Ministry of Education and Science of Ukraine
Ternopil Ivan Pul'uj National Technical University

(full name of higher education institution)

Faculty of Computer Information Systems and Software Engineering

(faculty name)

Computer Systems and Networks Department

(full name of department)

QUALIFYING PAPER

for diploma project (thesis)

Bachelor

(educational-proficiency level)

topic: Computerized system of energy independent control of a smart house

Комп'ютерезована система енергонезалежного керування розумним будинком

Submitted by: fourth year student group ICI-42

Specialism (field of study)

123 «Computer Engineering»

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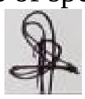

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Ternopil
2023

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(code and title)

APPROVED BY

Head of Department *Halyna Osukhivska*

Assignment
FOR QUALIFYING PAPER FOR STUDENT

Olakunle Oluwamayowa Raheem

(surname, name, patronymic)

1. Paper (thesis) theme. *Computerized system of energy independent control of a Smart House*

Project (thesis) supervisor Nataliia Stadnyk, PhD

(surname, name, patronymic, scientific degree, academic rank)

1.Approved by university order as of *20.04.2023 № 4/7-404*

2. Student's project (thesis) submission deadline 13.07.2023

3. Project (thesis) design basis *Technical assignment*

4. Contents of engineering analysis (list of issues to be developed)

Introduction

1. Analysis of the technical task

2. Project part

3. Practical part

4. Life safety, basics of labor protection

Conclusions

5. List of graphic material (with exact number of required drawings, slides)

1. Structural diagram

2. Basic electrical scheme

3. Diagram of electrical connections

4. Block diagram of the program algorithm

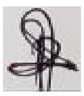
6. Advisors of design (thesis) chapters

Chapter	Advisor's surname, initials and position	Signature, date	
		assignment given	assignment accepted
Life Safety			
basics of labor protection			

7. Date the assignment was given *20.04.2023*

TIME SCHEDULE

L N	Diploma project (thesis) stages	Project (thesis) stages deadlines	Notes
1	*Development and approval of the technical assignment*	*20.04 – 28.04*	*Done*
2	*Analysis of the technical task and justification of the possible*	*20.04 – 30.05*	*Done*
	solutions		
3	*Development of a structural and functional scheme*	*18.05 – 30.05*	*Done*
4	*Selection of element base*	*18.05 – 30.05*	*Done*
5	*Development of software for the designed*	*18.05 – 30.05*	*Done*
	systems		
6	*Elaboration of the issues of the section "Security*	*20.05 – 25.05*	*Done*
	life activities, basics of labor protection"		
7	*Completion of the explanatory note of the qualification work*	*18.05 – 30.05*	*Done*
8	*Designing the graphic part*	*21.05 – 23.06*	*Done*
9	*Preliminary defense of a bachelor's thesis*	*04.06 – 28.06*	*Done*
10	*Defense of the bachelor's thesis*	*13.07*	*Done*

Student  *Olakunle Oluwamayowa Raheem*

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ABSTRACT

Computerized System Of Energy Independent Control Of A Smart House // Bachelors Qualification work // Olakunle Oluwamayowa Raheem // Ternopil Ivan Puluj National Technical University, Faculty of Computer Information Systems and Software Engineering, Department of Computer Systems and Networks, Group ICI-42 // Ternopil, 2023//

Keywords: Arduino Uno R3, Renewable energy, solar power.

This qualification work has been completed for a computerized system of energy independent control of a smart house.

The explanatory note contains 4 chapters.

In the first chapter, the analysis of the subject area is carried out. Conducted review of existing systems, their positive and negative sides are determined, as well as defined tasks of qualification work.

In the second chapter, a detailed structural diagram of the computerized system, a sequence diagram is described.

In the third chapter, the implementation of the computerized system of energy independent control of a smart house in real operating conditions is performed.

The fourth chapter describes the issues of life safety and the basics of labor protection.

CONTENT

LIST OF ACRONYMS

UDC - Ultrasonic distance sensor

LDR - LIGHT DEPENDENT RESISTOR

LED - LIGHT EMITTING DIODE

IR - Infrared

IC - INTEGRATED CIRCUIT

INTRODUCTION

Recent advancement of computer and electronic systems have led to development of automated systems that can do their job without the need for human input or interference. Furthermore, there has been growing interest in the development of systems of energy independent control. These are systems that aim to create a more sustainable and efficient way of managing energy usage by reducing reliance on traditional energy sources. This thesis will explore the current state of systems of energy independent control, their potential benefits, and their limitations. This thesis will also explore the use of electronic devices to demonstrate how we can create a computerized system which can effectively make a house “smart”. The goal is to provide insights into how these systems can be further developed and optimized to create a more sustainable future.

Energy efficiency is both important and required for the advancement and sustenance of humanity as inefficient use of energy can be very expensive both to our pockets and the environment. In recent times, solutions have been suggested to reduce our reliance on inefficient energy sources like fossil fuel. Solutions such as solar energy, wind energy, hydro-electric energy and so on have been proffered and have been adopted by a lot of countries but not at a wide scale. In addition to these solutions, we have found ways to manufacture electrical components that efficiently make use of energy and typically use very little amount of energy. These components can be combined to create sophisticated systems for different purposes and one such purpose is what will be covered in this thesis. This purpose is the use of these components to build a computerized system of energy independent control of a smart house.

In simpler terms, the project involves the use of these components to create a smart monitoring system which is energy efficient and does not require human interference in order to function. A house usually needs protection from intruders, ventilation, lighting (particularly at night) and sensing of natural conditions around the environment in order to make appropriate decisions. These chores can be done by humans but it can be inefficient and such inefficiencies can lead to an inefficient use of energy.

1 ANALYSIS OF SUBJECT AREA

1.1 Analysis of technical task

The goal of this project is an energy efficient way to build a smart home system. In addition, the smart home system should also be affordable and modular. Recent advancement in technology such as miniaturization of computer systems, increase in the number of components on a computer while being miniaturized and advancement in energy efficient technologies while increasing the capabilities of the system has made energy efficient and independent smart home projects possible.

In order to create a computerized system of energy-independent control of a smart house, we first need to understand what such a system should do and what it should be responsible for. In this situation, the system has about two or more capabilities.

- The ability to alert the inhabitants of the house of an intruder or a visitor.
- The ability to automatically control the lights in the house.
- The ability to sense moisture in the house.
- The ability to sense intruders in the dark.
- The ability to relay messages on what it is monitoring to the user’s smartphone through wireless means.

In addition, the system has to rely on renewable energy and also efficiently use the energy and in response to this, we have to use components that are energy efficient and affordable.

Also, in order for the system to do the things that it is required to do, it needs sensors that can send signals to a microcontroller and the microcontroller will be programmed to respond to these signals through other devices.

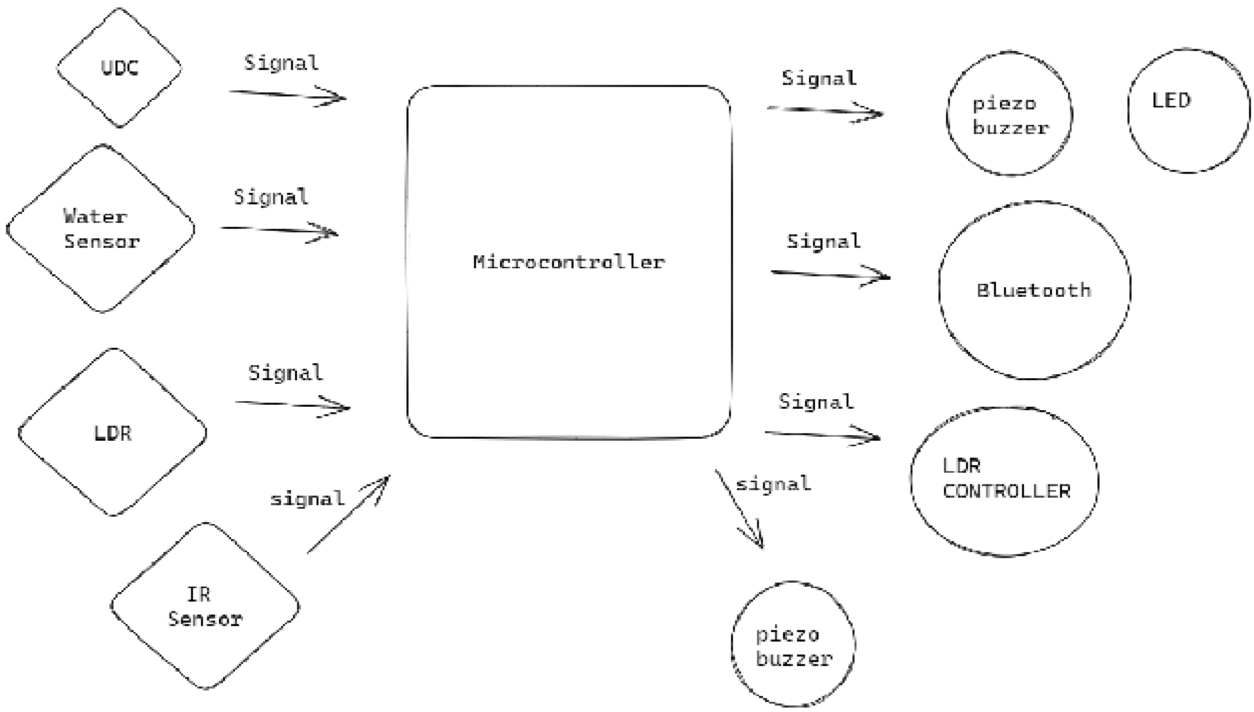

Figure 1.1 - Rough sketch of system

In the above diagrams, a rough visual representation of how the system will work is shown. The ultrasonic distance sensor sends electrical signals to the microcontroller and the microcontroller relays that signal to the led and optionally, the piezo buzzer. When the led lights up or the piezo buzzer buzzes, we can confidently tell that we have a moving body near the house. This is a very efficient and cheap way to secure the home from intruders. We also have the water sensor which senses moisture levels and can alert us if it is raining. The water sensor sends a signal to the bluetooth device which can notify us of rain through our smart phone. The LDR is responsible for sensing light intensity. The LDR is a special resistor whose resistance is dependent on the intensity of light it senses. It can be programmed in whatever way we want, through the microcontroller. In this case, we program the LDR in accordance with the LDR controller to switch on the LEDs when there is not enough light and vice versa. The IR sensor or the PIR (Passive Infrared Sensor) is a device that can sense light radiating from objects in its field of view. This is fantastic for sensing movement around the home since living organisms typically radiate infrared to their surroundings and the PIR sensor can sense it. The PIR sensor can send signals to the microcontroller and this signal can be used to control piezo buzzers to make sound.

The second diagram Figure 1.2 describes a solar panel and a battery. The solar panel is a device that converts solar energy into electrical energy. The energy is transferred to the battery which is capable of storing the electrical energy as chemical energy and transmitting it as electrical energy to an electrical circuit. This completes the computerized system of energy-independent control of the smart house.

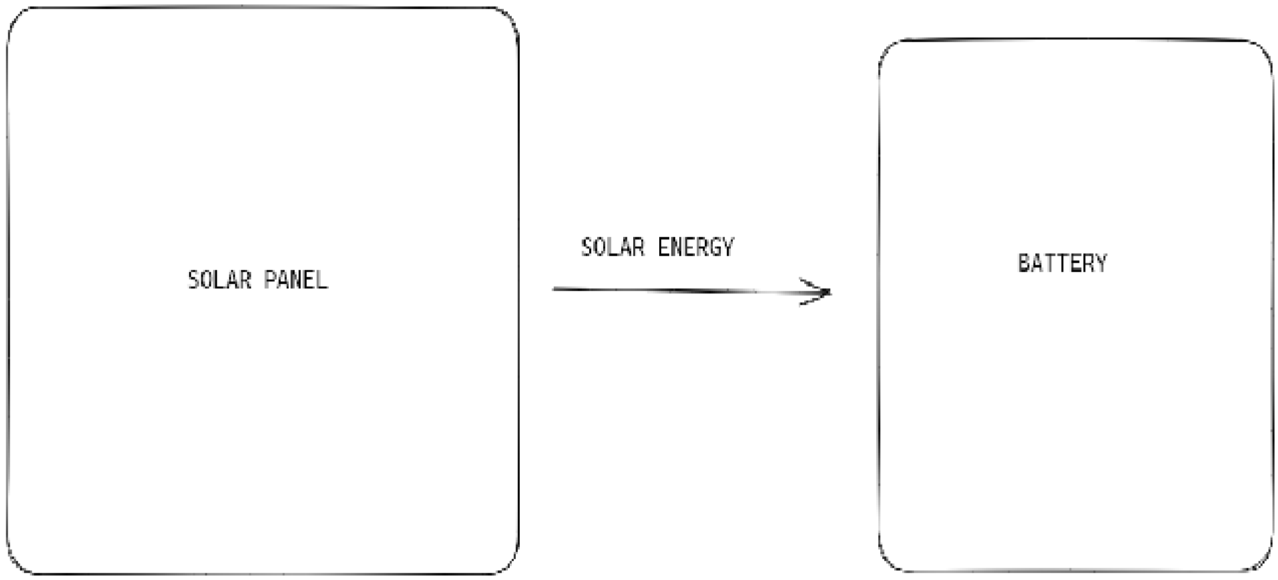

Figure 1.2 - Rough sketch of solar panel and battery

1.2 Basic requirement of system

- The ultrasonic distance sensor should not be more than a certain distance from the entrance of the house. The signal received by the UDS should be transmitted to the microcontroller and that signal should be transmitted to the indicators as fast as possible.

- The infrared sensor should be able to detect infrared radiation within its field of view and it will also be used for remote control of components in the system.

- The piezo buzzer has to be as loud as 90db to alert us of intruders.

- The solar panel and the battery are expected to be in the best of conditions as this system will not require external electricity. The battery will be used for powering the light dependent resistor controller and will not really be used as an energy source for the system. The energy source will be the solar panel.

- The Light Dependent resistor will be responsible for controlling the lights depending on the time of the day and the intensity of light in the environment.

- The water detector in combination with the rain sensor will both be responsible for the detection of moisture in the atmosphere and relaying the message to the smartphone.

- The Bluetooth module is an important part of the system. With the bluetooth module, we can connect to a remote device using bluetooth technology and multiple important information can be sent to the device, which is typically a smartphone.

- The Light emitting diodes will serve as a light source within the smart house. Primarily, they can be referred to as indicators for the light dependent resistors since they are going to be controlled by the LDR. Additionally, they are also an indicator of the fact that the problem of needing to manually turn off or turn on lights has been solved using the LDR.

