

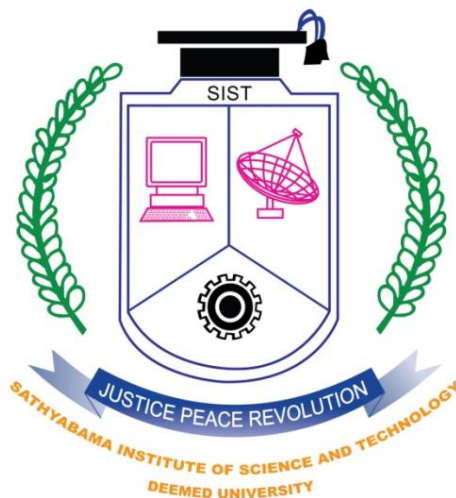
DESIGN AND IMPLEMENTATION OF SOLAR POWERED REAL-TIME ENERGY MANAGEMENT AND WATER WASTAGE CONTROL SYSTEM USING IOT

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **RIZWAN** (Reg. No. 39140046) and **RAMAVATAR YADAV** (Reg. No. 39140708) who carried out the project entitled "**DESIGN AND IMPLEMENTATION OF SOLAR POWERED REAL-TIME ENERGY MANAGEMENT AND WATER WASTAGE CONTROL SYSTEM USING IOT** " under our supervision from November 2022 to April 2023.

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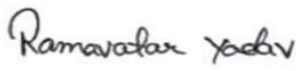
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DECLARATION

We **RIZWAN** (Reg. No. 39140046) and **RAMAVATAR YADAV** (Reg. No. 39140708) hereby declare that the Project Report entitled “**DESIGN AND IMPLEMENTATION OF SOLAR POWERED REAL-TIME ENERGY MANAGEMENT AND WATER WASTAGE CONTROL SYSTEM USING IOT**” done by us under the guidance of **DR. V. SENTHIL NAYAGAM** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

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DATE: 18.04.2023

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

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ABSTRACT

Energy is considered as an important mechanism in a country for the development, but in the current situation, the energy consumption is insufficient and the price is increasing. All these reasons directly effect the progressive development of our Country. Therefore renewable energy sources are imperative to implement for future use. However renewable energy such as solar energy is not always in all day. In term of renewable energy sources as hybrid system, it is necessary to provide a stable power supply for whole day. This research develops a prototype PV-Battery-AC Hybrid System as shown in block diagram with home automation and water Wastages detection.

The depletion of non-renewable energy sources and the impact of climate change has increased the demand for renewable energy sources. This project presents the design and implementation of a solar-powered real-time energy management and water Wastage control system using IoT. The system is designed to monitor energy consumption and detect water Wastage in real-time using multiple sensors, which are processed by an ESP32 microcontroller. The system is powered by a solar panel, enabling it to operate for extended periods without mains power. The data collected from the sensors is transmitted to a cloud-based platform, where users can access it through a web-based interface, enabling them to monitor energy consumption, receive notifications on water Wastage, and control the system remotely. This project demonstrates an efficient and sustainable solution for managing energy consumption and water Wastage.

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LIST OF SYMBOLS AND ABBREVIATIONS

ω_0	-	Resonant Angular Frequency
C_r	-	Resonant Capacitor
C_s	-	Series Resonant Capacitor
L_r	-	Resonant Inductor
L_s	-	Series Resonant Inductor
I_r	-	Resistance Current
R	-	Resistor
V_c	-	Capacitor Voltage
V_{ds}	-	Drain to Source Voltage
V_{in}	-	Input Voltage
V_{out}	-	Output Voltage
X_c	-	Capacitive Reactance
X_l	-	Inductance Reactance
Z	-	Impedance
AC	-	Alternating Current
API	-	Application Program Interface
CCM	-	Continuous Conduction Mode
DCM	-	Dis Continuous Conduction Mode
CISC	-	Complex Instruction Set Computer
CPU	-	Central Processing Unit
CTR	-	Current Transfer Ratio
DC	-	Direct Current

	DCM	-	Discontinuous Current Mode
	DIAC	-	Diode Alternating Current
	DVM	-	Discontinuous Voltage Mode
	ESR	-	Equivalent Series Resistance
	ICSP	-	In Circuit Serial Programming
I	GBT	-	Insulated Gate Bi-Polar Transistor
	ILBC	-	Interleaved Boost Converter
	MCLR	-	Master Clear
	PFC	-	Power Factor Correction
	PIC	-	Peripheral Interface Controller
	SIM	-	Simulator
	THD	-	Total Harmonic Distortion

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The Internet of Things (IoT) is a system of related computing devices, digital and mechanical machines, objects, people with unique identifiers and potential transfer of data over a network without human-to-human or human-to-computer interaction. Physical objects those are no longer disconnected from the virtual world, but can be controlled remotely through Internet services. A smart world is nothing but Smart devices, Smartphones, Smart cars, Smart homes, and Smart cities. “Smart” objects play a key role in the vision of IoT, since embedded communication and information technology would have the potential to revolutionize. With the growing presence of WIFI and 4G-LTE wireless Internet access, the evolution towards omnipresent information and communication networks is already evident. According to the International Energy Agency (IEA), Renewable energy will be the fastest growing source of electricity, in which solar PV are technologically mature and economically affordable. But still there is increase in world’s demand for energy.

Adopting Renewable Energy technologies is one of the advance ways of reducing the environmental impact. The latest edition of the IEA’s Medium-Term Renewable Market Report specifies the renewable energy growth about 13% more between 2015 and 2021 than it was in last year’s. The share of renewable energy in overall electricity generation will rise from over 23% in 2015 to almost 28% in 2021. Solar energy is universally available all over the world and can contribute to minimize the dependence of energy imports. In 90 minutes, enough sunlight strikes the earth to provide the entire planet’s energy needs for one year. Solar PV leads to no greenhouse gas (GHG) emissions and other pollutants during operation. Solar has many benefits like system-friendly deployment, improved operating strategies, advanced renewable energy forecasting and enhanced scheduling of power plants and also investment in additional flexible resources, comprising demand-side resources, electricity storage, grid infrastructure and flexible generation. The traditional method focuses on the levelized cost of electricity (LCOE)

which is a measure of cost for a particular generating technology at the level of a power plant that is no longer sufficient. About a million solar panels were installed every day around the world last year. Solar PV leads providing almost 40% of global renewable electricity capacity growth over the medium-term. Finally, in analyzing the evolution of electricity and energy- consuming sectors, it explores the prime role solar energy could play in the long-term future of our energy system.

The increasing demand for energy and water resources, coupled with the need for sustainability and conservation, has led to the development of innovative technologies to manage and optimize the consumption of these resources. The advent of the Internet of Things (IoT) has enabled the development of smart and automated systems that can monitor and control the consumption of energy and water resources in real-time. In this project, we propose the design and implementation of a solar-powered real-time energy management and water Wastage control system using IoT.

