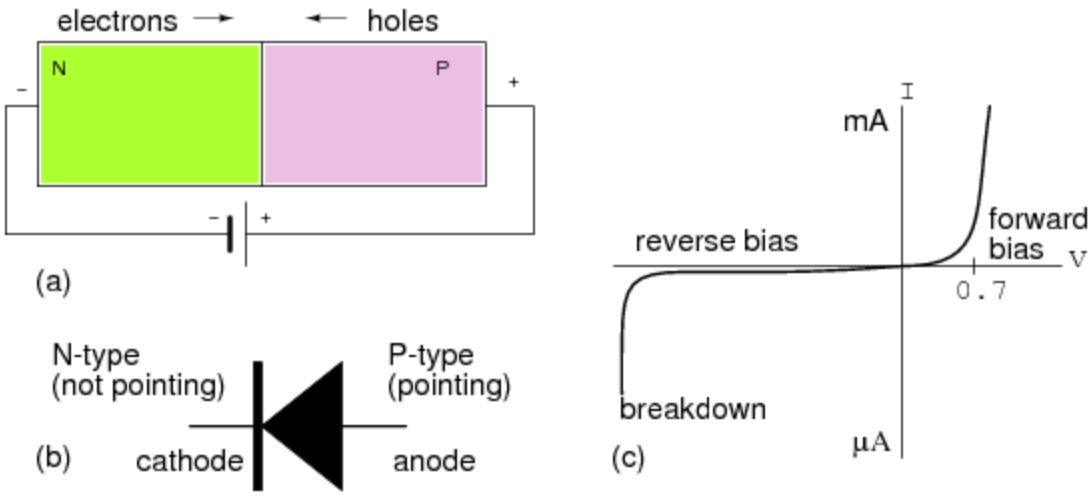


Figure 1: PN Junction Diode

Figure: PN Junction Diode

(Source: Kiran, 2017)

The current flow in the N-type material is similar to that of a copper wire conduction. The electrons move through the material as it would in a copper wire. The free electrons will be attracted by the battery positive terminal (Lui, 2009). The negative terminal will emit electrons that will get into the crystal, therefore, completing the circuit.

LEDs are very important in this project because we will use to show the different states of the system components. The common colors are green, red, yellow, and blue. They are made from silicon just like transistors.

The development of the home automation system requires several software requirements.

The application is required to issue commands from the GUI and check the status, control, and monitor home appliances by tabbing on specific buttons. It also sends appliance data and receive them form MySQL database using JSON (Kim & Yarlagadda, 2015).

This is a comprehensive integrated development environment for developing android applications. Android studio will be used to develop the android application required to control the home appliances.

This is an integrated development environment that supports python programming language. The server-side script which runs in the raspberry Pi has been coded using python. The status of the home appliances is controlled by the script.

Apaches server was configured to support MySQL database on the Pi to facilitate communication between the database and the android application. MySQL database stores tables that contain appliances status connected to the Raspberry Pi (Goodwin, 2013). The appliances status is updated depending on the data received from the android application.

This is a Debian based operating system and is free and is needed for the raspberry pi hardware. It has over 35000 pre-combined software packages to make the installation on the Raspberry Pi easy (K., & D., 2017).

The first idea or guideline in initiating the concept of home automation is to choose a network protocol which can be either wired or wireless and in other situation is a combination of both. Some of the technologies which are popular in offering such services for home automation are such as INSTEON, the UPB, Z-WAVE & ZigBee among other protocols which are dependable. The choice that will make with regards to the selected network protocol will help in determining the direction of the home automation system in the future (Home-Control, 2011). The decisions made by a person will be highly influenced by the existing smart devices at home and which can help one to be able to access them anywhere via cloud-based technologies (X10, 2018).

X10 is known to be one of the most original network protocols which are used as wired home automation. Advancement in technology has proved that it has aged and thus becoming obsolete by being replaced by the new and much more other versatile wired as well as wireless advanced technologies (fritz, 2011).