Application of energy independent smart house system:

- Security is the most important sector when it comes to a smart house system. A smart house system with no dependence on non-renewable energy and energy efficiency is perfect for security of residence. Instead of needing the services of a security agency or personnel, the smart home system can be an effective, affordable and energy efficient alternative. Smart home systems offer advanced security features, including motion sensors, door/window sensors, video doorbells, and surveillance cameras. These devices can be monitored and controlled remotely, providing homeowners with real-time alerts, video footage, and the ability to interact with visitors or deter potential intruders.

- Home Automation. This topic is the main objective of a smart home system. The smart home system can serve as a digital assistance for multiple chores and this can de-burden the inhabitants of the home and help them focus on more important things.

- Environmental Monitoring. The smart home system can also serve as a medium for monitoring environmental conditions in the house. Smart home systems can integrate environmental sensors to monitor factors such as temperature, humidity, air quality and CO_2 levels. This information can help homeowners maintain a healthy and comfortable living environment, while also enabling automatic adjustments to HVAC systems for optimal comfort and energy efficiency.

- Energy management can also monitor and control energy consumption by assisting in adjusting lighting levels, managing heating and cooling systems based on occupancy or schedule, both of which can be derived from sensors that are connected to or part of the system. They can also provide real-time energy usage data to homeowners. This is very critical to the objective of an energy independent computerized smart home as this will help reduce cost and also improve eco-friendliness.

- Water and Leak Management can incorporate water sensors and leak detection devices to identify leaks, monitor water usage, and automatically shut off water supply to prevent damage. This is another example of a smart home's energy efficiency and pocket friendly advantage as this can help homeowners save water, avoid costly repairs, and provide early detection of potential water-related issues.

- Voice Control and Virtual Assistants are compatible with voice assistants like Amazon Alexa, Google Assistant, or Apple Siri. This allows homeowners to control various aspects of their home using voice commands, such as adjusting lights, playing music, checking the weather, or accessing information.

- Energy Monitoring and Analysis. Smart home systems provide real-time energy monitoring and analysis capabilities. They can track energy usage patterns, identify energy-intensive devices or behaviors, and provide detailed insights into energy consumption. This information enables homeowners to make informed decisions about their energy usage and identify opportunities for efficiency improvements.

- Automated Lighting Control play a significant role in energy efficiency. They allow for automated control of lighting based on occupancy, time of day, or natural light levels. Motion sensors, occupancy sensors, and ambient light sensors can be integrated with the smart home system to ensure that lights are only active when needed. This avoids unnecessary energy waste and lowers electricity bills.

- HVAC Optimization. Heating, ventilation, and air conditioning (HVAC) systems are among the largest consumers of energy in a home. Smart home systems can optimize HVAC usage by adjusting temperature settings based on occupancy, outdoor weather conditions, and personalized preferences. Additionally, smart thermostats enable homeowners to remotely control and program their HVAC systems for energy-efficient operation.

- Appliance Control and Automation can manage and automate the operation of appliances for energy efficiency. They can schedule appliances to operate during off-peak hours when electricity rates are lower. Furthermore, smart plugs or outlets can be used to remotely control and monitor the energy usage of individual appliances, providing visibility and control over energy consumption.

- Energy-Responsive Automation can be integrated with energy management systems or utility programs that provide real-time energy pricing information. This allows the system to automatically adjust energy-consuming devices, such as pool pumps, electric water heaters, or electric vehicle chargers, to take advantage of lower-cost energy periods and reduce overall energy expenses.

- Integration with Renewable Energy Sources can facilitate the integration and optimization of renewable energy sources, such as solar panels or wind turbines. They can monitor energy production, manage energy storage in batteries, and intelligently distribute energy throughout the home based on demand and availability. This maximizes the utilization of renewable energy and reduces reliance on grid-supplied electricity.

- Smart Energy Management Platforms can integrate with energy management platforms or energy monitoring apps. These platforms provide users with detailed insights into their energy usage, personalized recommendations for energy-saving practices, and the ability to set energy-saving goals. They can also provide alerts or notifications about high energy consumption, enabling homeowners to take corrective actions promptly.

- Behavioral Insights and Recommendations can analyze energy usage patterns and provide behavioral insights to homeowners. They can detect wasteful energy practices or identify opportunities for improvement, such as adjusting thermostat settings, optimizing appliance usage, or adopting energy-efficient behaviors. By providing personalized recommendations, homeowners can make informed decisions to conserve energy.

- Demand Response Programs can participate in demand response programs. These programs allow utility companies to temporarily adjust energy consumption during peak periods to manage grid load. Smart home systems can automatically respond to signals from the utility company, reducing energy consumption during critical times and contributing to grid stability.

- Energy Efficiency Certifications and Standards can comply with energy efficiency certifications and standards, such as energy star, to ensure their devices and components meet stringent energy performance criteria. This promotes the use of energy-efficient products and encourages homeowners to adopt sustainable practices.

2 PROJECT PART

2.1 Development of the structure of the system

In the current world, energy efficiency is currently the most sought after innovation and this is evident from the amount of research and development that has gone into this subject. We have seen advances in energy dependent sectors such as the smartphone industry, the electric vehicle industry, and so on. We have had integrated circuits that can use a third of the energy requirements of their predecessors while doing more work and at a more efficient rate, we have seen electric vehicles that are incredibly eco-friendly, and renewable power sources that generate clean energy and are typically paired with electrical components that are energy efficient.

Along with this need for energy efficiency comes the need to ease unnecessary work. Menial tasks such as watching for intruders in one's abode, switching off lights in order to conserve energy and observing the environment for natural conditions that can potentially cause inconveniences in one's house can be fully automated and in turn, be energy efficient to the point that one does not even need to be add the system to their home electrical grid. This efficiency can be economically beneficial and its maintenance is potentially minimal.

Although, one might object to this apparently simple and efficient system and protest that CCTVs, automatic doors, ultrasonic detectors and photoelectric detectors already solve the problem of insecurity, they are typically very expensive, consume a lot of electrical energy and on top of that, can be very expensive to maintain. These problems make the aforementioned solutions inaccessible and too expensive for the average homeowner to afford without breaking the bank. Enterprises may be able to afford these solutions but usually at a steep cost which involves training personnels to make use of the systems and procuring the hardware required for the system.

However, the energy-independent system being suggested is a combination of affordability and energy efficiency. At its core, it has no clear disadvantage and is accessible for anyone who needs a simple and modular system to make their homes automated and smart. In addition, this system requires minimal to no human intervention to function.

Furthermore, this system does not need too much space to function. It takes minimal space and is not a burden on the ventilation system of the home. This system does not emit any greenhouse gas as all its components are entirely electronic and static in nature and it does not require any waste management system because it does not emit any kind of material that is a detriment to the environment. In a nutshell, it is eco-friendly and in an unlikely event of a malfunction, the components can be easily recycled and replaced at a small cost.

A home or a house is the smallest unit of a society. A home typically houses a household and serves as a communion point for a family. A home is also considered the safe space of one person or a group of people and it is the location everyone goes back to, after a long day of work or school. Conceptually speaking, everyone has a home for several purposes ranging from privacy, shelter, protection from the harsh elements of the environment, mental solace and a place of rest. The home is the most important part of everyone's life and without a home, it is difficult to function properly as a human being.

Although the home serves several important purposes, it can be subject to danger from armed robbery, burglary, carbon monoxide poisoning, fire, lack of ventilation and so on. As a result of the problems posed by these dangers, we all seek to properly protect our homes from them and some of the ways that humans have found are hiring security people to protect our homes, installing security cameras to monitor the surrounding, installing smoke and fire alarms to notify us of a potential fire outbreak and so on. These steps are very good steps and have saved a lot of homes from potential danger but the precautions can sometimes be a bit too expensive for a lot of people to afford. For example, only a small percentage of the population can afford to employ people to guard their homes and in fact, these hires can actually be a danger to that home by conniving with a group of people to rob their employers. Also, security cameras can be very expensive and without a personnel to monitor them, it may be very difficult for us to prevent intruders from entering our homes and potentially causing harm to our loved ones or stealing our prized belongings. In addition to this, some of these security equipment can be very expensive and so fragmented, that they consume so much electricity and might not be so effective in securing the home.

In order to proffer a solution, one has to consider several factors. Factors such as affordability, energy efficiency, eco-friendliness, maintainability and modularity.

- Affordability is the quality of being affordable. Something that is affordable is measured by its cost relative to the amount that the buyer is capable of paying. If something is affordable, it means that the consumer is able to pay for the goods without needing to break the bank. In our case, the system we are going to suggest has to be very affordable and can be purchased by anyone who needs such a system without paying through their noses.

- Energy efficiency can be defined as the quality of being able to utilize a resource without wastage. To paint a scenario, we have two vehicles A and B. Vehicle A requires 3 liters of petrol to cover 10 kilometers while Vehicle B requires 1.5 liters of petrol to cover the same distance. From the aforementioned example, we can infer that Vehicle B is more efficient than Vehicle A. In our case, our proposed system must be capable of efficiently consuming energy. This quality is both beneficial to the pocket of the user and the environment because it means that the system's wastage will be superbly minimal.

- Eco-friendliness is the quality of being non-damaging to the natural environment. Ecology is an important part of our existence and without a healthy exchange of resources in the environment, the environment will be hostile to life. Nowadays, it is important for products to be eco-friendly in order to reduce damage to the environment and consequently, improve the lives of the inhabitants of the environment. In this case, our proposed system must be eco-friendly in order for it to play nicely and fit perfectly into our homes. This system is effectively benign.

- Maintainability should also be easy to maintain. If there is a problem in the system, it should be easy to detect and effectively repair.

- Modularity should also have the quality of being modular. In simpler terms, modularity basically involves splitting our system into smaller parts which can then be combined to form a system that is maintainable and easy to work with.

Conceptually speaking, the system is a combination of an array of sensors and an array of indicators. The sensors are responsible for observing changes in the environment and the indicators depend on the signal sent from the sensors. In order to achieve modularity and separate concerns, a programmable microcontroller is used to relay the signals from the sensors to indicators. The system is powered by a solar panel which is connected to a battery. The battery saves electrical energy from the solar panel and stores the electrical energy as chemical energy until it is needed by the electrical circuit.

As earlier stated, the system is modular and energy efficient because of the kind of components that are used. For example, the ultrasonic distance sensor used is an hc-sr04 which is a cheap, fast and power efficient ultrasonic distance sensor. The microcontroller is a powerful arduino uno r3 microcontroller which is popular for its affordability, durability and programmability. The system also has an infrared sensor for controlling the system and also for surveillance.

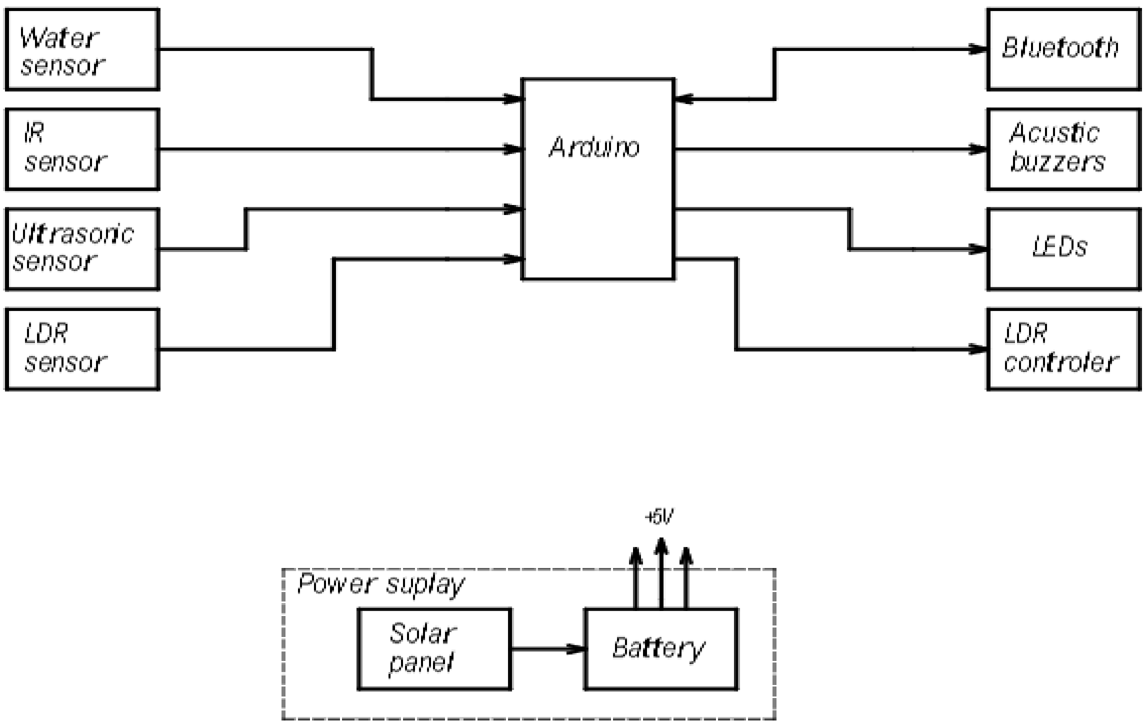

Figure 2.1 – Block scheme for the computerized system of energy independent control of a smart house

2.2 Justification of Hardware Selection

2.2.1 Selection of Arduino Uno R3 Microcontroller

The microcontroller is the most important component in the system. It is basically the brain and heart of the computer. It controls how each component responds, sends signals and how they receive signals. Without the microcontroller, the system will not be a system but a fragmented connection of components without a means to communicate with each other.

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

Sometimes referred to as an embedded controller or microcontroller unit (MCU), microcontrollers are found in vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances, among other devices. They are essentially simple miniature personal computers (PCs) designed to control small features of a larger component, without a complex front-end operating system (OS).

A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor. The temporary information that the microcontroller receives is stored in its data memory, where the processor accesses it and uses instructions stored in its program memory to decipher and apply the incoming data. It then uses its I/O peripherals to communicate and enact the appropriate action.

Microcontrollers are used in a wide array of systems and devices. Devices often utilize multiple microcontrollers that work together within the device to handle their respective tasks.

For example, a car might have many microcontrollers that control various individual systems within, such as the anti-lock braking system, traction control, fuel injection or suspension control. All the microcontrollers communicate with each other to inform the correct actions. Some might communicate with a more complex central computer within the car, and others might only communicate with other microcontrollers. They send and receive data using their I/O peripherals and process that data to perform their designated tasks.

Elements of a microcontroller:

- The Processor is a component within most computers that is responsible for computation operations. It can be thought of as the brain of the computer. It processes and responds to various operations that direct the microcontroller’s function. The processor handles all logical, arithmetic and input/output operations. It also handles data transfer operations, which communicates commands to other components in the larger embedded system.