The proposed system consists of a network of sensors, microcontrollers, and cloud-based platforms that work together to monitor and control the consumption of energy and water resources. The system includes a solar panel that generates power to operate the system and a set of sensors that monitor the energy and water consumption in real-time. The system also includes a water flow sensor that detects any water wastage and automatically shuts off the water supply to prevent wastage.

The system is controlled by an ESP32 microcontroller that is programmed using the Arduino IDE. The microcontroller reads data from the sensors and transmits it to a cloud-based platform using Wi-Fi or Bluetooth connectivity. The cloud-based platform provides real-time data visualization and analysis, allowing users to monitor and control the consumption of energy and water resources remotely.

The proposed system offers several advantages, including real-time monitoring and control of energy and water consumption, automatic detection and prevention of water Wastage, and sustainability through the use of solar power. The system can be deployed in homes, offices, and other buildings, helping to reduce energy and water consumption and promote sustainability.

The objective of this project is to design, develop, and test the proposed system using a combination of software development and hardware prototyping techniques. The report will describe the design and implementation of the system, including the hardware and software components, and present the results of the testing and evaluation of the system.

The proposed system is based on IoT with the water flow sensors integrated with Microcontroller to detect the Wastage of water in pipelines and provide an alert on the leaks and prevent the loss of water flowing through the pipelines.

1.2 RESEARCH MOTIVATION

The motivation behind the "Design and Implementation of Solar-Powered Real-Time Energy Management and Water Wastage Control System Using IoT" project stems from the increasing need for sustainable and energy-efficient building management systems. With rising energy costs and growing concerns about the environmental impact of traditional energy sources, there is a need for innovative solutions that can help reduce energy consumption and minimize waste.

The project also addresses the issue of water leaks, which can cause extensive damage to buildings and be very costly to repair. By implementing a system that can detect and prevent water leaks, building owners can save money on repairs and reduce their environmental impact by conserving water.

Furthermore, the use of IoT technology in building management systems provides greater flexibility and responsiveness in managing energy usage and water leaks. Real-time monitoring and control capabilities can help building managers make informed decisions about energy usage, adjust settings as needed, and prevent wastage.

CHAPTER 2

LITERATURE SURVEY

Riteshkumar Shankar Gajbhiye (2020) Using the Internet of Things Technology for supervising solar power generation can greatly enhance the performance, monitoring and maintenance of the plant. With advancement of technologies the cost of renewable energy equipment is going down globally encouraging large scale solar plant installations. This massive scale of solar system deployment requires sophisticated systems for automation of the plant monitoring remotely using web-based interfaces as majority of them are installed in inaccessible locations and thus unable to be monitored from a dedicated location. The Project is based on implementation of new cost-effective methodology based on IoT to remotely monitoring a solar plant for performance evaluation. This will facilitate preventive maintenance, fault detection of the plant in addition to real time monitoring

K.G.Srinivasan (2018) The Internet of Things has a vision in which the internet extends into the real world, which incorporates everyday objects. The IoT allows objects to be sensed or controlled remotely over existing network infrastructure, creating opportunities for pure integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. This technology has many applications like Solar cities, Smart villages, Micro grids and Solar Street lights and so on. As Renewable energy grew at a rate faster than any other time in history during this period. The proposed system refers to the online display of the power usage of solar energy as a renewable energy. This monitoring is done through raspberry pi using flask framework. Smart Monitoring displays daily usage of renewable energy. This helps the user to analysis of energy usage. Analysis impacts on the renewable energy usage and electricity issues.

Vijayakumar.T (2019) propose to the water supply shortage has increased in recent years due to overpopulation, climate change and obsolete water facilities, where

deteriorated pipes cause most of the water leaks. The problem is not the size of the leak, but the time it takes to detect it. This paper presents the implementation of a system installed in the hydraulic facilities of a residence, to detect water leaks. The system consists of a water sensor installed by a water reservoir of interest, a microprocessor to interpret the data and evaluate. The design of a water level sensor device that can detect and control the level of water in a certain water tank, the system firstly senses the amount of water available in the tank by the level detector part and then adjusts the state of the water pump in accordance to the water level information. There has been wastage of water daily through the pipeline Wastages due to its full water were never arrived to the taps. The aims of our proposed work are to develop a real-time prototype pipeline Wastage alert system whether it is a water leak or not, an SMS alert message, and an electrical actuator to shut off the main water supply to avoid Wastage.

Farmanullah Jan (2020) Water resources in numerous countries are becoming scarce due to over urbanization, rapid industrial growth, and current global warming. Water is often stored in the aboveground or underground tanks. In developing countries, these tanks are maintained manually, and in some cases, water is wasted due to human negligence. In addition, water could also leak out from tanks and supply pipes due to the decayed infrastructure. To address these issues, researchers worldwide turned to the Internet-of-Things (IoT) technology to efficiently monitor water levels, detect Wastage, and auto refill tanks whenever needed. Notably, this technology can also supply real-time feedback to end-users and other experts through a webpage or a smartphone. Literature reveals a plethora of review articles on smart water monitoring, including water quality, supply pipes Wastage, and water waste recycling. However, none of the reviews focus on the IoT-based solution to monitor water level, detect water Wastage, and auto control water pumps, especially at the individual level that form a vast proportion of water consumers worldwide. To fill this gap in the literature, this study presents a review of IoT-controlled water storage tanks (IoT-WST). Some important contributions of our work include surveying contemporary work on IoT-WST, elaborating current techniques and technologies in IoT-WST, targeting proper hardware, and selecting a secure IoT cloud server.

Yasin Kabalci (2020) propose to introduces an instant monitoring infrastructure of a renewable energy generation system that is constituted with a wind turbine and solar panel arrays. The monitoring platform is based on current and voltage measurements of each renewable source. The related values are measured with the developed sensing circuits and processed by an 18F4450 microcontroller of Microchip. The processed parameters are then transmitted to a personal computer (PC) over universal serial bus (USB) to be saved in a database and to observe the system instantly. The coded visual interface of monitoring software can manage the saved data to analyze daily, weekly and monthly values of each measurement separately.

Goto, Yoshihiro, (2019) et propose to explained about an integrated system that manages and remotely monitors telecommunications power plants has been developed and has started operations. The system is used to operate and maintain more than 200,000 telecommunication power Plants, which including devices such as rectifiers, inverters, and UPSs, and air conditioning plants installed in about 8,000 telecommunication buildings. Features of the system are the integrate the management and remote monitoring functions, into one system and improved user interfaces, which use information and communication technology such as web technology

Abdallah (2021), a flow sensor-based system integrated with microcontroller to detect the leak due to breakage has been discussed. This system is designed to prevent the further Wastage of water flowing through the pipe line. This paper is organized in the order of methodology which explains the working of the system, components used to build the system and the results which signify the efficient Wastage prevention based on a prototype.