UPB is the abbreviation of Universal Powerline Bus which is known for using the wiring which is built-in in transmitting the control signals of the home automation (RF_wireless, 2012). This network protocol technology was developed to overcome all the shortcomings which were experienced by X10 and thus making it more superior in terms of powerline technology as compared to the X10. One is needed to have a controller if in need of integrating the compatible X10 products with those of UPB (Simply-Automated, 2013).

This is another network protocol which has been developed to also overcome the challenges experienced in X10 (Smarthome, 2011). It is designed for bridging the wireless home automation to automation in powerlines (Haughn, 2017). Devices in INSTEON Technology may communicate to the power lines as well as through wireless. The good thing about this technology even if it has made X10 has to look obsolete, it is in many cases compatible with X10 network which may be in

existence (EnviousTEch, 2015). Another good perspective of INSTEON tech is that is known for supporting novices in home automation and thus making the non-technical persons to even be able to set up and adding devices across the existing network.

This is also an original wireless for technology in home automation where it set standards for automation in the wireless home (Develeco, 2017). Z-wave has created extensions in ranges which are usable in-home automation as it makes devices to be double just like the repeaters. The most known feature of Z-Wave is that it helped in increasing the reliability of the network thus enabling its applications commercially (Ambient.com, 2016). Z- Wave devices design is very easy when setting up and much more using and thus coming about its closeness to turnkey as the industry of home automaton making it helpful for one who is beginning enthusiasts (Z-wave, 2016).

This is all similar to Z-wave, however, Zigbee is basically a wireless home automation technology. There have been problems with its acceptance by the enthusiasts largely because their devices have difficulties when communicating with devices which are made by the manufacturers of different devices (Prindle, 2014). It is always not recommended to people who are new in the home automation technology unless in situations where they will use the devices which are only made by the same manufacturer.

Many manufacturers have started to design smart devices to be used at home to work with WIFI networks in existence at home. If one wants to connect to a home network, the only requirement will be to have a password (Escobar, 2015). The demerit of this path being taken is the bandwidth issue. In situations when they are many or multiple smart devices connected to the WIFI signals the network will be slow. It is known for draining the power from the device and thus it may inconvenience one in connecting to the network if the charge is not enough (JOHNSON, 2017).

In many cases, many manufacturers have been able to embrace wireless technology in Bluetooth which is applied in relatively short distance connections and sharing. Bluetooth technology is applied to open and closing smart doors and also lighting bulbs. This tech is easy to understand and much more very simple when working with it (Johri, 2015). One benefit of using Bluetooth is that it possesses a secure encrypted technology and thus there is a lot of expectation in seeing it growing fast when compared to any other technologies which are wireless in the future.

This is a wireless technology which is new and termed to be a kid when applied in the smart home devices. In the thread protocol, one can be able to connect for more than 250 smart devices as it may require little power. Most devices which are battery operated are always compatible with thread. Similar to ZigBee, Thread is known for using radio chips in forming a secure network with low-power (JA, 2011).

This section discuses how we are going to achieve the objectives of the project. The approach employed in this project is the incremental development model.

This model is based on the concept of developing an initial implementation and subjecting it to user review and comments and refining it through the various versions until an ideal solution has been achieved (Jajodia & Das, 2017). Specification, development, and validation stages are interleaved in this methodology. The system is developed as a series of increments (versions) by refining and adding more functionalities to the previous version.

In this project, Saleh and Hussam have adopted this software development approach because it makes it easy to add more functionalities and requirements as they emerge. There is limited flexibility in the implementation and design of hardware aspects in incremental model.

Version 1.0

Initially, we developed we developed an android application that could send requests to the Apache server and make changes to the MySQL database.

Version 1.1

Version 1.0 was refined and more functionalities were added such that when MySQL database was uploaded to the Apache server on Raspberry Pi, the application and the Raspberry Pi could connect over the network. Moreover, server script on Raspberry Pi was coded to react to MySQL database changes and modifications.

Version 1.2

Version 1.1 was incremented and appliance status functionalities was integrated on the application and also on Raspberry Pi to capture the status of the various devices and appliances. We fabricated and designed PCB to integrate Raspberry pi with AC appliances.