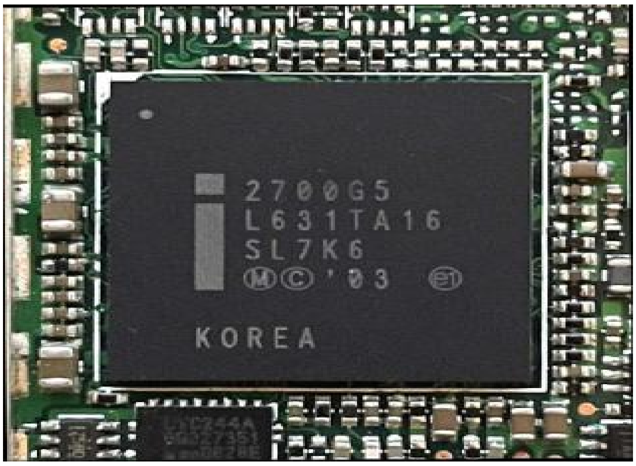

Fig 2.2 - Zoomed in Picture of a Microprocessor

- The Memory is the component which stores data that the processor receives and uses to respond to instructions that it has been programmed to carry out. A microcontroller has two main types of memory:

1) Program Memory. This type of memory stores long-term information which the microcontroller uses to perform operations it has been programmed to solve. Program memory is a non-volatile type of memory, which means it holds information for a long time without needing a power source.

2) Data memory. This type of memory temporarily stores data during the execution of instructions. Data memory is a volatile type of memory, which means it holds information for a short period of time and that information is only stored while the computer is connected to a power source.

- I/O Peripherals are an interface which connect the processor to the outside world. The input ports/peripherals are responsible for receiving the data from input devices and the output ports/peripherals are responsible for transmission of processed data from the processor to the output devices.

Other Supporting Elements of The Microcontroller are:

- Analog to Digital Converter is a circuit which converts analog signal into digital signal. It enables the microcontroller to communicate with analog devices.

- Digital to Analog Converter is a circuit which converts digital signal into analog signal. It enables the microcontroller to communicate with digital devices.

- The system bus is one of the most important elements which extends the connectivity of a microcontroller and its surrounding system. The system bus is a system of connections which link external components and the microcontroller together. Without an interconnectivity of wires, we cannot have a system.

The microcontroller board which was selected for this project is the arduino uno r3. A popular, affordable, durable and energy efficient microcontroller which is used for a lot of hobbyist embedded systems projects. The arduino uno r3 is a microcontroller board based on the ATmega328P, it has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHZ ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller.

The arduino uno r3 has the ATmega328P processor. The ATmega328P is a high performance, low power controller from microchip. It is an 8 bit microcontroller based on AVR RISC architecture. It is the most popular of all AVR controllers. The ATmega328P is a 28 pin chip and many of the pins have multiple functions.

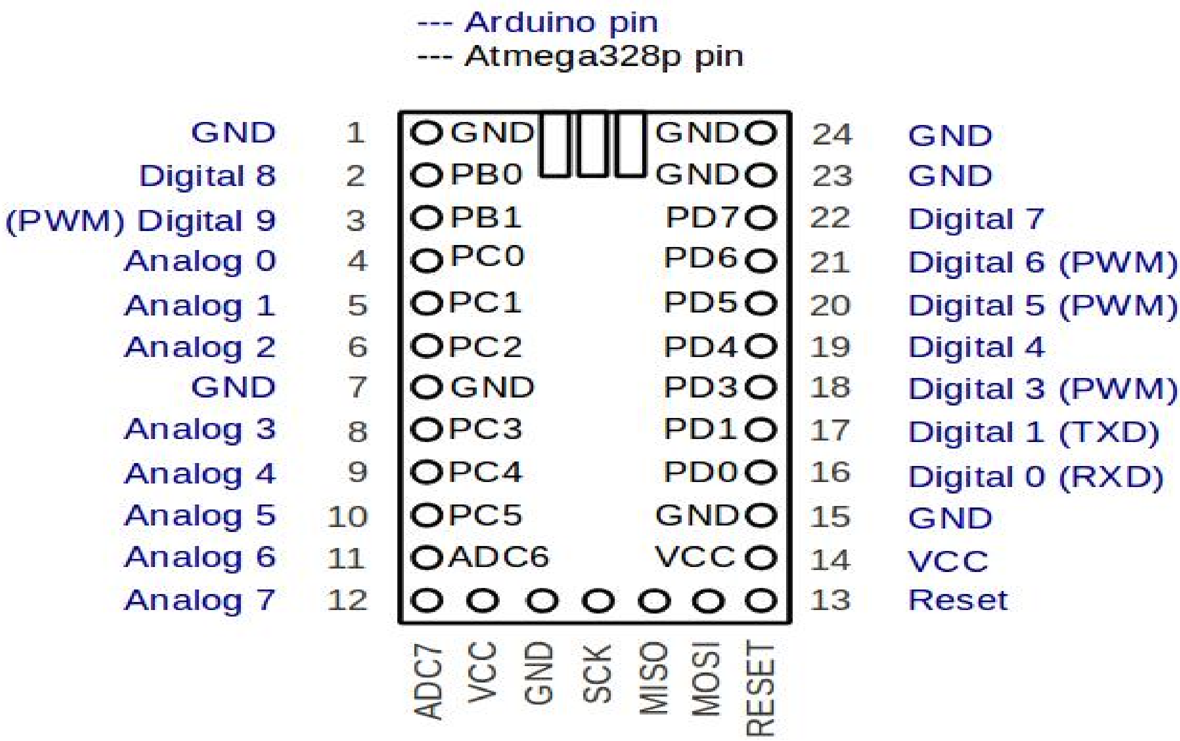

Figure 2.3 - Atmega328P chip

- Digital Input/Output is responsible for receiving and transmitting digital signals to components connected to it. This is an important component in the arduino microcontroller and is widely used in a lot of projects.
- Built in LED. The arduino chip also contains built in leds.
- 16MHZ Ceramic Resonator is used to help the microcontroller keep track of time or provide a stable clock signal.
- ATmega328P is the integrated circuit within the arduino chip and is basically the brain of the Arduino Uno R3. It is responsible for computer processing from logic to arithmetic processes and without it, the arduino will not be able to function.

- ICSP (In-circuit serial programming) is responsible for programming the ATmega328P circuit. It is responsible for the programmability of the Arduino Uno R3.

- The analog input is responsible for receiving analog signals. These signals are then converted into digital signals to be outputted by the microcontroller.

- Reset Button is used to reset the arduino to its default state.

- The USB connector can be used to power the arduino or be connected to a computer to receive user created programs.

- The poly fuse is used to protect the arduino from excessive current flow. This is very important in order to protect the microcontroller from permanent damage.

- DC Barrel Jack helps supply power to the microcontroller.

Arduino uno r3 has a wide range of applications across various fields, including home automation, robotics, Internet of Things (IoT), and industrial automation. It is commonly used in DIY projects due to its simplicity and low cost. In home automation, Arduino can be used to control lighting, temperature, and security systems. In robotics, it can be used to control sensors and actuators. In IoT, it can be used to collect and send data from sensors to the cloud for analysis. In industrial automation, it can be used to control and monitor machinery. Overall, Arduino is a versatile platform that can be used for a variety of applications.

In home automation, the Arduino Uno R3 can be used to control various devices such as lights, fans, and air conditioners. It can also be used to sense temperature, humidity, and other environmental factors. The board can be
connected to sensors and actuators to create an automated home that can be controlled with a smartphone or computer. With the help of the Bluetooth module, the board can be connected to a smartphone and controlled remotely.

In robotics, the Arduino Uno R3 can be used as the brain of a robot. It can be used to control motors, sensors, and other components. The board can be programmed to perform various tasks such as obstacle avoidance, line following, and object detection. The board's compatibility with various sensors and actuators makes it easy to create a robot that can perform complex tasks.

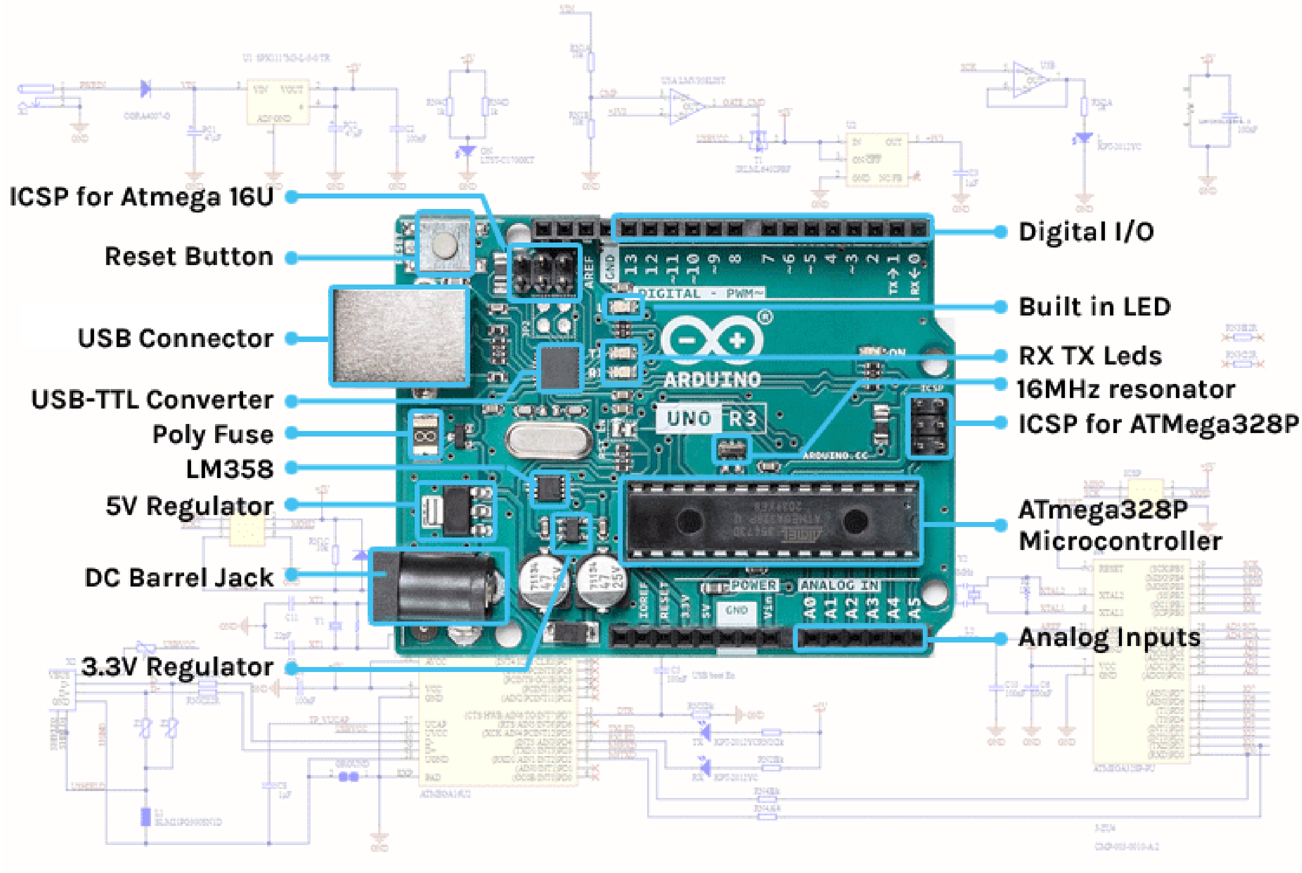

Figure 2.4 – Labeled picture Arduino Uno R3

In DIY projects, the Arduino Uno R3 can be used to create various electronic projects. It can be used to build a weather station that can sense temperature, humidity, and other environmental factors. It can also be used to create a home security system that can detect motion and send alerts to a smartphone. The board can be programmed to perform various tasks and can be connected to various sensors and actuators to create custom projects.

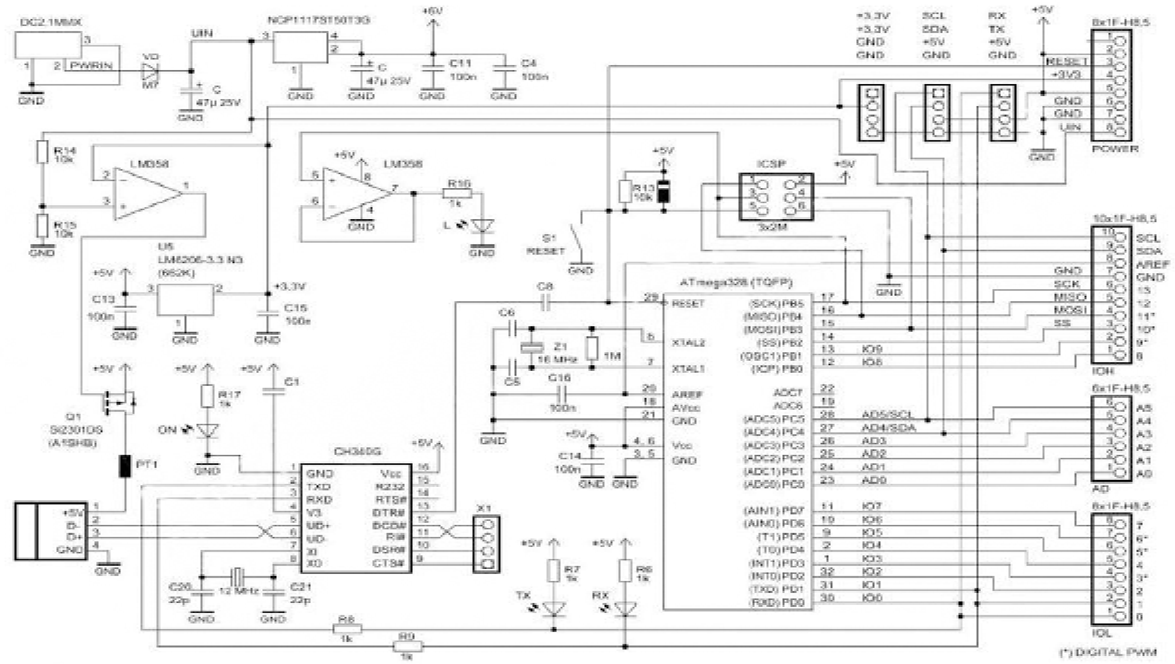

Figure 2.5 – Circuit diagram of Arduino Uno R3

In conclusion, the Arduino Uno R3 is a versatile microcontroller board that can be used for a variety of applications. Its compatibility with various shields and sensors makes it easy to expand its capabilities. Its ease of use and affordability make it a popular choice for DIY projects, robotics, and home automation.