2.1 MAJOR FINDINGS FROM LITERATURE SURVEY

1. There is a growing demand for energy-efficient and sustainable solutions for managing energy and water resources. IoT-based systems that utilize renewable energy sources such as solar power can effectively address this demand.
2. IoT technology offers several advantages for real-time energy management and water Wastage control, including remote monitoring, data analysis, and automation of control systems.
3. Solar-powered systems are a cost-effective and reliable source of energy for IoT-based applications. The use of solar panels in conjunction with batteries can provide uninterrupted power supply to the system.
4. Ultrasonic sensors are commonly used in water Wastage detection systems due to their high accuracy, non-invasiveness, and ease of installation.
5. Solenoid valves are widely used in water control systems due to their ability to control the flow of water accurately and efficiently.
6. The integration of different technologies such as IoT, solar power, and sensors can provide an effective solution for real-time energy management and water Wastage control.

2.2 PROBLEM IDENTIFICATION

This project aims to provide a proactive and automated solution to energy management and water Wastage detection by using IoT devices and sensors to monitor and control energy consumption and detect water Wastage in real-time. The system can identify areas for improvement, such as inefficient appliances or water leaks, and automatically adjust settings or alert maintenance staff to take corrective action. By providing real-time monitoring and control, the system aims to reduce energy waste, prevent water damage, and save costs associated with inefficient energy consumption and water Wastage.

1. The price of installation is also increased by this large machinery.
2. Data is transferred to the cloud.
3. Internet speed is required for transferring sensor readings to IOT server.

2.3 SCOPE OF THE PROJECT

Implementing Renewable Energy technologies is one recommended way of reducing the environmental impact. Because of frequent power cut it is important to use renewable energy.

The microcontroller can be interfaced with other sensors, such as water and LDR sensors, to retrieve a variety of data about a location. Prediction of the amount of solar energy will be stored in the battery. The data stored in cloud can also be analyzed using the cloud server.

2.4 OBJECTIVE

The objectives of the proposed work are as follows:

1. To develop an energy management system that optimizes energy utilization in real-time using machine learning algorithms.
2. Design a water Wastage detection and control system that detects water Wastage and prevents water wastage.
3. To develop an IoT-based system that collects data from various sensors installed in the system and transmits it to the cloud-based energy management system.
4. To utilize solar energy efficiently to power the IoT devices and other components of the system, reducing the reliance on non-renewable sources of energy.
5. To provide real-time monitoring and control of energy and water usage, enabling users to optimize their energy and water consumption patterns.
6. To develop a scalable system that can be used in households, commercial buildings, and other applications, contributing towards a sustainable future.

2.5 METHODOLOGY OF THE EXISTING SYSTEM

In this project, Using the Internet of Things Technology for supervising solar power generation can greatly enhance the performance an intelligent IoT-based solar inverter was designed and implemented using the microcontroller unit (Arduino and node mcu). The NodeMcu (Node Microcontroller Unit) is an opensource software and hardware development environment built around a low-cost System-on-a Chip (SOC) called the ESP8266. The Internet of things (IoT) describes exactly the network of physical objects - “things” that are embedded with sensor components, software, and other technologies to connect and exchange data with other devices and systems over the Internet. In addition, these physical objects are provided with unique identifiers (UIDs) and the ability to transfer data gathered over a network without requiring human-to-human or human-to-computer interaction.

CHAPTER 3

PROJECT DESCRIPTION

3.1 EXISTING SYSTEM

As it was stated earlier, it is seen in a number of cities that the light is one of the huge expenses in a city. The cost spent is huge that all the sodium vapor lamps consume more power. The expense spent on the light can be used for other development of the nation. Currently a manual system is used where the light will be made to switched ON/OFF i.e the light will be made to switch ON in the evening and switched OFF in the morning. Hence there is a lot of wastage of energy between the ON/OFF. This is one of the major causes of shifting to the automatic system, since there is less wastage of power and thus saving a lot of monetary expenses. Apart from this, the other disadvantages of the Figure 3.1 existing system are described below

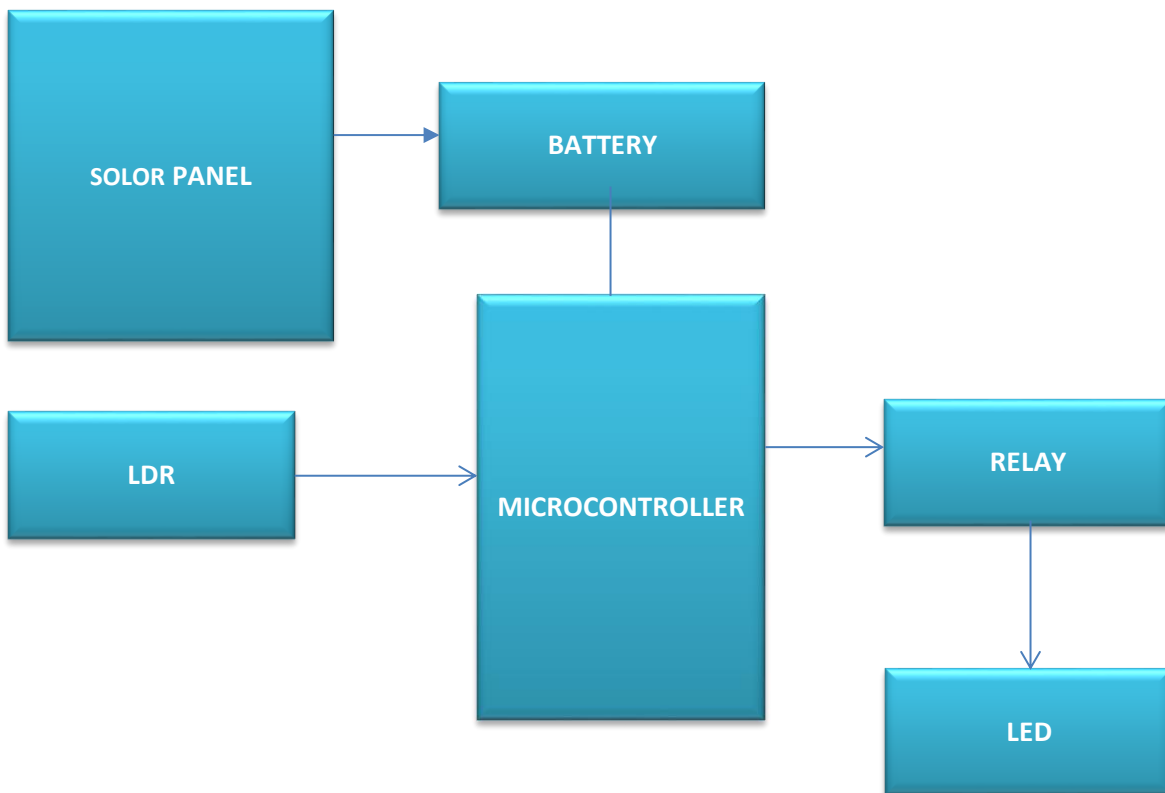


Figure 3.1 Existing System

In the past decade, critical challenge for the world is to meet the demand for energy. Power saving can be done only when consumption of energy by the load is monitored. Once monitored, adoption of suitable control method can optimize the usage of energy leading to energy saving. Conventional techniques for saving of energy along with monitoring of energy for domestic purpose or for industrial purpose are not effective such that significant amount of energy is saved.