Final Version

After the system has undergone all the three incremental versions, the final system was developed. In this version, the android application and the Raspberry pi could communicate with each other over Bluetooth connection. The application could show the status of all the appliances by clicking on specific buttons and send the appliance data to the MySQL database. The android application allowed remote and centralized monitoring and control of the appliances.

Material	Quantity
MALE BURGE 2-PIN	1
FEMALE BURGE 2-PIN (For Adaptor)	1
FEMALE BURGE 16-PIN (For LCD)	1
MALE BURGE STRIP 16-PIN (For LCD)	1
2-PIN PBT	4
FUSE CONNECTOR	1
FUSE	1
2-PIN WIRE (For AC Supply)	1
SOLDERING IRON	1

CUTTER	1
MULTIMETER	1
SCREW DRIVER	1
SOLDERING LED	
CONNECTING WIRE	
CD	
BLUETOOTH	1

Setting up Raspberry Pi

The following components are needed while setting up Raspberry Pi:

- Class 4 SD Card with minimum storage capacity of 8Gb and should be pre-installed with NOOBS
- Connectivity cable and display- any TV or DVI/HDMI monitor should work. In this project we used a display monitor with HDMI input.
- Standard mouse and keyboard will work with Raspberry Pi. For wireless mouse and keyboards, it should first be paid so as to work.
- Power supply- USB micro power supply is used to power the Raspberry Pi. Since we are using model 3B, we need stable power of at least 5V and 2A.
- USB wireless dongle to support wireless connection; initial configuration should be done.

We used NOOBS (New out of the box software) because it is an easy OS installation manager for Raspberry Pi. The recommended and the operating system that we chose id Raspbian.

Because of the budget constraints we could not buy pre-installed SD card. Alternatively, we bought a blank SD card and downloaded Raspberry Pi from raspberrypi.org/downloads.

After downloading the NOOBS, we transferred the files to the formatted blank SD card using a computer. We took the following steps to configure the blank SD card with NOOBS:

- Formatted the 16 GB SD card as FAT
- Extracted the downloaded NOOBS zip file and copied it to the formatted SD card root folder.
- The 'RECOVERY' FAT will be resized automatically on first boot to a minimum and the list of operating systems available for installation are displayed. The list of available OSes is Raspbian, Pidora, OpenELEC, OSMC, Risc OS, and Arch Linux.

Users require internet connection in order to download the application. Open Google play store app on the phone or tablet and search for 'Blue control V2.0'. It is a free application. Click on install in order to install the application. If you have a good internet connection, the download and installation process should not take more than one minute. After the application has successfully installed, go to the applications' menu and you will be able to see the Blue control application icon (Harish, 2017). Open the app and start using and you are all set.

Turn on Bluetooth connection from the phone setting and allow it to scan for the available devices. Look for "HC-05" device and click on it upon discovering. When prompted to enter pin key in 1234. After successfully paring the two devices, open the Blue control application and press on the options button. From the option given click on connect and the list of available devices will be displayed. Look for HC-05 and click on it and use 1234 as pin when prompted and click on ok. Now the set-up process is complete and the app is ready for use.

It may be hard for one to be able to test the home automation systems. Using the experience gained in this study, many shops which are professional don't like doing testing and thus it leaves a customer unhappy and leading to the sap of profits from the project. Over the last 12 years this is what has been observed in the businesses of audio, controls and videos respectively (GS, 2017).

1. That tiered testing is not in any way done
2. There is no plan for written testing
3. Most of the work with regards to the testing is done by the programmers instead of being done by a third party who is independent.

4. Testing which is done by programmers is not in a methodical manner and thus making them not to be detailed enough in any way.
5. When changes are made in the project regression testing is not done at all.

The following are some of the challenges explained in details.