2.2.2 Selection of Hc-Sr04 Ultrasonic Distance Sensor

The ultrasonic distance sensor used for this project is the HC-SR04, which is a very popular model for hobbyist and embedded systems engineers alike. In this project, its primary purpose is to sense intruders.

An Ultrasonic distance sensor is an instrument that measures the distance of an object using ultrasonic sound waves.

An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object’s proximity.

High frequency sound waves reflect from boundaries to produce distinct echo patterns.

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse. An ultrasonic sensor can convert electrical energy into acoustic waves and vice versa. Typically, a microcontroller is used for communication with an ultrasonic sensor. To begin measuring the distance, the microcontroller sends a trigger signal to the ultrasonic sensor. The duty cycle of this trigger signal is 10µS for the HC-SR04 ultrasonic sensor. When triggered, the ultrasonic sensor generates eight acoustic (ultrasonic) wave bursts and initiates a time counter. As soon as the reflected (echo) signal is received, the timer stops. The output of the ultrasonic sensor is a high pulse with the same duration as the time difference between transmitted ultrasonic bursts and the received echo signal.

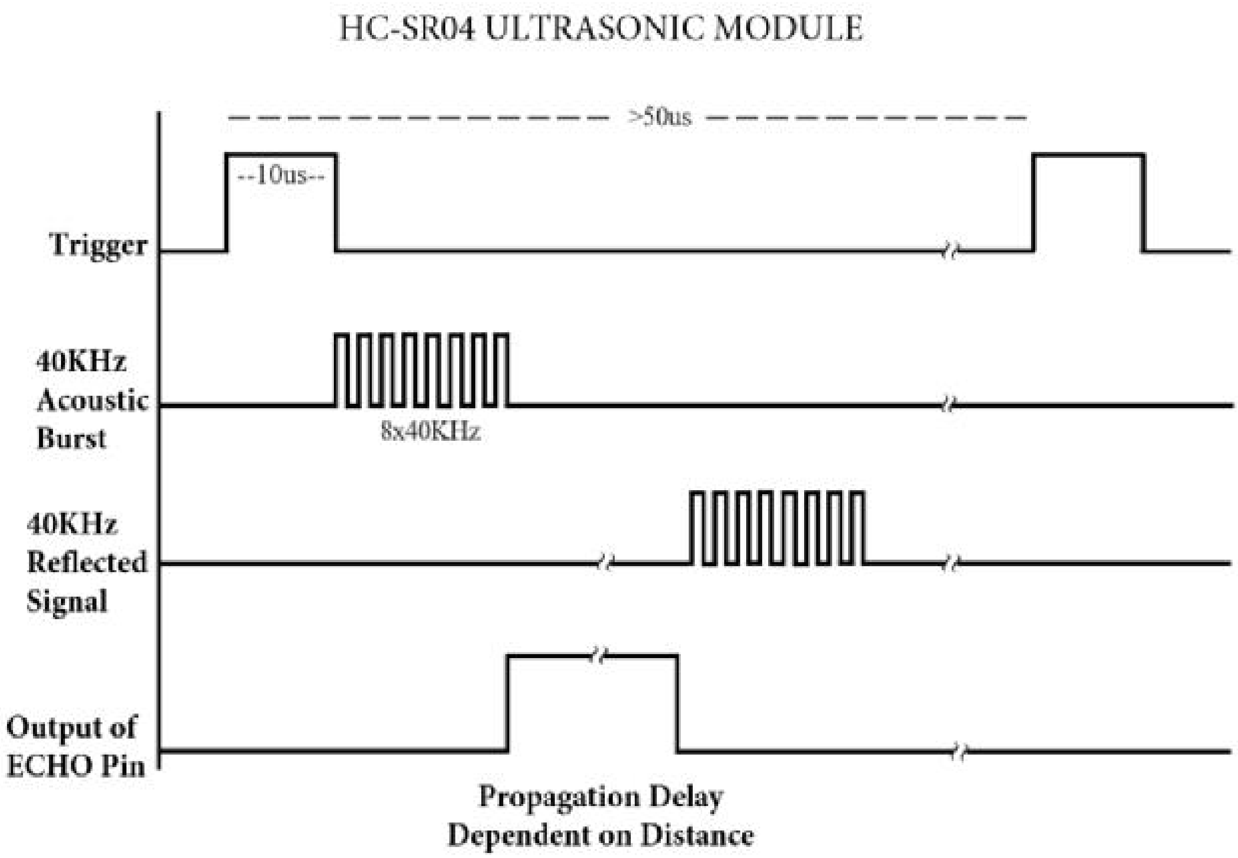

Figure 2.6 Trigger signal of the Ultrasonic distance sensor

The microcontroller interprets the time signal into distance using the following function:

$$Distance\ (cm) = \frac{echo\ pulse\ width\ (uS)}{58}$$

$$Distance\ (inch) = \frac{echo\ pulse\ width\ (uS)}{148}$$

Theoretically, the distance can be calculated using the TRD (time/rate/distance) measurement formula. Since the calculated distance is the distance traveled from the ultrasonic transducer to the object—and back to the transducer—it is a two-way trip. By dividing this distance by 2, you can determine the actual distance from the transducer to the object. Ultrasonic waves travel at the speed of sound (343 m/s at 20°C). The distance between the object and the sensor is half of the distance traveled by the sound wave.[iv] The following equation calculates the distance to an object placed in front of an ultrasonic sensor:

$$distance = \frac{time\ taken\ x\ speed\ of\ sound}{2}$$

The HC-SRO4 is a very popular ultrasonic distance sensor which is used for a lot of projects because of its affordability and energy efficiency. The HC-SR04 provides 2cm-400cm non-contact measurement function, the ranging capacity can reach up to 3mm. The HC-SR04 Ultrasonic ranging module as it is officially called, includes ultrasonic transmitters, receiver and control circuit.

Figure 2.7 - HC-SR04 Ultrasonic distance sensor

2.2.3 Selection of Infrared Sensor

An infrared sensor is a radiation-sensitive optoelectronic component with a spectral sensitivity in the infrared wavelength range 780mm - 50m. IR sensors are now widely used in motion detectors, which are used in building services to switch on lamps or in alarm systems to detect unwelcome guests. In a defined angle range, the sensor elements detect the heat radiation (infrared radiation) that changes over time and space due to the movement of people. Such infrared sensors only have to meet relatively low requirements and are low-cost mass-produced items. The type of infrared sensor used here is called a passive infrared sensor (PIR). The term *passive* refers to the fact that PIR devices do not radiate energy for detection purposes. They work entirely by detecting infrared radiation (radiant heat) emitted by or reflected from objects.

Infrared sensors work based on the principle that all objects with an absolute temperature above zero emit heat energy in the form of electromagnetic radiation. A PIR sensor can detect changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in the field of view of the sensor. When an object, such as a person, passes in front of the background, such as a wall, the temperature at that point in the sensor’s field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection.

PIR sensors come in different configurations for a wide variety of applications. The most common models have fresnel lenses or mirror segments, an effective range of about 10 meters and a field of view of less than 180 degrees.

Applications of Passive infrared sensors:

- Movement Detection. Passive infrared sensors are typically used for detecting movement within a field of view.

- Automatic Lighting. Passive infrared sensors are also used to control lighting systems.

In this project, PIRs are used for sensing intruders. When the PIR sensor observes a change in radiation within its field of view, it will send a signal to the microcontroller. This signal is then sent based on the programming of the microcontroller, to the piezo buzzer.

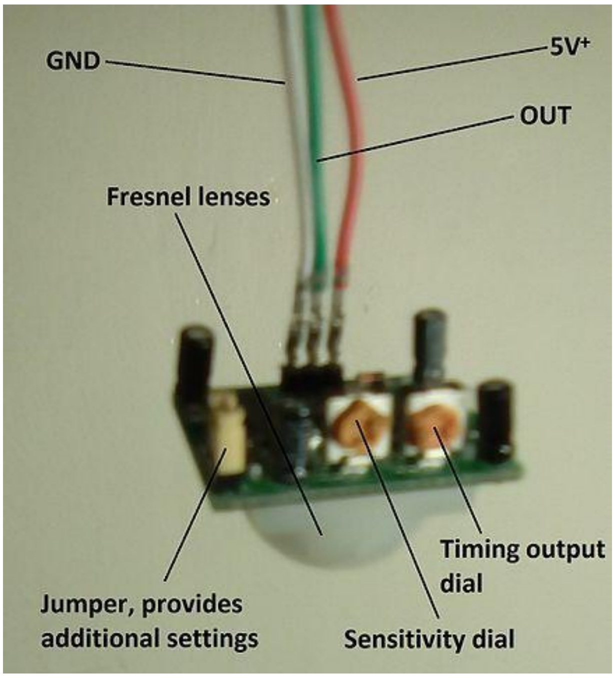

Figure 2.8 – Connection Passive infrared sensor

2.2.4 Selection of Rain Sensor

A rain sensor is a device which is used to detect rainfall. The rain sensor works like a switch and the working principle of this sensor is, whenever there is rain, the switch will be normally closed.

Basically, the rain sensor board includes nickel coated lines and it works on the resistance principle. This sensor module permits to gauge moisture through analog output pins and it gives a digital output when the moisture threshold is exceeded.

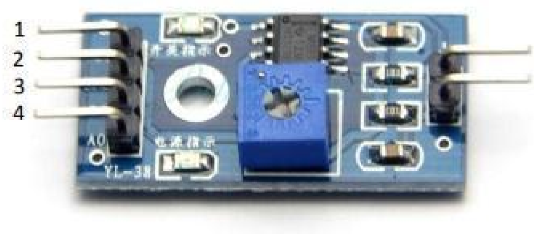

Figure 2.9 - Rain sensor module

The PCB is used to collect moisture. When the raindrop falls on the module, it creates a parallel resistance path to calculate through the operational amplifier.

This sensor is a resistive dipole, and its resistance is based on the amount of moisture present on the PCB. The more moisture it senses, the less the resistance and vice versa.

The pin configuration of this sensor is shown below. This sensor includes four pins which include the following.

- Pin1 (VCC): It is a 5V DC pin.
- Pin2 (GND): it is a GND (ground) pin.
- Pin3 (DO): It is a low/ high output pin.
- Pin4 (AO): It is an analog output pin.

The specifications of the rain sensor include the following (fig. 2.10):

- This sensor module uses good quality double-sided material.
- Anti-conductivity & oxidation with long time use.

- The area of this sensor includes 5cm x 4cm and can be built with a nickel plate on the side.

- The sensitivity can be adjusted by a potentiometer.

- The required voltage is 5V.

- The size of the small PCB is 3.2cm x 1.4cm.

- For easy installation, it uses bolt holes.

- It uses an LM393 comparator with wide voltage.

- The output of the comparator is a clean waveform and driving capacity is above 15mA.

Figure 2.10 - Water detector and Rain Sensor Module

Technical characteristics Water detector:

- This sensor module uses good quality double-sided material.

- Anti-conductivity & oxidation with long time use

- The area of this sensor includes 5cm x 4cm and can be built with a nickel plate on the side.

- The sensitivity can be adjusted by a potentiometer.

- The required voltage is 5V.

- The size of the small PCB is 3.2cm x 1.4cm.

- For easy installation, it uses bolt holes

- It uses an LM393 comparator with wide voltage.

- The output of the comparator is a clean waveform and driving capacity is above 15mA.

2.2.5 Selection of Piezo Buzzer

An acoustic buzzer or piezo buzzer is an electronic component that produces sound. It is commonly used in alarm systems, musical instruments, and other electronic devices that require an audible alert. The buzzer consists of a piezoelectric disk that vibrates when an electric current is passed through it. This vibration produces an audible sound.

Fig 2.11 - Piezo Buzzer

The sound produced by the buzzer can be controlled by changing the frequency and duration of the electric current passed through it. In the context of the thesis, the acoustic buzzer is used to alert the inhabitants of the smart house of any intrusion or movement detected by the ultrasonic sensors.

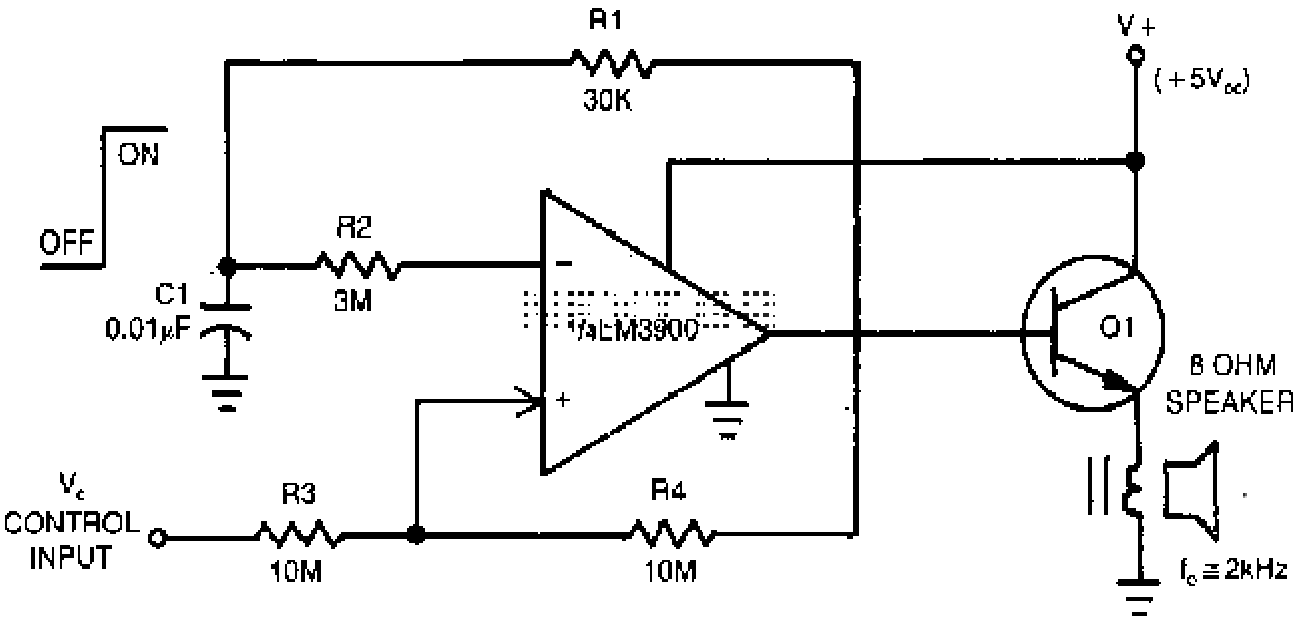

Fig 2.12 - Circuit diagram of Piezo Buzzer

2.2.6   Selection of Solar Panel

As earlier stated, this project is intended to be energy efficient and the energy source should be cheap and renewable. In response to this, the power source for the system is renewable. The system uses a solar panel for energy.