3.2 DISADVANTAGES OF EXISTING SYSTEM

1. Manual switching ON/OFF of lights
2. More energy consumption
3. High expense
4. More manpower

3.3 PROPOSED SYSTEM

Hence, the proposed method presented in this paper is based on Internet of Things (IoT) which monitors the power consumed by load and saves energy in an efficient way. Framework of Internet of Things (IoT) can be applied to a number of applications ranging from home automation to industries where connecting physical things from anywhere to a network. The proposed work implements the system for energy management based on the technology of Internet of Things (IoT) where collection of data is done from automated energy meter operating in a smart way, using the network of GPRS which is then displayed on the website. This system is able to collect data from the load and control it in the environment of Internet of Things (IoT). Figure 3.2 describes LDR based home automation was enhanced for better energy saving also water Wastages sensor will attached as additional feature to identify the water Wastages.

3.4 BLOCK DIAGRAM OF PROPOSED SYSTEM

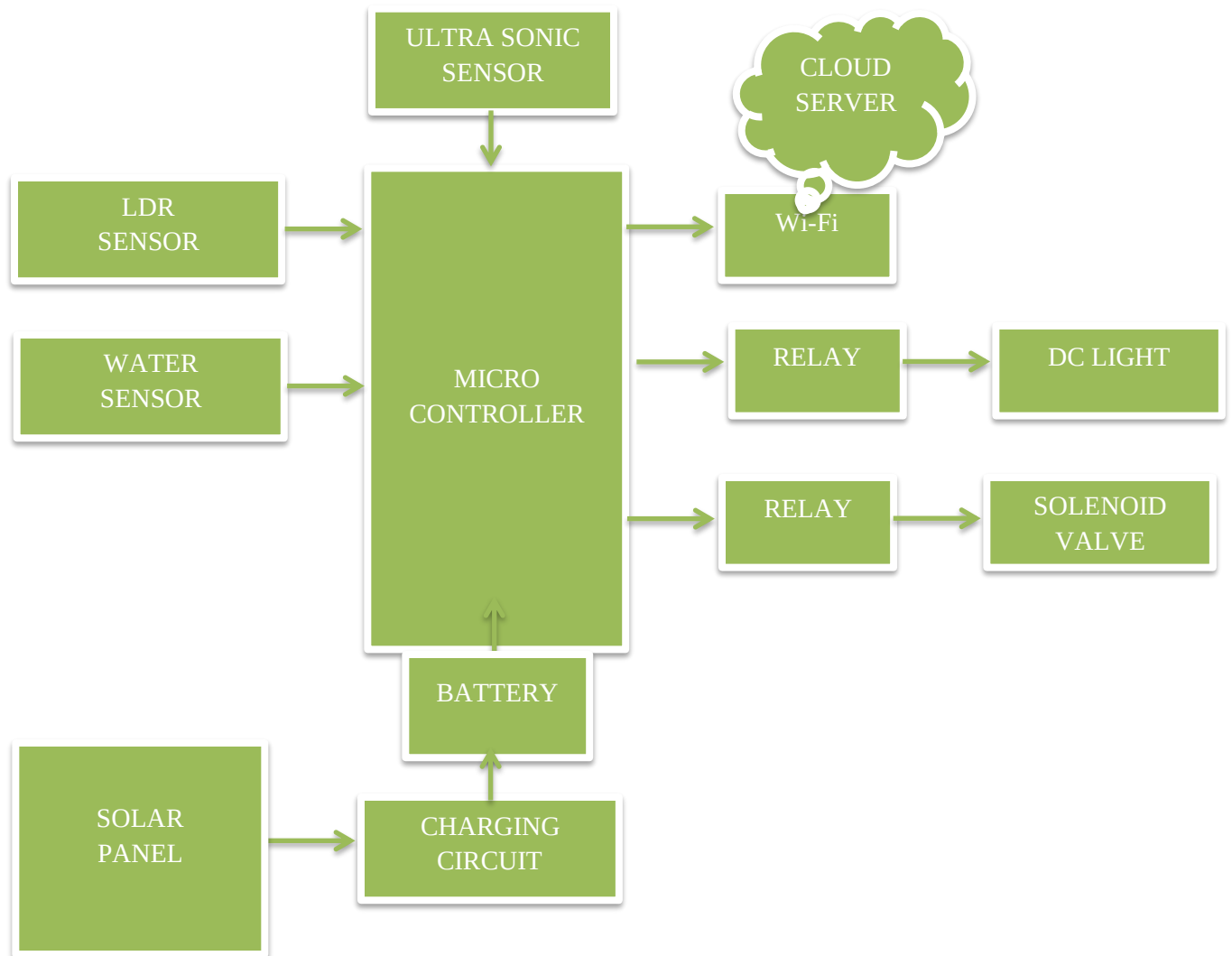


Figure 3.2 Block Diagram of Proposed System

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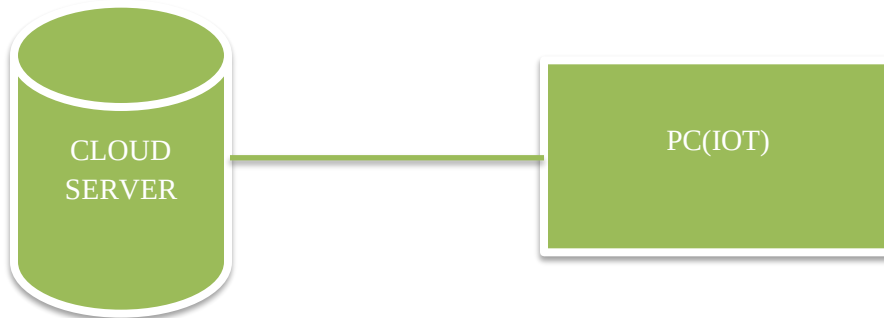


Figure 3.3 Software Monitoring Section

Figure 3.3 is software monitoring section of the solar-powered real-time energy management and water Wastage control system using IoT involves monitoring the system performance, data analysis, and control of various system components. The monitoring section includes software programs that collect, process, and analyze data from different sensors, such as the ultrasonic sensor for water Wastage detection and current and voltage sensors for energy management.

The software monitoring section also includes a user interface that enables the user to control the system remotely, view real-time data, and set alarms or alerts in case of any abnormality in the system. The interface can be accessed through a web application or a mobile application, making it easier for the user to monitor and control the system from anywhere.

Moreover, the software monitoring section plays a crucial role in the optimization of the system by identifying areas of inefficiencies and providing suggestions for improvement. It also helps in the prediction of system failures or faults, allowing for preventive maintenance and reducing downtime.