Continuity Test

We performed continuity testing on all the electronic devices to ascertain if the current is flowing, that is, if there is a complete circuit. Saleh and Hussam accomplished this test by using small voltage device with a series of LED across the selected path (Goodwin, 2013). If the flow of current is inhibited by damaged components, broken conductors, or excessive resistance, the LED would light red and if there was continuous flow of current the LED will light green. We used a multimeter and specialized continuity tester to carry out continuity test because it has the ability to measure current and are inexpensive. We maintained the multimeter at buzzer mode and connected its ground terminal to the ground.

Continuity tests is normally carried out after configuration and soldering of the hardware components have been completed. The purpose of carrying out this test is to identify any open electrical paths in the circuit (Gomez & Paradells, 2010). Some of the cause of broken circuit include using soldering iron improperly, rough or wrong PCB handling, presence of bugs in the circuit, failure of the components, and improper soldering.

This test is done to check if the voltage and current flowing at different terminals is as required or not. We accomplished this test by using the multimeter. We set the multimeter to voltage mode. The first step that we took was to check on transformer output to check if the required 12v is available. We carried out this test without the microcontroller because any excess current can damage it (Goes, 2017). We then applied the 12v to the power supply unit. We then checked voltage regulator input if it is 12v and output if it is 5v. We carried out similar test to all the other components to ensure that the voltage at every component is as required.

Tiered Testing

In testing, it is not all about finding the bugs in programming in a given automated system. It is all about ensuring that the given project is addressing all the needs of the customers. In this case, there is an introduction to the first level of testing in a new system which is used for validating if the system is satisfying the goals of the clients (Stitzel, 2012).

If the requirements of the customer are met to save the energy and improve the safety in their home for an automation system and thus this will help in doing a great job in offering provisions whole house audios without any integration with systems such as HVAC or the system security thus termed as a major issue.

The second tier of testing is making sure that home automated systems are very easy when using them. The idea is bringing sense to the customer as it is with the programmer. In this case, many programmers have tended to make things always complicated and complex. For instance, the implementation of Crestron's such as the Alexa voice control (Duke, 2012). The understanding is that what may make sense to the group of programmers may not make sense at all to the non-technical people who will be using the system.

Skills applied in programming this system will be used in cases where one has to define the light loads in the room with stated name LIGHT as it is the default light that one may want to turn on or either OFF 99 percentage of the time. The mind of the engineers doesn't entirely think like a normal user which is entirely making the commands which are simple in turning the basic light on in a given room especially when walking in and there is darkness (Rudenity, 2006).

Lastly, is the third-tier testing which has helped in making sure the developed functionalities are working very well and thus meaning that each and every function is working out properly after being tested.

Written test Plans

It is not easy to write a good testing plan. The testing plan should be a checklist form and must be covering all the button press which are available to the user giving a description of the outcome of the program of each pressed button (N R, 2016).

To get down in this level in details it may be time-consuming and more very costly. In a situation, if one is a professional and the reuse codes on the multiple projects then one can be able to reuse the written test plan. This may help one to save one a great deal in time and much more saving the customers money (Patil & Reddy, 2013). Another benefit associated with written test plan is that the final version that contains all the items in the document must be checked off to have passed the test and one thus it can be submitted to the clients as proof or evidence of the all the work done assuring that the quality of the system has been delivered to them. The test plan should have a date and a signature of the individual responsible for testing.

The Person who should do the testing?

Programmers should not be the only person performing the detailed testing. They are the people who develop the system and thus the many insights on how the system is working and thus making they make a lot of assumptions when they are doing testing. The programmers don't have any role in testing. Their idea of testing should be done when they are writing it to their abilities and thus making them not to qualify to be the people who are supposed to do the final testing. A very large integrator may employ a quality assurance which is dedicated that has not taken any part in writing the test plans and testing the systems (Robinson & Cook, 2013). This approach is not entirely practical for the majority of people in the specific organization.

The project manager responsible for selling the job should be the best choice in carrying out the testing. The views from the focused customer will also make them ideal for testing. This will also force then in learning all the details of how the system has been functioning or will so that they can be helped in training the customers on how to use the system.

Testing Must Be Detailed.