A solar panel is a device that converts solar energy into electrical energy by using photovoltaic cells. Photovoltaic cells are made of materials that generate electrons when exposed to light.

Photovoltaic modules consist of a large number of solar cells and use light energy from the sun to generate electricity through the photovoltaic effect. Most modules use wafer-based crystalline silicon cells or thin film cells. The structural member of a module can be either the top layer or the back layer.

The way that a solar panel works is well understood and easy to replicate but a primitive replication may not be able to produce enough electrical energy. When a black body is exposed to sunlight, the black body absorbs all the wavelengths of the sunlight. This can be seen when one walks barefoot along an asphalt road on a sunny day. The asphalt emits a lot of heat and can make it very difficult to walk barefoot on top of an asphalt. This same principle can be carried over to an apparatus built for absorbing sunlight. A black body surface can be built and in order to prevent escape of absorbed solar energy, a glass or a transparent plastic can be placed atop the black body surface or photovoltaic cell to trap the absorbed sunlight. This approach maximizes the amount of sunlight which will be available for energy.

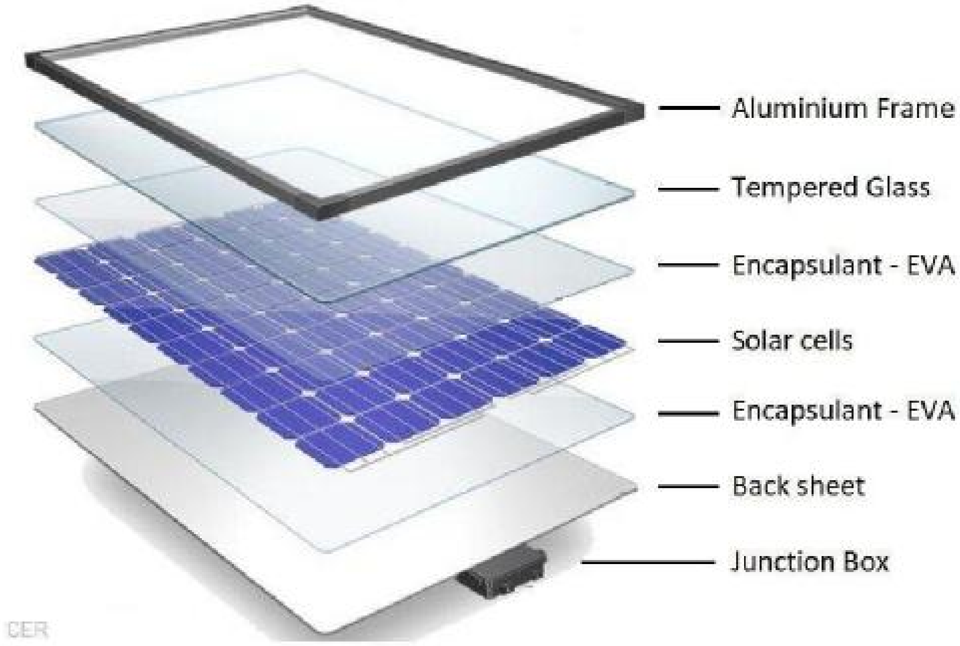

Figure 2.13 - Solar Panel

2.2.7 Selection of Bluetooth Module

The bluetooth module is a device which has a bluetooth feature and can be set as both a receiver or a transmitter of information. It can receive information from the devices in the system and transmit that information to a remote device such as a smartphone. The bluetooth module which is used for this project is the HC-05 bluetooth module which is energy efficient, affordable, durable and powerful. In this project, it is used for transmitting information about the state of the smart home to a mobile device.

The HC-05 has six pins.The first pin is the key/en pin. If this pin is set to high mode, then the module will work in command mode. If not, it will be set to data mode. The second pin is the VCC pin. This is the pin that receives electrical charge. The third pin is the ground pin of the module. The fourth pin is the TXD (Transmit serial data). The TXD pin is responsible for transmitting data. The fifth pin is the RXD which is responsible for receiving data in a serial manner.

HC-05 module information:

- HC-05 has a red LED which indicates connection status, whether the Bluetooth is connected or not. Before connecting to the HC-05 module this red LED blinks continuously in a periodic manner. When it gets connected to any other Bluetooth device, its blinking slows down to two seconds.
- This module works on 3.3V. We can connect 5V supply voltage as well since the module has on board 5 to 3.3 V regulator.
- As HC-05 Bluetooth module has 3.3V level for RX/TX and microcontroller can detect 3.3 V level, so, no need to shift transmit level of HC-05 module. But we need to shift the transmit voltage level from the microcontroller to the RX of the HC-05 module.
- The data transfer rate of the HC-05 module can vary up to 1Mbps and is in the range of 10 meters.

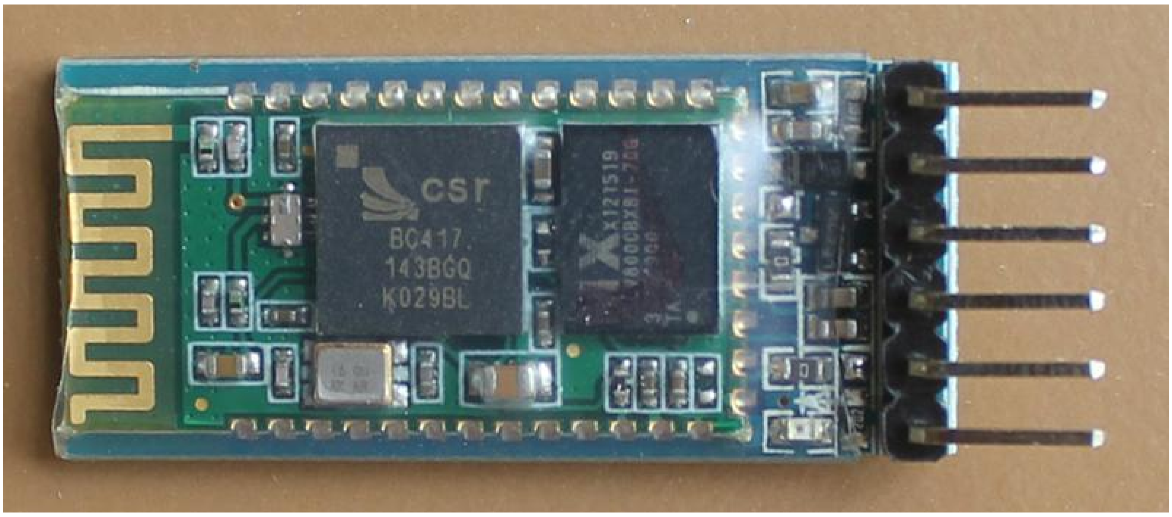

Figure 2.14 - HC-05 Bluetooth module

2.3 Description of Data Exchange Buses

The system’s connection starts from the microcontroller. The microcontroller is the heart of the system and all the transmission and reception components will be directly connected to the input or output section of the microcontroller. In the case of the sensors, such as the ultrasonic distance sensor, the passive infrared sensor and the light dependent resistor, they are transmission components and will be connected to the digital input port of the arduino uno r3.

In the case of the indicators, such as the piezo buzzer, leds and so on, they will be connected to the output port of the arduino uno r3.

Power will be provided to the components through a breadboard which will serve as a connection point for most of the devices. The solar panel will be connected to a capacitor which will in turn be connected to the positive and negative terminal of the breadboard.

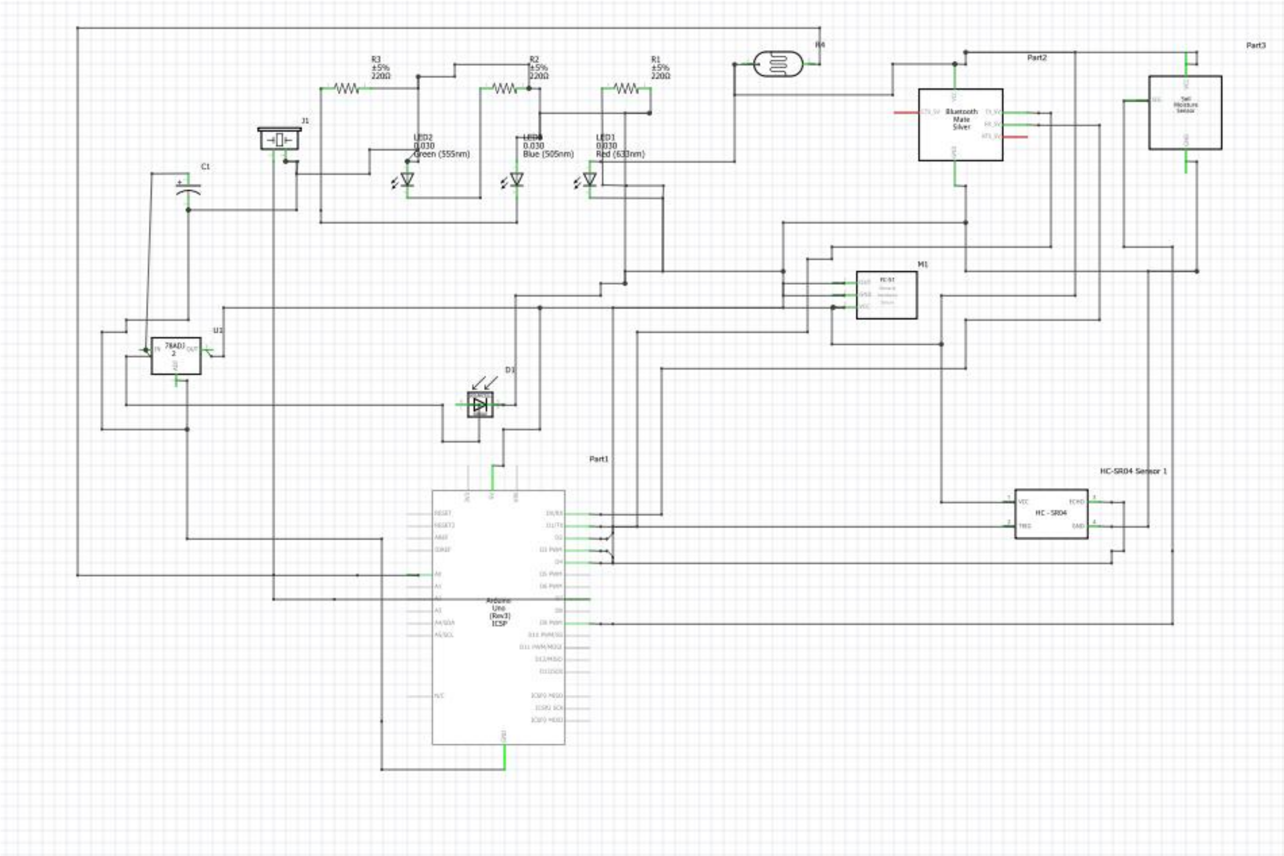

Figure 2.15 – Circuit diagram of the project

2.4 Description of the algorithm of the project

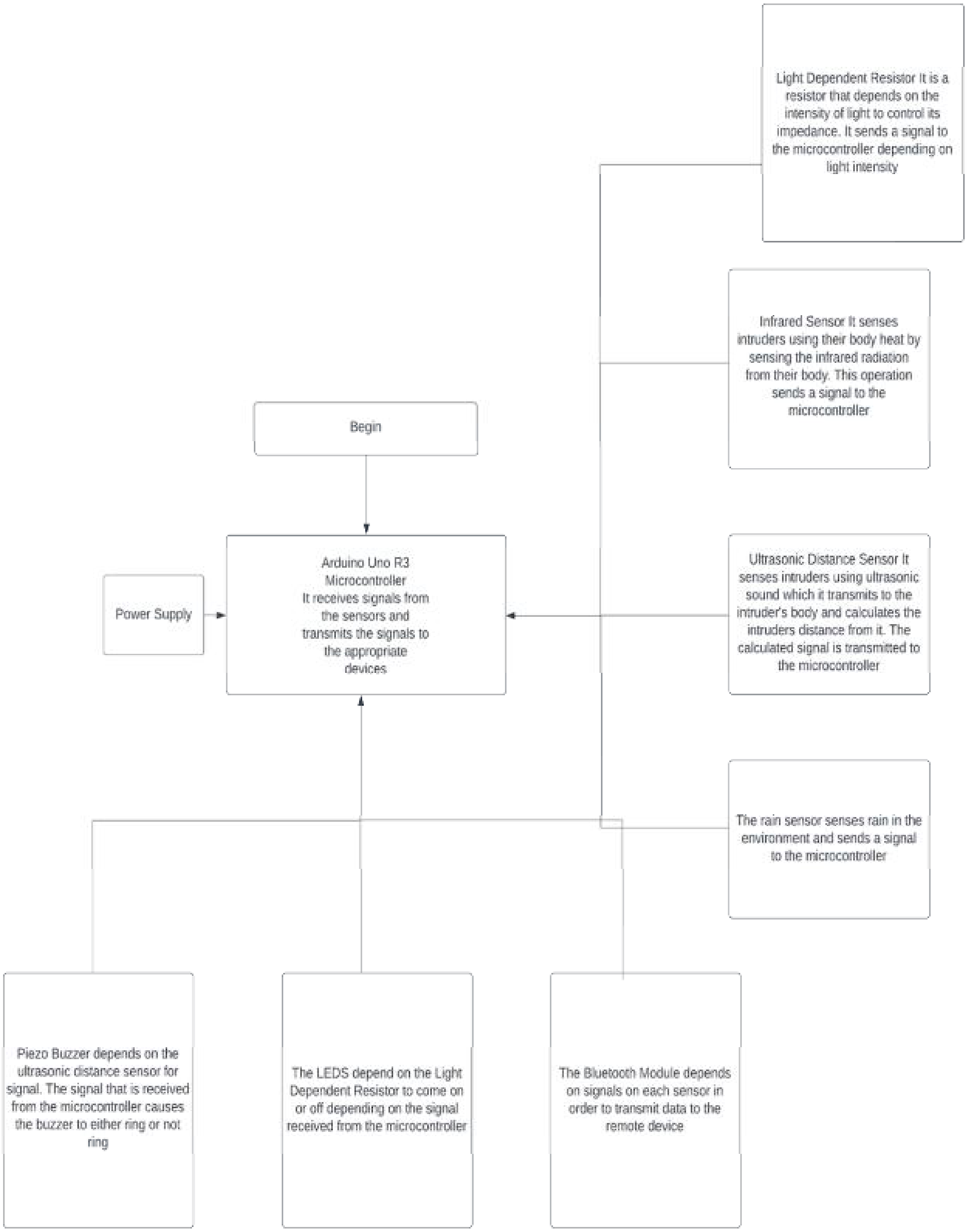

Figure 2.16 – Flowchart of the system process

According to the flowchart above, the algorithm of the system is pretty simple to follow and understand. The system consists of the microcontroller which is the brain of the system and through which all signals are transmitted and received. The sensors are an integral part of this system as without them, we cannot have a smart home. The Ultrasonic distance sensor is advised to be positioned some distance away from the home particularly because it is the first line of sensor which would alert the homeowner of an intruder. The ultrasonic distance sensor sends off a high frequency sound wave which can bounce off an intruder and depending on the calculations made by the UDS, a signal is sent to the microcontroller. According to our setup, our microcontroller is connected to the sensor through one of the input /output ports on the Arduino Uno R3.