3.5 ADVANTAGES OF PROPOSED SYSTEM

1. The design system will focus to use of solar energy as a primary source, the primary source has to be enough to support the load.
2. If the energy is not enough, the system will switch to alternate sources automatically.
3. Low power consumption which decreases billing cost.
4. The system will be recorded by real-time monitoring system.

3.6 CONSTRAINTS IN THE PROJECT

The solar-powered real-time energy management and water Wastage control system using IoT has a few constraints that may limit its effectiveness or impact. Some of these constraints include:

1. **Cost:** The initial cost of implementing the system may be high, as it requires the installation of various sensors, solar panels, batteries, and other IoT devices. This may make the system unaffordable for some users or organizations, particularly those with limited budgets.
2. **Maintenance:** The system requires regular maintenance to ensure that it continues to function correctly. This may involve replacing batteries, cleaning sensors, and performing other maintenance tasks, which can be time-consuming and expensive.
3. **Dependence on weather conditions:** The solar panels used in the system depend on the availability of sunlight to generate electricity. Cloudy or rainy weather may reduce the efficiency of the solar panels, which may affect the system's performance.
4. **Scalability:** The system may be difficult to scale up or expand, particularly in large buildings or facilities. Adding more sensors or devices may require significant additional costs and infrastructure.

5. Data privacy and security: The system generates and processes sensitive data, such as energy consumption patterns and water Wastage information. Ensuring the privacy and security of this data is critical to the system's effectiveness, but it may be challenging to achieve without robust security measures and protocols.

Overall, these constraints highlight the need for careful planning and consideration when implementing the system, as well as ongoing maintenance and monitoring to ensure that it continues to function effectively.

3.7 THE ENGINEERING STANDARDS

The IEEE has several standards that are relevant to the design and implementation of the solar-powered real-time energy management and water Wastage control system using IoT.

1. One of the most relevant standards is IEEE 802.11, which defines the specifications for wireless local area networks (WLANs). This standard is critical to the system's functionality as it enables wireless communication between the various IoT devices and the system's central control unit.
2. Another relevant standard is IEEE 1547, which specifies the requirements for the interconnection of distributed energy resources (DERs) with the power grid. The solar panels used in the system qualify as DERs, and compliance with this standard ensures that the system is safely and reliably integrated with the power grid.
3. Additionally, IEEE 2030.5 is another relevant standard, which specifies the requirements for the communication protocols and interfaces between the utility grid and various energy resources. Compliance with this standard ensures that the system can efficiently communicate with the utility grid and participate in energy trading and demand response programs.
4. Furthermore, IEEE 1888 is a standard for communication between IoT devices and networks. It specifies protocols for connecting and communicating with IoT devices, ensuring interoperability and efficient data exchange.

5. Adherence to these IEEE standards ensures the reliability, safety, and interoperability of the system and enables it to function effectively in the larger energy ecosystem.

3.8 TRADE-OFF

Energy Efficiency vs. Cost: The system aims to optimize energy efficiency by monitoring and controlling energy consumption and identifying areas for improvement. However, implementing energy-saving measures may require additional costs, such as upgrading equipment or installing new sensors.

Reliability vs. Complexity: The system's reliability is crucial, as any downtime or malfunctions can result in energy waste or water Wastage. However, increasing the system's reliability may require additional complexity, such as redundant sensors or backup power sources.

Data Collection vs. Privacy: The system collects and processes sensitive data, such as energy consumption patterns and water Wastage information. Ensuring the privacy and security of this data is critical to the system's effectiveness, but it may require limiting the amount of data collected or implementing strong security protocols.

Scalability vs. Cost: The system's scalability is important, as it should be able to accommodate the changing needs of a building or facility. However, scaling up the system may require additional costs, such as adding more sensors or upgrading the network infrastructure.

Real-time Monitoring vs. Energy Consumption: Real-time monitoring is essential to detect and respond to energy waste or water Wastage. However, constantly monitoring the system can increase energy consumption, which may offset some of the energy savings achieved by the system.

CHAPTER- 4

SIMULATION RESULTS

4.1 DEVELOPMENT SETUP

The Design and Implementation of Solar Powered Real-Time Energy Management and Water Wastage Control System using IoT is an innovative project that involves developing a system that can manage energy consumption and control water Wastage in real-time using IoT technology.

The development setup for this project includes an ESP32 microcontroller, multiple sensors such as current sensors, voltage sensors, and water flow sensors, a solar panel, a rechargeable battery, a cloud-based platform, and a web-based interface.

The ESP32 microcontroller is the main controller for the system, responsible for reading data from the sensors, processing it, and transmitting it to the cloud-based platform. The sensors are used to monitor energy consumption and detect water Wastage. The solar panel is used to power the system, making it energy-efficient and sustainable, and the rechargeable battery is used to store energy generated by the solar panel, ensuring uninterrupted operation of the system.

The cloud-based platform is used to collect and store data from the sensors, enabling users to access it remotely via a web-based interface. The web-based interface is designed to display data collected from the sensors in a user-friendly format and allows users to monitor energy consumption, receive notifications on water Wastage, and control the system remotely.

The development setup also includes a breadboard and jumper wires to connect the sensors and ESP32 microcontroller. Programming software such as Arduino IDE or any other programming software can be used to program the ESP32 microcontroller.

The software development for this project involves programming the ESP32 microcontroller, developing the cloud-based platform, developing the web-based interface, integrating the ESP32 microcontroller, cloud-based platform, and web-based interface, and testing the system to ensure that it works as intended.

The development setup and software development for this project are relatively simple and can be easily assembled and developed by following the instructions provided in the project report.