Test plans are anticipated to cover each aspect of the developed system. Such aspects may include things like all the details of all buttons on the touch panel and any other functional area in the specific system (Duke & Comer, 2012). When there is no such level of details the customers will ultimately do the system testing and thus ends up being frustrated with the issues and challenges that they will uncover.

Regression Testing

Unforeseen consequences can be experienced when one add or try to fix a bug in the functionality of a given automation system. When one changes the code there is always a high probability for one to add a bug and in most cases in other areas. For instance, a customer may decide to add Cable TV box in the home theater and at the same want to watch the satellite. This code may be modified by the system in offering provisions of controlling the new satellite TV Box. Nevertheless, the portion of the code which is used in turning all the audio and video devices in the Theater system will also be modified and the order will be changed (Dennis, 2015). This may lead to turning on the amplifier even before the satellite TV box is turned on. The outcome of this may lead to a loud pop which is generated which may lead to speakers being damaged.

In this case, if the cost is not mattering to you as the consumer, then one may go back again and do re-testing of the whole system after the code has changed. In this case, it may not be practical for one will have to re-evaluate all the system functional areas and retesting them those which have a high probability of being affected by the changes made in the code. High-quality testing is very expensive and it may not be that easy. Nevertheless, an investment when it comes to testing will

always provide you with customers who are happy, gives one a very good a reputation and much more a better bottom line (Schneider, 2015). In this case, as the owner of the home with the automated systems one will be enjoying the benefits of a system which is reliable and thus having a happier family life.

The final product expected from the project is a working home automation system which is capable of monitoring and controlling home appliances from an android application. The android application will serve as the graphical user interface to control home appliances and all the appliances will be connected to the PCB board (Carbou, Diaz, Exposito, & Roman, 2013). The raspberry Pi will act as the backend which has been programmed to control GPIO pins status eventually controlling the home appliances and capture their status. the outcome of the project has been able to meet the set objectives and the users can now control and check the status of the home appliances right from their phones or tables (Should be running android operating system). As such, we can consider the project as a success.

While developing and developing the system, we face several challenges including:

- It took us a lot of time and effort to get and set up a working Raspberry Pi.
- It was quite a difficult to get the most appropriate hardware component because it required in-depth research and consultation to get the most reliable and stable components that would meet our requirements
- We faced a lot of complexities while designing the hardware such as PCB fabrication. Generally, the entire process was quite a challenging one.
- The development of the android application and coding the server-side scripts was quite easy but the errors we got were critical errors that consumed a lot of energy and time.
- Some sub-system failed to integrate such as entertainment units dropping out, cameras not connection, and heating unit not responding. This was the major challenge that we faced because controlled heating system and simple device plugins failed to work at first. This required us to seek professional experts to because the problem could have been due to several causes.
- Insufficient functionalities and features. This was major problem that we encountered during the development of the system because we installed some of the systems without sufficient functionality and features.
- Developing and configuring a centralized application to control and monitor all the home appliances was a big challenge. This was because we did not fully understand how some of he home appliances operate making it a challenge for us to integrate (Balaso, 2016).
- More time spent when building the project which was very frustrating for us because of the lengthy delays during the initial home automation system construction. This was because

home automation technology has many elements and the process of installing home appliances is quite long.

- Insufficient knowledge from some of the subsystem suppliers. When we visited some stores where we bough some of the components, the vendors did not have comprehensive knowledge on how some of the components could be properly integrated into one big centralized system (Shailendra & Bhatia, 2018). This forced us to develop a module which facilitated full integration of such components in to the centralized control system.

At first people may think that home automation is a nifty manner to show off or adopt emerging technologies, but what they do not know is the benefits that comes with it. The following are some of the benefits that are associated with home automation:

Centralized management of home appliances. This is a very convenient way to keep up with the new technology by connecting all the home appliances to a single interface and allow monitoring and controlling from an application on a phone or tablet. The users only need to learn how to use the application because all the other functionalities have been abstracted making it easy for users to learn and interact with the application (Andrews, 2013). Additionally, one would not have to depend on the neighbors to watch over their house when you are away because it is possible to check the status of every house component right from anywhere.