This connection facilitates the transmission of digital signals from the UDS based on the calculations from the TRIG and ECHO pin to the Arduino Uno R3, the already agreed upon distance preset during setup and based on the program which has been written for the Arduino Uno R3, if the object is stipulated to be within the allowed distance, the piezo buzzers will be set off. The connection that makes this possible is the fact that the piezo buzzers are also connected to a digital input/output port on the Arduino Uno R3 and an algorithm can easily be written to cause an increase in the current flowing into the piezo buzzer. This is remarkably easy to write due to the fantastic user experience afforded to the users of the arduino Integrated development environment.

Furthermore, the infrared sensor does a similar job to the Ultrasonic Distance Sensor. The infrared sensor can detect intruders through infrared emitted by the intruder. Fundamentally, all things emit a level of infrared radiation and intruders, who are typically human beings are not an exception. The infrared sensor can detect changes in infrared radiations along its field of view. This change can also cause a process in the circuit of the infrared sensor and lead to a transmission of signal to the microcontroller. This, like the ultrasonic distance sensor, is facilitated by the connection of the infrared sensor to one of the digital input/output ports of the arduino Uno R3. Once this signal is sent to the Arduino Uno R3, the program code that has been written which involves piezo buzzers and LEDs will cause an increase in the current flowing through the buzzers and the LEDS. The Light dependent resistor system relies on light intensity to control the lighting circuit. This circuit works because when there is an intensity in light, the impedance of the resistor weakens and when light is less intense, the impedance of the resistor is strengthened. As a result of this process, when there is enough sunlight, which indicates daytime, the LEDs will be off by the light dependent module and when there isn't enough sunlight, which indicates nighttime, the LEDs will be on by the light dependent module. This process really drives home the point of automation and energy efficiency in computerized energy independent smart homes.

The last but not least process to discuss, is the rain sensor. The rain sensor represents an important part of what a smart home should be capable but not limited to. A smart home should be smart enough to bring to the awareness of its owner, the natural condition of the surrounding and one of these conditions is the weather condition. The rain sensor, as the name implies, senses rain. It consists of a sensing pad and a rain sensor. When rain falls upon the sensing pad, the signal is sent to the rain sensor and based on the intensity, the rain sensor sends a signal to the Arduino Uno R3 and this signal can do a number of things depending on how the microcontroller is programmed to behave on reception of the rain signal. The bluetooth module is present in the system to signify how the system can send information to a remote device through long range signal technologies such as bluetooth, wifi or infrared.

3 PRACTICAL PART

3.1 Connecting and setting up the system

3.1.1 Connection of the Power Source (Solar Panel And Battery)

The power sources are both first set up. The solar panel is unboxed and set up. The positive terminal is connected to a capacitor and the capacitor is connected to a voltage regulator which is directly connected to the breadboard. The breadboard is a component which makes it possible for all the other components to connect to each other without complications.

Since the breadboard now has electric current passing through it, all other components can now be connected with electric current passing through them if need be.

3.1.2 Connection of the Arduino Uno R3

The arduino uno r3 is also connected to the breadboard. It is also important to note that the microcontroller is the heart of the system and therefore, needs to be connected to all the other components.

3.1.3 Connection of the Ultrasonic Distance Sensor

The ultrasonic distance sensor used in this project is the hc-sr04. The hc-sr04 has about four terminals. The VCC terminal, the trigger terminal, the echo terminal and the ground terminal.

The VCC terminal is the terminal through which electric current flows through the ultrasonic distance sensor. The VCC terminal supports 5 volts of power and it is connected to the positive terminal of the system's power source.

The Trigger terminal is the input pin. This pin is connected to a digital input terminal within the arduino uno r3. The echo terminal is the output pin of the ultrasonic distance sensor and it is also connected to the digital I/O pin of the arduino uno r3.

Fig 3.1 - Connection Of The Ultrasonic distance sensor

The ground terminal is the terminal which is connected to the ground connection of the system.

3.1.4 Connection of the Piezo Buzzers

The piezo buzzer is an indicator for both the Ultrasonic distance sensor and the Passive infrared sensor. In this system, the piezo buzzer is typically used to alert users of an intruder. This essentially makes the piezo buzzer an output device since it depends on the input from the microcontroller to function.

The piezo buzzer has two terminals, namely the positive terminal and the negative terminal. In order to make the piezo buzzer controllable and depend on input from the other sensors, the piezo buzzer's positive terminal will be connected to a digital input/output terminal from the arduino uno r3 while the negative terminal will be connected to the ground connection of the system.

The picture below is a rough simulation of how the buzzer should be connected to the system.

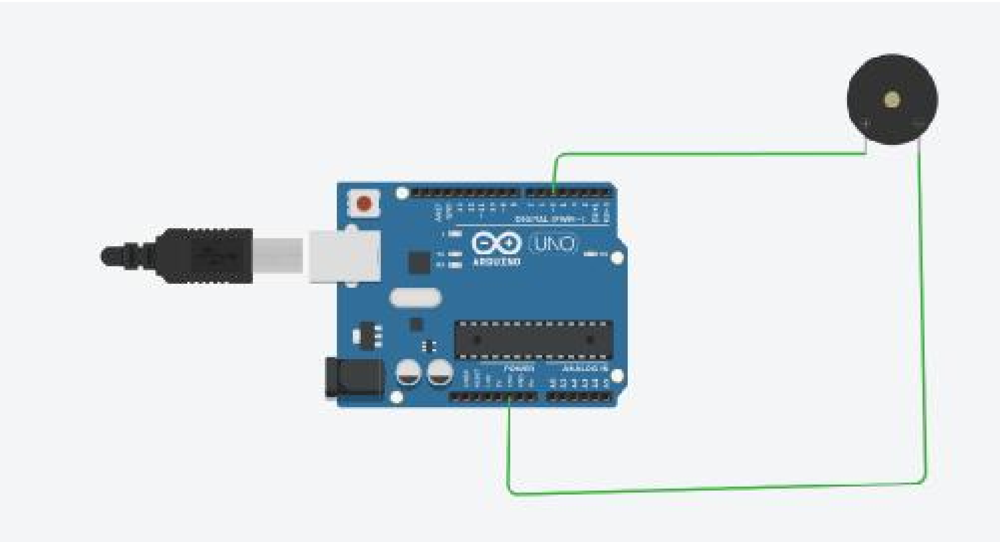

Figure 3.2 - Connection of The Piezo Buzzer

3.1.5 Connection of the Infrared Sensor

The infrared sensor is a sensor within the project. This sensor is stated to be used for detecting infrared from objects in its field of view.

The infrared sensor consists of about three terminals, namely the signal terminal, the power terminal and the ground terminal.

The signal terminal is the point which sends input signals to the microcontroller. It is responsible for sending changes in the device's system to the microcontroller.

The power terminal is the terminal which is connected to the power source of the system. The infrared sensor needs a small amount of energy to operate which makes it efficient at energy usage. The ground terminal is connected to the ground connection of the system.

The Figure 3.3 below describes how the PIR sensor can be connected to the arduino uno r3 microcontroller.

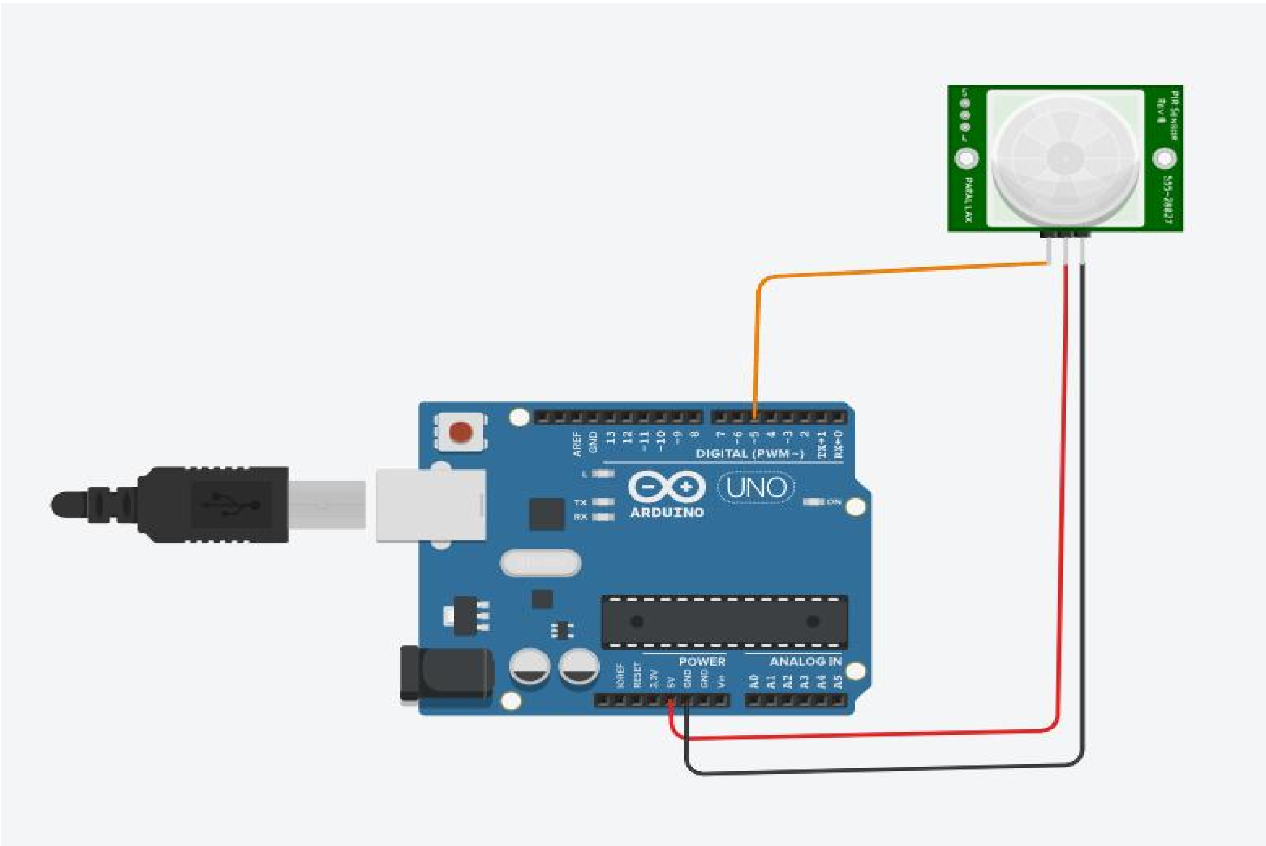

Figure 3.3 - Connection of a PIR sensor

3.1.6 Connection of the Rain Sensor

The rain sensor’s purpose is to detect moisture and rainfall. The rain sensor being used in this project has about four terminals. The four terminals are as follows, the VCC terminal, the GND terminal, the digital input/output terminal and the analog input and output terminal.

The VCC terminal is the terminal responsible for the reception of electric current and this terminal helps power the sensor. The ground terminal is connected to the ground connection of the system. The digital input/output terminal is going to be connected to the microcontroller. The microcontroller will receive the signal from the rain sensor and depending on the state of the signal, the microcontroller will do the appropriate thing as instructed by the program. Alternatively, the rain sensor has an analog output terminal.

3.1.7 Connection of the Bluetooth Module

The bluetooth module is the final device which will be connected to the system. This device will be used to facilitate wireless connection for the system. The bluetooth module has about six terminals. The first terminal is the key/en pin, the second terminal is the VCC terminal, the third terminal is the ground pin, the fourth terminal is the TXD pin, the fifth terminal is the RXD pin and the sixth terminal is the state pin.

The key/en pin is used to bring the bluetooth module in AT commands mode.

The VCC pin is the power source terminal. It is used to power the device. This pin is going to be connected to the power source of the smart home system.

The Ground pin is the ground terminal and it is connected to the ground connection of the system.

The TXD terminal is the transmission pin and it will be connected to the arduino uno r3 RX digital pin.

The RXD terminal is the reception pin and it will be connected to the arduino uno r3 TX digital pin.

3.2 Software code testing

A typical arduino function has two main sections, the setup and the loop. The setup is the section in which the Input/Output sections of the arduino uno r3 are set up by interpolating the pin number with whether the pin should be an output section or an input section. The loop is basically a loop in which all the business logic will reside.

Outside both functions, each pin number (Input/Output) is assigned to a variable in order for them to persist during the lifetime of the program. Some of them are stored in a variable with a data type of integer and some are stored in a data type of character. All variables in this program code are declared globally so that they can be accessed throughout the code. Additionally, some are stored in a constant instead of variables.

The pinMode function accepts two arguments, the pin and the enum type OUTPUT or INPUT. The pinMode function creates a connection between the pin number and whether the pin is to be an output port or an input port. The Serial.begin is a function attached to the object Serial. It sets the data rate in bits per second (baud) for serial data transmission. For communicating with Serial Monitor, make sure to use one of the baud rates listed in the menu at the bottom right corner of its screen. You can, however, specify other rates - for example, to communicate over pins 0 and 1 with a component that requires a particular baud rate.

An optional second argument configures the data, parity, and stop bits. The default is 8 data bits, no parity, one stop bit.

The delay function accepts only one argument and that argument is the amount of time in which the program is to be paused. Within the loop function, which runs continuously, the main logic of the smart home system is performed. The following is a summary of what the function contains:

- Ultrasonic Distance Measurement uses an ultrasonic sensor connected to 'trig' and 'echo' pins to measure the distance of an object. The distance is calculated based on the time it takes for the ultrasonic pulse to travel and return.

- LDR (Light-Dependent Resistor) Detection reads the value of an LDR connected to 'ldrPin' to detect the ambient light level. If the light level is above a certain threshold, an LED connected to 'ledPin' is turned on.