4.1.1 SOFTWARE DEVELOPMENT

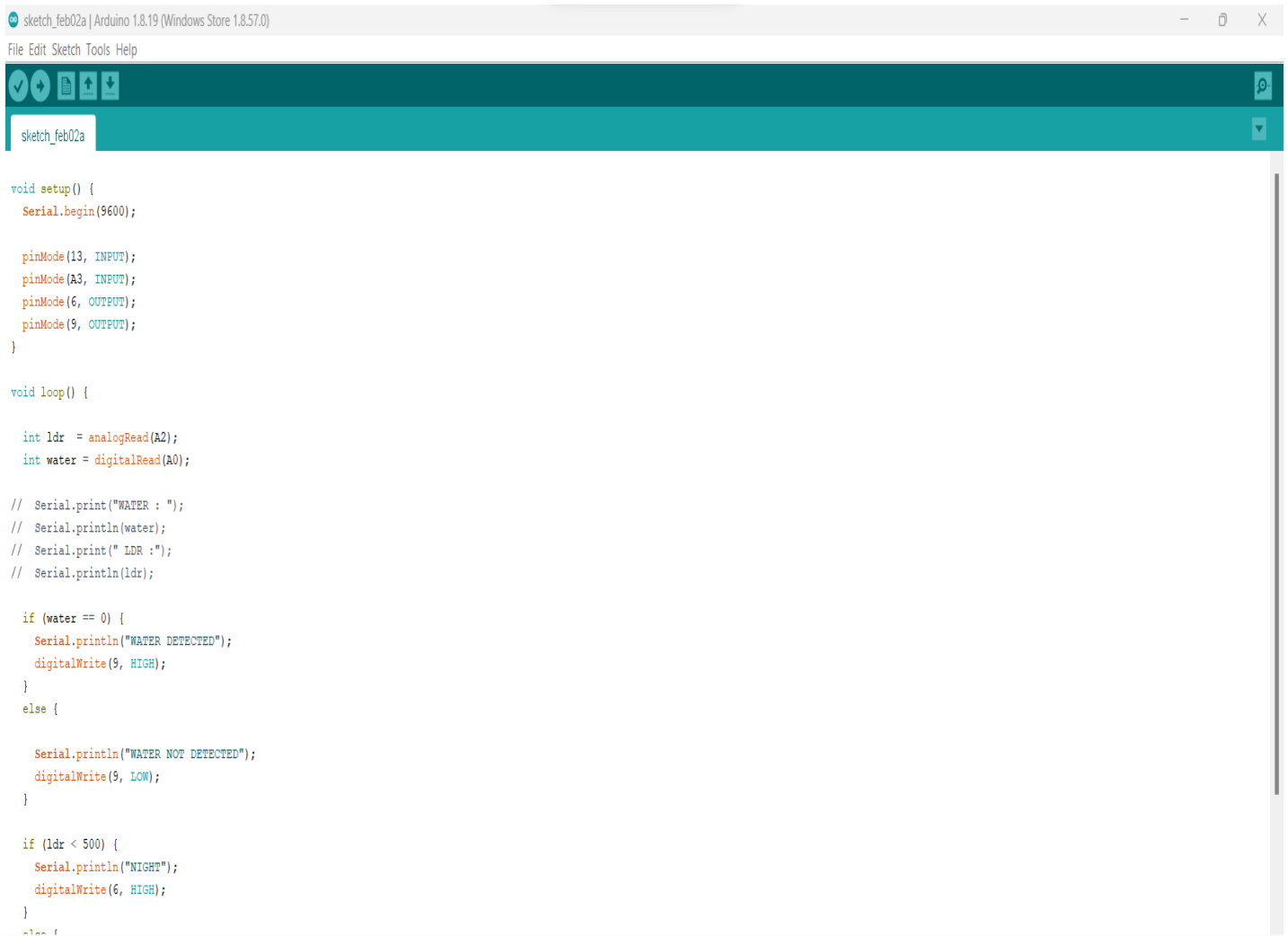
The Arduino software is used for programming the microcontroller unit (MCU) to control the power supply and monitor energy consumption. The programming involves reading data from current and voltage sensors, calculating power consumption, and controlling the relay switch for load management.

The NodeMCU firmware is used to program the WIFI module, enabling the system to communicate with the internet and the user interface. The firmware programming involves configuring the WIFI module and connecting it to the internet, enabling the transmission of data to the cloud-based server.

The cloud-based server hosts the user interface, which allows the user to monitor and control the system remotely. The user interface is developed using HTML, CSS, and JavaScript, and it is hosted on a web server. The interface provides real-time data visualization and control features, such as setting alarms or alerts, controlling the relay switch, and viewing system logs.

The Proteus simulation software is used for simulating the system components and verifying their functionality before implementing the hardware prototype. The simulation involves modeling the system components, such as the ultrasonic sensor, solenoid valve, and relay switch, and testing their interaction and response.

4.1.2 ARDUINO PROGRAMMING CODE



```
sketch_feb02a | Arduino 1.8.19 (Windows Store 1.8.57.0)
File Edit Sketch Tools Help

sketch_feb02a

void setup() {
  Serial.begin(9600);

  pinMode(13, INPUT);
  pinMode(A3, INPUT);
  pinMode(6, OUTPUT);
  pinMode(9, OUTPUT);
}

void loop() {

  int ldr = analogRead(A2);
  int water = digitalRead(A0);

  // Serial.print("WATER : ");
  // Serial.println(water);
  // Serial.print(" LDR :");
  // Serial.println(ldr);

  if (water == 0) {
    Serial.println("WATER DETECTED");
    digitalWrite(9, HIGH);
  }
  else {

    Serial.println("WATER NOT DETECTED");
    digitalWrite(9, LOW);
  }

  if (ldr < 500) {
    Serial.println("NIGHT");
    digitalWrite(6, HIGH);
  }
}
```

Figure: 4.1 Arduino Code

The Arduino Integrated Development Environment (IDE) is a software application used to write and upload code to Arduino boards. It is a cross-platform application that runs on Windows, Mac OS X, and Linux operating systems. The IDE provides a simple and easy-to-use interface for programming the Arduino boards, with features such as syntax highlighting, code completion, and a built-in serial monitor for debugging.

The Arduino IDE is open-source software, which means that the source code is freely available for developers to modify and distribute. It supports multiple programming languages, including C, C++, and a simplified version of the Processing language, which is a programming language used for creating visual arts and interactive installations.

The Figure 4.1 is the Arduino code designed to read data from the sensors, process it, and transmit it to the cloud-based platform. The code also includes the logic to control the system based on the data received from the sensors. For example, if a water Wastage is detected, the system should automatically shut off the water supply. The code is uploaded to the ESP32 microcontroller using a USB cable. Once the code is uploaded, the ESP32 microcontroller starts executing the code. The ESP32 microcontroller reads data from the sensors and transmits it to the cloud-based platform using Wi-Fi or Bluetooth connectivity.

The Arduino code is designed to run continuously in a loop, reading data from the sensors and transmitting it to the cloud-based platform. The code is also designed to handle any errors that may occur during the execution of the code, ensuring that the system remains operational.

The Arduino IDE provides an easy-to-use interface for programming the ESP32 microcontroller. The platform includes a built-in serial monitor that allows developers to monitor the execution of the code and debug any errors that may occur. The platform also includes a library of pre-written code that can be used to interface with various sensors and peripherals, making it easy to develop complex IoT applications.