Flexibility for home appliances and new device. Home automation system are very flexible and tend to easily accommodate any new appliance, device, or technology. Appliances will continue to evolve not matter how state-of-the-art they are currently; more advanced and impressive designs will come up as time goes (Vujovi? & Maksimovi?, 2015). As a home owner acquires new appliances and replaces old ones, it would be quite easy to remove and add new ones and facilitates them to easily upgraded to the newest technology.

Improve home security. Implementing surveillance and security components to the home automation enhances home security. There are several security features that can be implemented in a home automation system but only a few options are being considered currently for instance, automatic door locks, camera surveillance, motion detectors, among other options can be implemented and all this can be activated right from your mobile phone. One can also check the security status or receive alerts on the various home appliances and devices at any time of the day and monitor real-time activities of the various components.

Control of home functions remotely. Controlling home appliances and functions remotely-from a distance- is very convenient and should never be underestimated. When it is cold you can turn on the heater to warm the house before you get home or you can start the oven to start pre-heating some

food when you are hungry such that by the time you get home it will be ready. Additionally, you can check who is at the front door or if the lights are on, or turn off all the media when you are away.

Energy saving. Home automation system allows the home owners to control how the devices are used thus are able to turn off the appliances that are not being used to conserve energy. One can install a smart thermostat that can be program to schedule cooling or heating your home and learns your preferred temperatures and schedule and propose energy efficient configurations for the entire day. Motorized shades and lights can be set to turn on in the evening as the sun sets and automatically switch off when you get into the house.

Appliance functionality is improved. Automating home appliances and devices enable one to run and manage them more efficiently. For instance, if you have a smart TV, it will recommend your favorite tv programs and find better channels and applications for you or a smart oven will help you prepare chicken perfectly without undercooking or overcooking.

It provided insights to home management and provides more knowledge and how your home operates. One can be able to monitor what they cook, the frequency and channels you watch on TV, energy consumption, or the food in the fridge. One can be able to analyze every day habits from these insights and change the behavior or adjustments to fit the lifestyle you want.

Home automation saves one a lot of money. It allows you to only used the home appliances and systems when you need reducing the bills that you have to pay. Less energy will be consumed translating to less bills because the lights will remain off when you are not at home. Additionally, it reduces the worries of having to think whether or not you locked the door, turned off the lights or TV. You can also check on what is in the fridge and check which food or groceries to buy without going home to check then visiting a store to buy them.

We put a lot of effort, time, skills, and resources while developing the home automation system and ensure that it met all the set objectives. However, although we met our objectives, there are areas that can be improved to make the system better, easy to use, and more reliable. Additionally, the system has the following limitations:

- There are no sensors to automatic control appliance and provide real-time data logging.
- The system only allows connection of limited number of appliances.

The system can further be improved by interfacing it with various sensors to provide automatic monitoring and controlling of the appliances. For instance, temperature sensors could be placed in the rooms to provide the current room temperature and either turn the air conditioner, heater, or fan

on and off. Moreover, by interfacing Raspberry Pi and Arduino, more devices can be added to the system.

Technology integration will lead improve home automation technology through artificial intelligence and home components like door will open when it senses your DNA.

System improvements can be heightened by facing it with several sensors which will be offering provisions of automatic features for monitoring and controlling the appliances. A good example will be a situation where the sensors could be used in rooms where they will offer provisions to the current room with current room temperature and can also turn on the air conditioner, heaters in use or even the fan depending on the temperature in the room.

Home automation is still not viewed as a standard for every home owner despite not being a new industry. This is as a result of the slow transition in terms of growth for a number of decades up to now. This makes it hard to determine where technology in home automation with be in a number of years to come. Considering portable devices like tablets and smartphones, there is a possibility of designing home automations that will be capable of interacting with these devices while they are in our pockets.