- IR (Infrared) Object Detection checks the state of an IR sensor connected to the 'ir' pin. If an object is detected, it triggers an alert by turning on an IR LED and a buzzer connected to 'irled' and 'irbuz' pins, respectively.

- Ultrasonic Risk Level Indication. Depending on the measured distance, the code determines the risk level and provides feedback accordingly. It uses different LED and buzzer patterns to indicate extreme, high, medium, and low risk levels.

- Rain Detection reads the value of an analog rain sensor connected to 'A0' pin. If the value falls below a threshold, it indicates that it is raining outside by turning on a rain LED and a buzzer connected to 'rainled' and 'rainbuz' pins, respectively.

- Check Function reads data from the serial port and assigns the corresponding value to the 'determinant' variable based on the received character. The 'determinant' variable is then returned. The check function consists of conditional statements which indicates the use of the if and else statements.

Furthermore, within the loop function, there are multiple functions such as digitalWrite, tone and noTone. The digitalWrite function accepts two arguments, namely, the pin number and an enum value between HIGH and LOW. If the pin has been configured as an OUTPUT with pinMode(), its voltage will be set to the corresponding value: 5V (or 3.3V on 3.3V boards) for HIGH, 0V (ground) for LOW.

If the pin is configured as an INPUT, digitalWrite() will enable (HIGH) or disable (LOW) the internal pullup on the input pin. It is recommended to set the pinMode() to INPUT_PULLUP to enable the internal pull-up resistor. If you do not set the pinMode() to OUTPUT, and connect an LED to a pin, when calling digitalWrite(HIGH), the LED may appear dim. Without explicitly setting pinMode(), digitalWrite() will have enabled the internal pull-up resistor, which acts like a large current-limiting resistor.

3.3 Future Improvements

As efficient and as reliable as this current computerized system of an energy independent smart house is, I believe that improvements can be made in multiple places in order to improve the security of the home, improve the computation of signals, improve the interoperability of the components and to improve the speed of computation.

Currently, the system uses an arduino uno r3 microcontroller. This device is a very good fit for the project, it is limited in the amount of processes it can execute and in addition to this, it cannot multitask. Furthermore, the arduino uno r3 cannot process large amounts of data and cannot really store additional information which can be beneficial when it comes to ensuring that the system is reliable.

A solution to this problem is to replace or extend the microcontroller with a better computational device. Devices such as Raspberry Pi 3, Raspberry Pi 4, Arduino Uno R4, Arduino Uno R3 with WIFI can serve as extensions or worthy replacements for the now limited Arduino Uno R3. The Raspberry Pi devices for example, are not only better than the Arduino Uno R3. They are basically computers with impressive features such as high RAM counts, high storage capacities, extension ports that can improve their performances and extend the features that can be offered, Wifi capabilities, bluetooth capabilities, and advanced user interfaces for easy configuration.

The Raspberry pi can even handle parallel and multithreaded executions without problems and can do so while being just as energy efficient as the Arduino Uno R3. The replacement of the Arduino Uno R3 with much more powerful computation devices can also increase the number of components that can be added to the system for different purposes.

Also, the bluetooth module can only go so far. Although the maximum range of a bluetooth signal can be high enough for testing purposes, this can be a problem when the distance between the smart home and the homeowner is increased for different reasons. The homeowner may not be able to gain information from the house's system. This can cause the homeowner to not be informed of an intrusion, can prevent the owner from being aware of environmental conditions and so on. A solution to this is the addition of a mobile network enabled module which can connect to the internet and send information from the system to the homeowner's mobile phone regardless of distance. In fact, replacing the Arduino Uno R3 with a Raspberry Pi as discussed earlier can solve the bluetooth range limitation problem.

Another improvement that can be made is to replace the HC-SR04 Ultrasonic distance sensor. While the HC-SR04 Ultrasonic distance sensor is a reliable and powerful Ultrasonic distance sensor, it can be pretty fragile and can easily be damaged by dirt or wind. Another problem is the fact that it is not water-proof and for a device that will be used for detecting intruders, it must be used outside. A worthy replacement is the AJ-SR04M-V2 Ultrasonic distance sensor or any Ultrasonic distance sensor that is sturdy, water-proof and durable enough to be used outside. We must also note that the replacement UDS must also have a greater range than the previous HC-SR04 in order for it to be an improvement in all ramifications.

Other features can be added to the system. A prime feature that can be added to this system is a camera. The camera can be used to identify the faces of visitors and intruders. This camera, in combination with the Raspberry pi can be used for very complex, but important purposes like using artificial intelligence to recognize the faces of guests and regular visitors, sending the faces of intruders to the police in order to ensure that criminals are brought to book, automatically allowing entry of authorized people and so on. This can improve the living experiences of the homeowners and also increase automation of the smart home system.

Another fantastic addition is the inclusion of a temperature sensor to improve living conditions for the homeowners. For example, having a temperature sensor can help automate the turning on and off of the air conditioners and can also help to prevent fire hazards.

These future improvements can enhance the functionality, convenience, efficiency, and security of smart home systems, making them even more valuable to homeowners. As technology continues to advance, we can expect further innovations in the field of smart homes.

4 SAFETY OF LIVELIHOOD ACTIVITIES, BASIS OF LABOR PROTECTION

4.1 Medical aid in case of electric shock

Since the purpose of the work is related to the use of various electrical devices connected to the electrical network, we will consider the issue of actions in case of electric shock.

First of all, free the victim from the effects of the current, because from the duration of such action significantly depends on the severity of the electric injury. The safest way to free the victim from the effects of electric current is to turn off the electrical device that the victim touches, using the nearest switch, circuit breaker or other device for de-energizing.

The victim, after release from the electric current, can usually be in one of three states:

- If the victim is conscious, then it is necessary to put him on bedding of fabric or clothing, create an influx of fresh air, unbutton clothing that constricts and prevents breathing, rub and warm the body and ensure rest until the arrival of a doctor.

- The victim, who is in an unconscious state, should be given sniff ammonia or splash cold water on your face. When the victim regains consciousness, give him to drink 15-20 drops of valerian tincture and hot tea.

- In the absence of signs of life (breathing and pulse), it is necessary to immediately start cardiopulmonary resuscitation (CPR), because the probability of success is less the more time has passed since the onset of clinical death. CPR measures include artificial respiration and indirect heart massage.

Artificial respiration is performed by "mouth-to-mouth" or "mouth-to-nose" method. The person providing help exhales from his lungs into the lungs of the victim directly into his mouth or nose, there is still enough oxygen in the air exhaled by theperson.

First, the victim must be placed with his back on a hard, flat surface, free from constricting clothing (unbutton the shirt collar, belt, loosen the tie), place a small roller of any material under the shoulder blades, tilt the head as far back as possible.

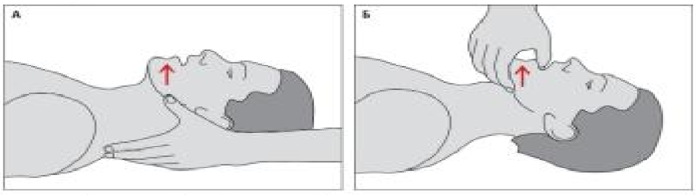

Figure 4.1 – Correct position of the victim's head

a - the rescuer turns the victim's head away with his left hand, at the same time supporting his neck with the right;

b - the rescuer holds the victim's head in a tilted position with the left hand, simultaneously pulling the lower jaw with the right hand.

Before starting artificial respiration, it is necessary to make sure patency of the upper respiratory tract, which can be closed by an inflamed tongue, foreign objects, accumulated mucus.

The rescuer takes a deep breath, and then, tightly pressing his mouth through the gauze to the victim's mouth (at the same time, as a rule, covers the victim's nose with his cheek), blows air into the lungs, as shown in fig. 4.2. At the same time, the victim's chest expands. Due to the elasticity of the lungs and chest wall, the victim exhales passively. At this time, his mouth should be open. The frequency of air blowing should be 12 times per minute. Similarly, artificial respiration is performed by the "mouth to nose" method; at the same time, air is blown through the nose, and the victim's mouth must be closed.

Figure 4.2 – Mouth-to-mouth artificial respiration

You should be careful when performing artificial respiration: when the first signs of weak shallow breathing appear in the victim, it is necessary to adjust the rhythm of artificial respiration to it.

There are special means for artificial respiration, which, first of all, allow to avoid direct contact between the mouth of the victim and the mouth of the rescuer. In order not to harm the victim, the rescuer must be able to use such means.

In case of cardiac arrest, which can be determined by the absence of in the case of an injured pulse on the carotid artery and dilation of the pupils or in the case of heart fibrillation, it is necessary to carry out indirect heart massage simultaneously with artificial respiration. The victim is placed with his back on a hard surface, his chest is exposed, and the belt is unfastened. The rescuer stands to the left or right of the victim, placing his hands on the lower third of the chest (one on top of the other), energetically (with thrusts) presses on it. You need to press quite sharply, using the weight of your own body, and with such force that the chest bends 4-5 cm towards the spine. The required frequency is 60-65 clicks per minute.

Heart massage must be combined with artificial respiration. If CPR is performed by one person, measures to save the victim must be carried out in the following sequence: after two deep breaths into the mouth or nose, make 15 chest compressions, then repeat two breaths and 15 pressures to massage the heart. If two rescuers provide help, then one should perform artificial respiration, and the other should perform indirect heart massage, and during the air injection, the heart massage is stopped.

Measures for revitalization can be considered effective if the pupils have narrowed, the skin has started to turn pink (primarily, the skin of the upper lip), and the pulse on the carotid artery can be clearly felt during massage strokes.

Thus, skillful provision of assistance in case of electric shock current can save a person's life.

4.2 Social importance of labor protection

The social significance of labor protection lies in promoting the growth of the efficiency of social production through continuous improvement and improvement of working conditions, increasing their safety, reducing industrial injuries and occupational diseases.

The social importance of labor protection is manifested in growth labor productivity, preservation of labor resources and increase of the aggregate national product.

Labor protection consists in promoting the growth of production efficiency, which is achieved through continuous improvement and improvement of working conditions, increasing their safety, reducing industrial injuries and occupational diseases.

The increase in labor productivity occurs as a result of increasing the working time fund due to the reduction of intra-shift downtime by eliminating microtraumas or reducing their number, as well as due to the prevention premature fatigue through the rationalization and improvement of working conditions and the introduction of optimal modes of work and rest and other measures that contribute to increasing the efficiency of the use of working time.

An important issue is the increase in labor productivity, which occurs as a result of increasing the working time fund due to the reduction of intra-shift downtime by eliminating microinjuries or reducing their number, as well as by preventing premature fatigue by rationalizing and improving working conditions and introducing optimal work modes and rest and other activities that contribute to increasing the efficiency of the use of working time.

The fact that the preservation of labor resources and the increase in the professional activity of working people occurs due to the improvement of the health condition and the extension of the average life expectancy through the improvement of working conditions, which is accompanied by high labor activity and an increase in production experience. The professional level also increases thanks to the growth of qualifications and skills. Accordingly, the increase in the aggregate national product is due to the improvement of the above indicators and their constituent components.

Preservation of labor resources and increase in the professional activity of working people occurs due to the improvement of the state of health and the extension of the average life expectancy through the improvement of working conditions, which is accompanied by high labor activity and an increase in production experience. The professional level also increases thanks to the growth of qualifications and skills.

The increase of the total national product is due to the improvement of the above indicators and their constituent components. In addition, the social importance of labor protection is manifested in the growth of labor productivity, preservation of labor resources.

According to research, a set of measures to improve working conditions can increase labor productivity by 15-20%. Thus, the normalization of workplace lighting increases labor productivity by 6-13% and reduces shortages by 25%. Rational organization of the workplace increases labor productivity by 21%, rational painting of workplaces by 25%.

An increase in the effective working time fund can be achieved by reducing the temporary incapacity of workers due to illnesses and industrial injuries.

CONCLUSIONS

The experience while building this project was exhilarating and engaging. All the intricacies of the microcontroller, how they work, how they receive input signals and generate output signals were worked out. In addition to this, it has been analyzed that the arduino uno r3 is such a complex system with a microcontroller and multiple other components that make it possible for the arduino uno r3 to run as expected. The arduino uno r3 was selected for multiple purposes and the purposes are as follows:

- Ease of Use the arduino uno r3 is such an easy microcontroller to understand. It is particularly easy for beginners in electronics to make use of and it is also very accessible. The arduino uno r3 also comes with an easy to understand manual that can be accessed on the internet. It is designed to be accessible for beginners and experts alike, making it an excellent choice for learning and prototyping.
- Extensive Community Support. The arduino uno r3 is so popular that it is available in multiple countries and has a large community of electronics enthusiasts and experts who regularly contribute to multiple hobby projects and regularly help people who are stuck and in need of help. Additionally, there is a large amount of tutorials and resources for people who are interested in building projects with arduino uno r3 and for people who are stuck on a problem. Furthermore, there are libraries, frameworks and extensions that have been built by multiple people in order to make it even easier for people to work with arduino uno r3 and other related microcontroller boards.
- Versatility. The arduino uno r3 is also a very versatile microcontroller board. It can be used for so many projects and it can even be reused for other projects if

need be. The possible connections that can be made by the arduino uno r3 is quite a lot. It contains a lot of I/O ports for both analog and digital devices for multiple purposes.

In the project was also introduced to the very powerful and lightweight arduino IDE (integrated development environment) which makes it possible for one to write code for a project and upload to the arduino uno r3 in a rather simple and effective manner and this improves the experience of the user.

Furthermore, an analysis was carried out the principle of operations of components such as the UDS, the PIR and the bluetooth module. The way the UDS works is such an interesting concept to understand. It is a simple application of sound waves. Sound waves typically need a medium of propagation and intruders who are typically human beings are thick enough to be a medium of propagation. When the sound waves generated by the UDS bounces off of a body, the wave is transmitted back to the UDS and the UDS does some calculations to confirm that an intruder is present. Using the heat emanating from an object in its field of view, the infrared sensor can sense intruders quite quickly and send a signal to the microcontroller for further actions.

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APPENDIX A. Technical task

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
Ternopil Ivan Puluj National Technical University
Faculty of Computer Information Systems and Software Engineering

Computer Systems and Networks Department

“Approved”
Head of department
________ Osukhivska H.M.
“___” ____________2023

COMPUTERIZED SYSTEM OF ENERGY INDEPENDENT CONTROL OF THE SMART HOUSE

Bachelor’s Degree

“AGREED”	“PERFORMER”
Supervisor	Student of Group ICI-42
________ Nataliya Stadnyk	________ Olakunle O. Raheem
“___” ____________2023	“___” ____________2023

Ternopil 2023

1. Terms

This document describes tasks for the development of a computerized system of energy independent control of a smart house by creating a system of a microcontroller and multiple sensors and indicators. The main objective is to build a smart home system. The project will be based on the Arduino Uno R3.