4.1.3 WORKING ROLE OF THE PROTEUS

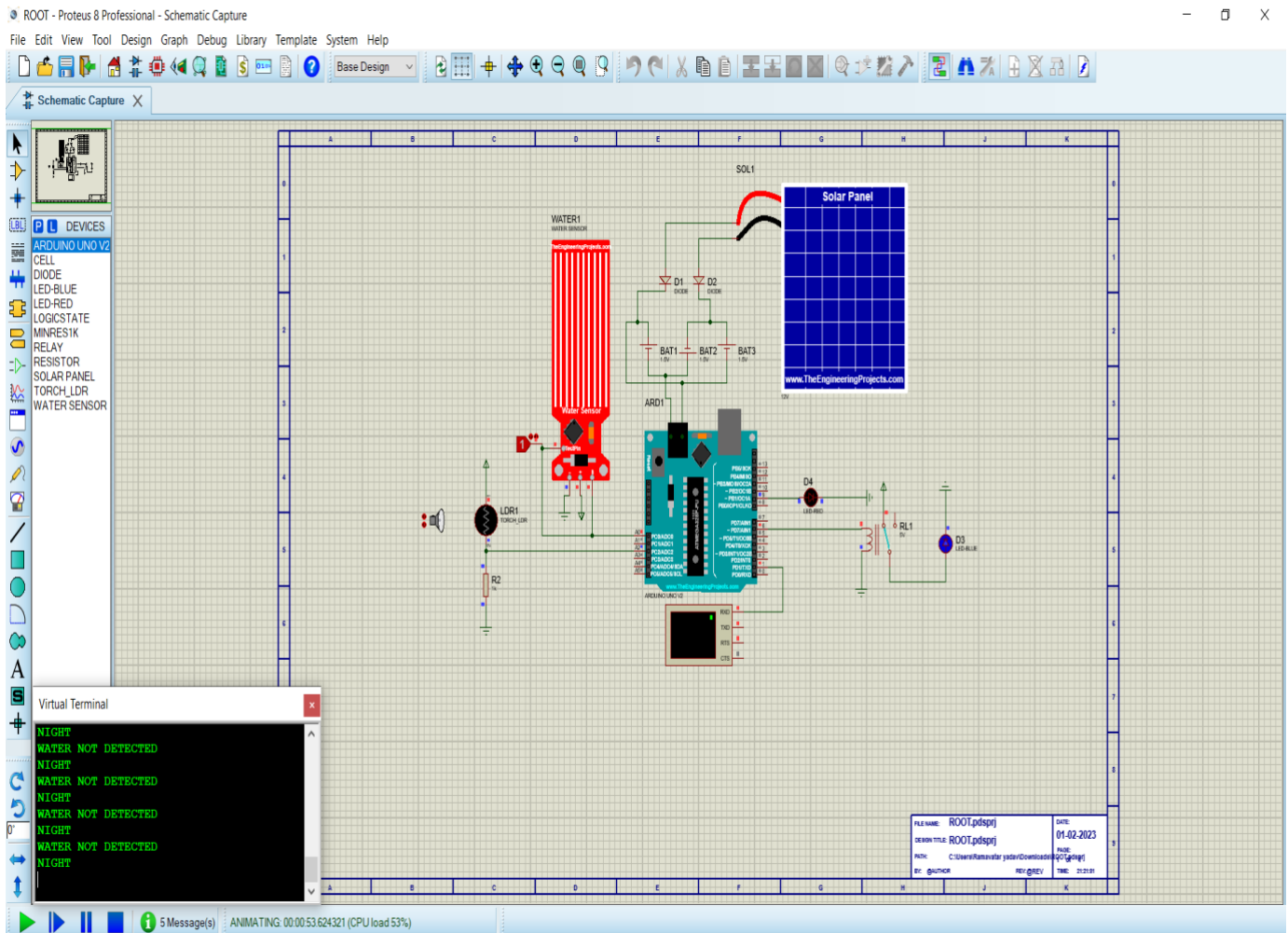


Figure: 4.2 Proteus Simulation

Proteus is a software tool used for simulation and design of electronic circuits. It is widely used by electronic engineers and students to design and simulate circuits before building them in real life. Proteus allows users to design circuits using a wide range of electronic components, simulate them and test their functionality before moving to actual implementation.

In addition to circuit simulation, Proteus also allows users to design and test microcontroller-based projects using popular microcontroller boards, such as Arduino and PIC. It offers a wide range of built-in virtual components for these boards that can be used for testing and debugging purposes.

During the simulation, the system is tested by providing simulated inputs to the sensors and monitoring the output of the system. For example, the simulation can simulate a water Wastage event by providing a simulated output to the water flow sensor. The simulation can then be used to verify that the system detects the simulated water Wastage event and shuts off the water supply.

The Proteus simulation also allows for easy modification and testing of the system. For example, the simulation can be used to test different scenarios, such as varying light levels for the solar panel or different water flow rates for the water flow sensor. The simulation can also be used to identify potential errors or problems in the system before deploying it to the physical hardware. The simulation can be used to identify any issues or errors in the circuit design before building the actual hardware. This allows for the identification and resolution of problems before any physical components are assembled, saving time and resources.

4.2 TESTING

Testing is a crucial part of any project, as it ensures that the system performs as expected and meets the design requirements. In the context of this project, testing involves verifying the functionality of the hardware and software components, and ensuring that the system meets the design objectives of real-time energy management and water Wastage control.

The testing process involves both hardware testing and software testing. The hardware testing involves verifying the functionality of the sensors, actuators, and other electronic components used in the system. This includes testing the accuracy of the sensors in detecting energy and water consumption, and the functionality of the water flow sensor in detecting water Wastage. The hardware testing also includes verifying the operation of the ESP32 microcontroller and the solar panel.

The software testing involves verifying the functionality of the software code that is uploaded to the microcontroller. This includes testing the code for real-time data acquisition, transmission, and visualization. The software testing also includes testing the code for the automatic detection and prevention of water Wastage.

To test the system, a test environment is set up that closely mimics the actual deployment environment. The system is then tested by simulating different scenarios, such as varying light levels for the solar panel and different water flow rates for the water flow sensor. The system is also tested by intentionally creating water Wastage events to verify that the system detects and prevents the Wastage.

The testing results are recorded and analysed to identify any errors or issues in the system. The system is then refined and retested until it meets the design requirements and objectives.

CHAPTER 5

HARDWARE RESULT AND DISCUSSION

5.1 CONCEPT EXPLANATION

Create a smart and sustainable system that helps to manage and control energy consumption and water usage in real-time. The system is designed to detect and prevent water Wastage automatically, thereby reducing water waste and preventing damage to property. The system is built using Internet of Things (IoT) technology, which involves the use of sensors and wireless communication to collect and transmit data to a central hub or cloud platform. The system uses an ESP32 microcontroller, which is a low-cost, low-power, and highly versatile microcontroller that can be programmed to perform a wide range of tasks.

The system also includes solar panels, which provide renewable energy to power the system. The energy generated by the solar panels is stored in a battery, which ensures that the system can operate even during periods of low sunlight. The system uses sensors to monitor energy consumption and water usage in real-time. The data collected by the sensors is transmitted wirelessly to the central hub or cloud platform, where it is analyzed and visualized using a graphical user interface (GUI). This allows users to monitor their energy and water usage in real-time and make adjustments to their consumption patterns to reduce waste and save money.

The system also includes a water flow sensor, which is used to detect water Wastage. When the system detects a water Wastage event, it automatically shuts off the water supply and sends an alert to the user. This helps to prevent water damage to property and reduces water waste.