The use of Home security systems is a new technology that is expected in the future as a great change. Last year, the release of user-friendly home security system was released by ADT. In fact, the system can connect with almost 16 dissimilar security cameras which can be managed by anyone with basic computer skills through an internet browser. Netatmo face-recognition camera is the most advanced camera which was released in the year 2015. This is a programmable camera that can be used to recognize friends and family member's faces and send a notification to the administrator's phone when any of them is at the doorstep. A live feed video can be watched and a notification sent in case of an unfamiliar face appearing at the doorstep.

Fire protection and carbon monoxide monitoring are one of the areas that are expected to rise in popularity by the use of smart home products to ensure family safety. There has been a release of the Nest protect which connects to other internet-enabled devices and smartphones acting like a fire alarm and carbon monoxide detector. To ensure an immediate protection of your home and family an alert is sent to the smartphone anytime an issue arises.

Due to the increased number of devices in our homes, there is a need for further integration of equipment for the sake of protecting and monitoring devices that are internet-enabled. For instance, Circle with Disney was released by Disney last year, a device that has capabilities to connect to a wireless router straight and remotely control all devices that are capable of accessing the internet. This device is also able to monitor access to sites that may be restricted alongside controlling the

maximum time one spends on a certain website and application. This being the case, parents can easily monitor the sites their children can visit and even allocate time to them accordingly. This is just some of the good things that come with these smart home devices whereby home owners can now make their family lives cheaper and safer.

In the current world, most people are investing more in state-of-the-art technology more than ever before. This is because of the fact that almost everyone wants to be associated with things apparatus that are as a result of technological innovations. In fact, there is concrete prove that more and more people are venturing into home automation software developed from smart technology. In particular, consider how it was hard for an ordinary citizen to have an internet that is fully-functioning in his home or even a music player or a touch-screen phone. Only those that were seen to be the most privileged in the society were termed as owners of technology. However, currently, most of these technological stuffs are to an extend seen as basic necessities whereby those who do not have access to them are seen as living in the past.

To be specific, as a result of technologies in home automation, there is a need to prioritize security and step up more advancements that witnessed (Meyer, 2008). To mention just but a few, issues to do with cyber-attacks and other internet related crimes is the reason as to why people have to be alert day-in-day-out. This extends to the central hosts of this valuable item being a house where there are high risks of burglars both at night and daytime. There is an advancement in these technologies where home owners can control locks, energy, among others making it safer in times of security breakdown in homes and other facilities (Kumar, 2018). As a result of these eminent and growing security threats, many home owners are driven to abandoning the past and manual methods and forced to embrace technology in terms of home automation for the purpose of securing themselves and their possessions.

Digital footprints have been shared to allow convenience. In the smart home tech, the physical footprint has been shared. In this, it does not matter how much the systems have been compromised and the consequences it will cause but the idea is the lost social security numbers (Elsenpeter & Velte, 2013). When one addresses privacy & security, this may be termed to be a very fundamental aspect that will help in shaping the industry.

Integration of Smart Home Devices.

This can break or make the smart home tech. when one navigates goofy artificial intelligence misunderstanding for about 12 appliances in the front door is not the future. The idea is the smart homes making sure that they can remember to turn on and off the lights or do lock up and lastly is the activation and deactivation of the alarms upon face recognition.

In this case when one wraps up all the repairs and renovates on the investment property, one may opt to install the Nest and Ring products which will offer a secure environment. Video surveillance has been used with AI in automating threat detections and in other cases proactively alerting on if there is something that is going awry (Cyril Jose & Malekian, 2015). This has been witnessed by the revolutionization of the human aspect in remote video monitoring.

Many home users will be carried away by the cool ways through which they can control their homes. Surveillance has become so necessary when it comes to combating crime as many people will be working from home and may need protection for their property may it be intellectual or physical (Schwartz, 2014). Appliances have also been focused by people in that they can take or carry more workloads.

Majority of applications are claimed to have revolved around the security and thermostats in 2017, claiming that the applications did not interoperate well. In this year makers of the smart home, gadgets have considered other platforms which will help the appliances to interoperate and much use cases emergence such as the diagnostics of the appliances, conservation of energy and thus helping in preventing the major issues and damages which may be caused by natural disasters (Bagale, 2017).