The full name of the project is the Computerized System of Energy Independent Control of a Smart House

Identification:

1.1 Order For System Development

1.2 Performer

Performer - student of ICI-42 group, department of computer systems and networks, Ternopil Ivan Puluj National Technical University, Olakunle Oluwamayowa Raheem.

1.3 Input documents for System development

- Specification of Arduino Uno R3
- Specification of Ultrasonic Distance Sensor
- Specification of Infrared Sensor
- Specification of Piezo Buzzers
- Specification of Arduino IDE
- Specification of Solar Panel
- Specification of Bluetooth Module

- Specification of Rain Sensor
- Documentation of Arduino Uno R3

A. Connecting the Arduino Uno R3
B. Connecting the Ultrasonic Distance Sensor
C. Connecting the Infrared Sensor
D. Connecting the Bluetooth Module
E. Connecting the Rain Sensor
F. Connecting the piezo buzzers

1.4 Date of Start And Submitting

Planning date of start -
Submission date -

1.5 The sequence of results presentation

Projects consist of the lists of documentation which responds to the approved requirements of the computer systems and networks department. Requirements response to the standards in the field of computer engineering development (ISO standards).

Presentation of intermediate results of the diploma project is carried out according to the schedule approved by the supervisor.

1.6 Standards and regulatory documents

- Standard ANSI/EIA/TIA 568 - “Commercial Building Telecommunications Wiring Standards” and ANSI/EIA/TIA 569 - “Commercial Building Standard For Telecommunications Path waisand Spaces”

2 Appliance and Purpose Of System Design

2.1 Appliance Of System

The Arduino Uno R3 is a microcontroller board. The arduino uno R3 is an improved version of the arduino uno R2. It is based on the ATMEGA328P microcontroller, which is an 8-bit microcontroller based on the AVR RISC. It is the most popular of all AVR controllers.

2.2 Objective Of The System Design

The objective is to create a computerized system of energy independent control of a smart house at a very affordable price while focusing on modularity and energy efficiency.

2.3 Characteristic of Design Object

Arduino Uno R3, Ultrasonic Distance Sensor, Infrared Sensor, Rain Sensor, Bluetooth Module, Piezo Buzzers, Light emitting diodes, Light dependent resistors.

3 System’s Requirement

3.1 Requirements in general

3.1.1 Requirements to the system structure and system operation

The structure of the hardware is to be simple and basic to be carried out easily, but system software must use the available hardware resources as efficiently as possible through the required objective.

The functionality and flexibility of the system is ensured by the modification of the program code of the Arduino Uno R3 and other components

3.1.2 Channels of system components communication

The consistency and the role of every component to be done, for each component to be connected and transferring the actions and getting the reactions through the system.

3.1.3 Requirements to the modes of system operation (normal mode (reliability), emergency mode)

3.1.4 Requirements to the system diagnostic

In order to diagnose the system, it must be monitored using the appropriate tools included in the relevant system software. The tools should provide an easy interface for viewing diagnostic events and monitoring the program execution process.

3.1.5 Perspective of modernization

The system software can be modified to newer versions, the microcontroller can also be replaced with an updated model. Additionally, the other components can be replaced with newer and better versions as time passes. The program code can also be modified to make room for additions of other components.

3.1.6 Requirement to the end users and their qualification

System administrators maintain the system in automatic or manual mode through management and monitoring. The minimum number of service personnel is one person.

3.1.7 Criteria of appliance

The system must be able to scale:

- By productivity
- By capacity of information process
- Scaling capabilities must be provided by the basic software and hardware used.

3.1.8 Reliability requirements

The system must be operational and restored in the following situations:

- If a sensor outlives its usefulness, it must be replaced as quickly as possible
- When there is a problem with the microcontroller, the reset button can be activated to restart the system. This restart can be all that the problem needs in order to start working properly.

3.1.9 Safety Requirements

The external elements of the technical measures of the system, which are under voltage, must have protection against accidental contact, and the technical measures themselves must have a zeroing or protective grounding GOST 12.1.030-81 and PUE. The power supply system must provide a protective switch during overloads and short circuits in the load circuits, as well as manual emergency shutdown. General fire safety requirements must comply with the standards for household electrical equipment. In the event of fire, no poisonous gasses or vapors should be produced. After disconnecting the power supply, ensure that all fire extinguishers can be used. Harmful factors should not exceed the standards of SanPiN 2.2.2./2.4.1340-03 of 06/03/2003.

3.1.10 Requirements for operation, maintenance, repair and storage of system components

The microclimate in rooms with the corresponding hardware has to correspond to norms of an industrial microclimate (GOST 12.1.005-88).

For normal operation of the network it is necessary to support (according to GOST 23.865-85):

- air temperature in the range from + 15C to + 20C;
- relative humidity at 20 C in the range from 30% to 70%;
- atmospheric pressure 760 mm Hg.

The technical means used must be regularly maintained according to the requirements of the technical documents, but not less than once a year. Regular maintenance and testing of technical means should include maintenance and testing of all used means, including workstations, servers, cable systems and network equipment, and uninterrupted power supplies. According to the test results of technical means, the reasons for the defects should be analyzed and eliminated. The location of the premises and its equipment must prevent uncontrolled entry by outsiders and ensure the security of confidential documents located in these premises and technical means.

3.1.11 Requirements to standardization and unification

The Arduino Uno R3 is a microcontroller that can be used for multiple purposes and has important features

- It is light and energy efficient
- It is very versatile
- It is programmable and configurable
- It has great connectivity

3.2 Requirements for types of collateral

3.2.1 Requirements to the system's hardware (technical characteristics of each devices in the system)

The system consists of an Arduino Uno R3, an Ultrasonic distance sensor with a model of HC-SR04, an Infrared Sensor, a bluetooth module, piezo buzzers and many others.

3.2.2 Structure and Contest of design system

The composition and content of system design work includes: (translate)

- design and coordination of the technical task for the system;
- system design;
- writing an explanatory note;
- design of graphic material;
- Defense of the qualifying paper.

4 Technical and economic indicators

The cost of development should not exceed 4000 UAH

The service life of the system should be at least 18,000 thousand hours. (2 years)

5 Stages of system design

Num	Stage	Duration
1	Development and approval of the technical task	*20.04 – 28.04*
2	Analysis of the technical task	*20.04 – 30.05*
3	Substantiation of possible technical solutions	*18.05 – 30.05*
4	System design and implementation	*18.05 – 30.05*
5	Testing of the designed system	*20.05 – 25.05*
6	Section of labor protection and safety in emergency situations	*18.05 – 30.05*
7	Registration of the qualifying paper	*21.05 – 23.06*
8	Preliminary defense of the qualifying paper	*04.06 – 28.06*
9	Defense of the qualifying paper	*13.07*

6 The order of control and acceptance

The control of the process of execution of the diploma project is carried out by the head of the diploma project.

Normal Control of the diploma project for compliance with the requirements of the standards is carried out at the Department of Computer Systems and Networks.

The presentation of the results of the diploma project is done by defending the diploma project at the relevant meeting of the SEC, illustrating the main achievements through the graphic material.

7. Requirements for documentation

The documentation must meet the requirements of ESKD and DSTU Set of design documentation:

- explanatory note;
- applications;
- graphic material;

a) wiring diagrams of the device board through specialized interfaces;

b) block diagram of the device components;

c) algorithms of the created software;

d) block diagram of the device software;

e) the deployment scheme of this solution.

8 Additional Conditions

During the implementation of the thesis project, changes and additions may be made to this technical task.

```
char dataIn = 'S';
char determinant;
char det;

int irled  = 6;
int irbuz = 9;
int ir = 2;
int tp = 13;
int trig = 3;
int echo  = 4;
long duration;
int distance;
int ultraled = 7;
int ultrabuz = 11;
int  rainled = 5;
int rainbuz = 8;
const int ledPin = 12;
const int ldrPin  = A1;



void setup() {
     Serial.begin(9600);
  Serial.println("Welcome");
  delay(500);
  Serial.println("Starting Smart Home System");
  Serial.println("Made  By Olakunle Raheem");
  delay(2000);
   pinMode(irled,OUTPUT);
  pinMode(irbuz,OUTPUT);
  pinMode(ir,INPUT);
  pinMode(tp,OUTPUT);
pinMode(trig, OUTPUT);
pinMode(echo,  INPUT);
```

```
pinMode(ultrabuz,OUTPUT);
pinMode(ultraled,OUTPUT);
pinMode(rainled  , OUTPUT);
   pinMode(rainbuz , OUTPUT);
     pinMode(ledPin, OUTPUT);
  pinMode(ldrPin, INPUT);


}

void loop() {
 digitalWrite(trig,  LOW);
    delayMicroseconds(5);
    digitalWrite(trig, HIGH);
    delayMicroseconds(10);
    digitalWrite(trig, LOW);

    duration = pulseIn(echo, HIGH);
    distance  = duration*0.034/2;
     if( digitalRead( ldrPin ) == 1){
      digitalWrite(  ledPin,HIGH);
       }
   else{
      digitalWrite( ledPin , LOW);
   }


  det = check();
    switch (det){
      case 'A':
   if (digitalRead(ir)== LOW){
    Serial.println("Alert Ir Detects Object");
    digitalWrite(irled , HIGH);
    digitalWrite(irbuz , HIGH);
     delay(10);
```

```
    }
      else
  digitalWrite(irled , LOW);
    digitalWrite(irbuz ,  LOW);
     delay(10);

det = check();
    break;

    case  'B':
      digitalWrite(tp,LOW);
      digitalWrite(irled , LOW);
    digitalWrite(irbuz  , LOW);
det = check();
break;
case 'C' :
  if (digitalRead(ir)== LOW){
    Serial.println("Alert Ir Detects Object");
    digitalWrite(irled , LOW);
    digitalWrite(irbuz , LOW);
     delay(10);
  }
  else {
   digitalWrite(irled  , LOW);
   digitalWrite(irbuz , LOW);
   delay(10);

}


det = check();
break;
case  'D' :
    if (digitalRead(ir)== LOW){
    Serial.println("Alert Ir Detects  Object");
    digitalWrite(irled , HIGH);
    digitalWrite(irbuz , HIGH);
     delay(10);
```

```
    }
      else {

    digitalWrite(irled , LOW);
    digitalWrite(irbuz  , LOW);
    delay(10);
  }
  det = check();
break;
    case 'E':
     if (distance <= 75){
    Serial.print(distance);
    Serial.println("cm  Extreme Risk ");
 digitalWrite(ultraled , HIGH);
 tone(ultrabuz,900);
  delay(900);
    digitalWrite(ultraled , LOW);
  noTone(ultrabuz);
  delay(900);
     }

     else if (distance >= 76 && distance <=151){
     Serial.print(distance);
       Serial.println("cm  HIGH Risk");
digitalWrite(ultraled , HIGH);
  tone(ultrabuz,1400);
  delay(1400);
    digitalWrite(ultraled , LOW);
  noTone(ultrabuz);
  delay(1400);
  }

     else if (distance >= 152  && distance <=227){
    Serial.print(distance);
       Serial.println("cm  Medium Risk");
      digitalWrite(ultraled , HIGH);
  tone(ultrabuz,1500);
```

```
delay(2000);
  digitalWrite(ultraled , LOW);
noTone(ultrabuz);
delay(2000);
   }

   else if (distance >= 228 && distance <=300){
  Serial.print(distance);
     Serial.println("cm  Low Risk");
    digitalWrite(ultraled , HIGH);
tone(ultrabuz,2000);
delay(3000);
  digitalWrite(ultraled , LOW);
noTone(ultrabuz);
delay(3000);
}
else {
  digitalWrite(ultraled,LOW);
  digitalWrite(ultrabuz,LOW);
}
det = check();
  break;

  case 'F':
 digitalWrite(ultraled,LOW);
   digitalWrite(ultrabuz,LOW);

Serial.print("");
det = check();
  break;

case 'G':
   if (distance <= 75){
   Serial.println("Extreme Risk");
 digitalWrite(ultraled,LOW);
   digitalWrite(ultrabuz,LOW);
```

```
  }

  else if (distance >= 76 && distance <=151){
  Serial.println("HIGH  Risk");
 digitalWrite(ultraled,LOW);
  digitalWrite(ultrabuz,LOW);
}

  else if (distance >= 152 && distance <=227){
    Serial.println("Medium  Risk");
 digitalWrite(ultraled,LOW);
  digitalWrite(ultrabuz,LOW);

  }


  else if (distance >= 228 && distance <=300){
    Serial.println("Low  Risk");
 digitalWrite(ultraled,LOW);
  digitalWrite(ultrabuz,LOW);

  }
  else{

   digitalWrite(ultraled,LOW);
   digitalWrite(ultrabuz,LOW);
  }

det = check();
 break;

 case 'H':
    int value1=analogRead(A0);

 if (value1<700){
    Serial.println("Raining Outside");
    digitalWrite(rainled  , HIGH);
```

```
        tone(rainbuz,900);
        delay(2000);
        digitalWrite(rainled ,  LOW);
        noTone(rainbuz);
        delay(3000);
    }

   else {
     digitalWrite(rainled  , LOW);
     digitalWrite(rainbuz , LOW);
   }
  det = check();
  break;
case 'I'  :
   digitalWrite(rainled , LOW);
   digitalWrite(rainbuz , LOW);
det =  check();
break;

    }
}


int check(){
  if (Serial.available()  > 0){// if there is valid data in the serial port
    dataIn = Serial.read();//  stores data into a varialbe
if (dataIn == 'A'){//Forward
      determinant  = 'A';
    }
    else if (dataIn == 'B'){//Backward
      determinant =  'B';
    }
    else if (dataIn == 'C'){//Backward
      determinant = 'C';
    }
    else if (dataIn == 'D'){//Backward
      determinant = 'D';
```

```
    }
    else if (dataIn == 'E'){//Backward
      determinant = 'E';
    }
    else if (dataIn == 'F'){//Backward
      determinant = 'F';
    }
    else if (dataIn == 'G'){//Backward
      determinant = 'G';
    }
    else if (dataIn == 'H'){//Backward
      determinant = 'H';
    }
    else if (dataIn == 'I'){//Backward
      determinant = 'I';
    }
    else if (dataIn == 'J'){//Backward
      determinant = 'J';
    }
    else if (dataIn == 'K'){//Backward
      determinant = 'K';
    }
    }
  return determinant;
}
```