The sharing of data between the homeowners and the businesses is probably expected to be the next biggest thing in smart home tech. a good example is a situation where a fridge can order the food that you need or setting the lights and the needed temperature when one arrives at home (Li, et al., 2016). When on share such data with this home devices it will be of great interest to the associated companies that have helped in building such products.

Artificial Intelligence is always set for disrupting homes. Technology has become more efficient in that in the future one will be able to control everything from appliances to volumes of radios to security in a centralized location or place at home (Lalanda, et al., 2010). According to the anticipated Artificial Intelligence experienced within people there will be no need to control anything as all devices will be automatically controlled by adjusting to our preferences.

The entry of many smart home appliances' in the markets, there is a higher opportunity that the forward-thinking companies will be using the customers as differentiators. In the internet of things environment, there has been the presentation of major challenges which has been ranging from the consumers with basic troubleshooting problems to those with privacy concerns (Jamil & Ahmad, 2015). Companies which have been innovative and knowledgeable in delivering the customer service excellence will be the one remaining standing out.

in this case, a proliferation of solutions of integrated platforms will be seen as big players in technology. Amazon has been offering the in-home delivery of food straight to one fridge and thus leveraging it as a platform for the smart home. Security, in this case, will be a concern in that a customer can get robbed by the contractor (Goodwin, 2013). Another aspects or concern is hacking of passwords and thus making people to get robbed and this will need the big players to have planned for.

In this concept, there is an expectation of kitchen gadgets such as rice cookers to be connected to Alexa and the integrated apps.

This section gives a summary of the total cost that we incurred while developing, operating, and maintaining the home automated system.

Cost of development per hour=$10

Total working hours per day= 5

Total development days= 50

Total working hours= 50 x 5= 250 hours

Total development Cost= 250hrs x $10= $2500

Name	Quantity	Price
Raspberry Pi 2 Model B (1 GB RAM)	1	$300
MicroSD card 8GB	1	$20
Wi-Fi 802.11n dongle	1	$12

Relays(5V)	5	$25
Jumper Wires	1	$20
Resistors	1	$15
Capacitors	1	$15
PCB	1	$30
		$437

Cost of electricity= $10 per month

Software and hardware maintenance cost= $20 per month

Total maintenance cost= $30

Conclusion

In conclusion, the idea was to develop a complete working Home Automated system that has all the facilities which can control and do monitoring of all the appliances has been realized. The project outcomes are 27 on the array of appliances used at home which can be used over the internet using a mobile app and the facilities for streaming videos live. The project was a success in that the outcome showed that there was continuous and tireless effort from all the members who participated in the project, the supervisors, the associated faculties as well as colleagues and any other hands which helped.

This project was a great experience and a good opportunity through which one can learn and do experiments. More so, many authors can get a chance in which they can be able to get a chance

where they can closely experiment and much more learning about what happens in the design and development stages respectively of the home automated systems. There is a lot of delight in that all the above was explored with regards to this topic as the major project title and in one way or another, there was a creation of a version of home automated systems of our own. This has made it to closely relate with the current tech which was of greater interest when doing the study and the overall research in ensuring there is revolutionization of the way people live in the future. The following are some of the things and associated benefits which should be noted if such smart home automated appliance system is put into implementation in the future.

1. It will be self-sufficient

This can be achieved where one will be using the water harvesting systems and wind power thus helping one in becoming self-reliant.

2. There will the efficiency of energy.

Most smart home appliances are designed to be green and thus they utilize less amount of power. The sensors and detectors for cooking will allow very less waste.

3. The cost will be effective.

The misconception that is expensive should be developed to people in that they might be expensive when initially buying them but the save of energy at home will be cost-effective as it runs on a long-term basis.

4. Control

Smart home appliances have enabled to govern the appliances by just using an app on one's mobile phone irrespective where an individual is. This will enable one to do work even when far away from the point of work.

5. Quality of Life

People who have disabilities problems has gained a lot of advantages from the smart tech because when still at home they can operate on just using their voice commands and thus making such easy to use.

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