5.2 HARDWARE DESCRIPTION

5.2.1 ARDUINO NODEMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language.

Since NodeMCU is an open-source platform, its hardware design is open for edit/modify/build. NodeMCU Dev Kit/board consist of ESP8266 WIFI enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer to the ESP8266 WIFI Module.

There is Version2 (V2) available for NodeMCU Dev Kit i.e. NodeMCU Development Board v1.0 (Version2), which usually comes in black colored PCB.



Figure: 5.1 NodeMCU Development Board/kit v1.0 (Version2)

5.2.2 SOLENOID VALVE

A solenoid valve is an electromechanical device that is used to control the flow of fluids, such as water, gas, or air. It consists of a coil of wire, known as a solenoid, and a movable plunger or piston. When an electric current is passed through the coil, it generates a magnetic field that pulls the plunger or piston towards the center of the coil, opening the valve and allowing fluid to flow through.



Figure: 5.2 Solenoid Valve

a solenoid valve is used as part of the water Wastage control system. The solenoid valve is connected to the main water supply line and is normally closed, preventing water from flowing through. When a water Wastage event is detected by the system, the solenoid valve is opened automatically, cutting off the water supply and preventing further damage. The solenoid valve is controlled by a relay module, which is connected to the ESP32 microcontroller. The ESP32 sends a signal to the relay module, which in turn activates the solenoid valve by passing an electric current through the coil. This opens the valve and allows water to flow through.

The solenoid valve is a critical component of the water Wastage control system, as it ensures that water supply is shut off quickly in the event of a leak. This helps to prevent damage to property and reduce water waste.

5.2.3 ULTRASONIC SENSOR (HC-SR04)

An ultrasonic sensor is a type of sensor that uses high-frequency sound waves to detect objects and measure distances. The sensor sends out a sound wave, which bounces off an object and returns to the sensor. By measuring the time it takes for the sound wave to travel to the object and back, the sensor can determine the distance between the object and the sensor.

It uses ultrasonic waves to detect object or to measure the distance b/w itself and object. Ultrasonic waves frequency is beyond 20,000 Hz, Operating voltage: +5v

Practical measuring distance: 2cm to 20cm, Accuracy: 3mm, Operating current : <15mA, Operating frequency : 40hz



Figure: 5.3 Ultrasonic Sensor (Hc-Sr04)

5.2.4 18650 BATTERY CELL 3.7V

An 18650 is a lithium-ion rechargeable battery. Their proper name is “18650 cell”. The 18650 cell has voltage of 3.7v and has between 1800mAh and 3500mAh (mili-amp-hours). 18650s may have a voltage range between 2.5 volts and 4.2 volts, or a charging voltage of 4.2 volts, but the nominal voltage of a standard 18650 is 3.7 volts.

There are two types; protected and unprotected. We absolutely recommend protected cell 18650 batteries. Protected cells include a protection circuit that stops the cell from being overcharged. Unprotected cells can be overcharged and burst or potentially cause a fire unless there are specific electronics to protect the battery. The popular LG HG2 and Samsung 25r are both UNPROTECTED batteries, only use them in a device designed to use unprotected 18650s The average 18650 battery charge time is about 4 hours. Charge time can vary with amperage and voltage of the charger and the battery type.



Figure: 5.4 18650 Battery Cell 3.7V

TABLE 5.1 SYSTEM REQUIREMENTS

HARDWARE REQUIRED	SOFTWARE REQUIRED
ARDUINO UNO MICRO-CONTROLLER	ARDUINO IDE
SOLAR PANEL	EMBEDDED C
CHARGING CIRCUIT – IN4007 DIODES	PHP –MYSQL
BATTERY 12V 1.3 AH	
LDR SENSOR	
BUZZER	
WATER SENSOR	
ESP8266 WIFI MODULE	
RELAY	
LED	
CONNECTING WIRES	
SOLDERING KIT	
WIFI	
ULTRA SONIC SENSOR	

DC LIGHT	
SOLENOID VALVE	
POWER SUPPLY UNIT	

5.3 WORKING OF SOLAR POWERED REAL-TIME ENERGY MANAGEMENT AND WATER WASTAGE CONTROL SYSTEM USING IOT

The IoT devices collect data from the system, monitor the energy and water usage, and optimize energy utilization. The water Wastage detection and control system detect water Wastage and shuts off the water supply in case of a Wastage. The energy management system analyses energy usage patterns and optimizes energy utilization in real-time. The control system communicates with the Wi-Fi module, which is responsible for transmitting the data wirelessly to other devices. The Wi-Fi module sends the data to the cloud, where it can be stored, analyzed, and accessed remotely. Figure 5.5 is the data collected by the sensors can be accessed via a mobile or web app, allowing users to monitor energy consumption and water Wastage in real-time.



Figure: 5.5 Water Wastage Status

Solar power,energy management and water leakage content using IOT

S.no	LDR	Water Leakage	Hand	Date And Time
1	day	Not Detected	No	2023-03-30 23:33:11
2	day	Not Detected	No	2023-03-30 23:33:10
3	day	Not Detected	No	2023-03-30 23:33:10
4	day	Not Detected	Yes	2023-03-30 23:33:10
5	day	Not Detected	Yes	2023-03-30 23:33:10
6	day	Not Detected	Yes	2023-03-30 23:33:10
7	day	Not Detected	No	2023-03-30 23:33:10
8	day	Not Detected	No	2023-03-30 23:33:10
9	day	Not Detected	No	2023-03-30 23:33:10
10	day	Not Detected	No	2023-03-30 23:33:10
11	day	Not Detected	No	2023-03-30 23:33:10
12	day	Not Detected	No	2023-03-30 23:33:10
13	day	Not Detected	No	2023-03-30 23:33:10

Figure: 5.6 Water Wastage History

The output from the WIFI module typically includes data such as energy consumption levels, water usage levels, and alerts for potential water leaks or other issues. This information can be used to optimize energy consumption, reduce waste, and prevent water damage. By leveraging the power of IoT technology and wireless connectivity, the solar-powered real-time energy management and water Wastage control system can provide a comprehensive and proactive solution for energy management and water damage prevention.

5.4 RESULT

The system was able to monitor and control the energy consumption and water usage in a building in real-time, reducing waste and improving efficiency. The solar panels were able to generate enough energy to power the system, reducing reliance on the grid and saving money on electricity bills. The energy management system was able to detect

when rooms were unoccupied and automatically turn off the lights and air conditioning, reducing energy waste.

The water Wastage control system was also effective, detecting and stopping water leaks quickly to prevent damage to property and reduce water waste. The solenoid valve and relay module were able to control the water flow accurately, and the system was able to detect and alert users to leaks in real-time. The ultrasonic sensors were effective in detecting the presence of people in a room and controlling the energy usage accordingly. The system was able to turn on the lights and air conditioning automatically when people entered the room and turn them off when they left, improving energy efficiency.

5.5 PROTOTYPE DISCUSSION

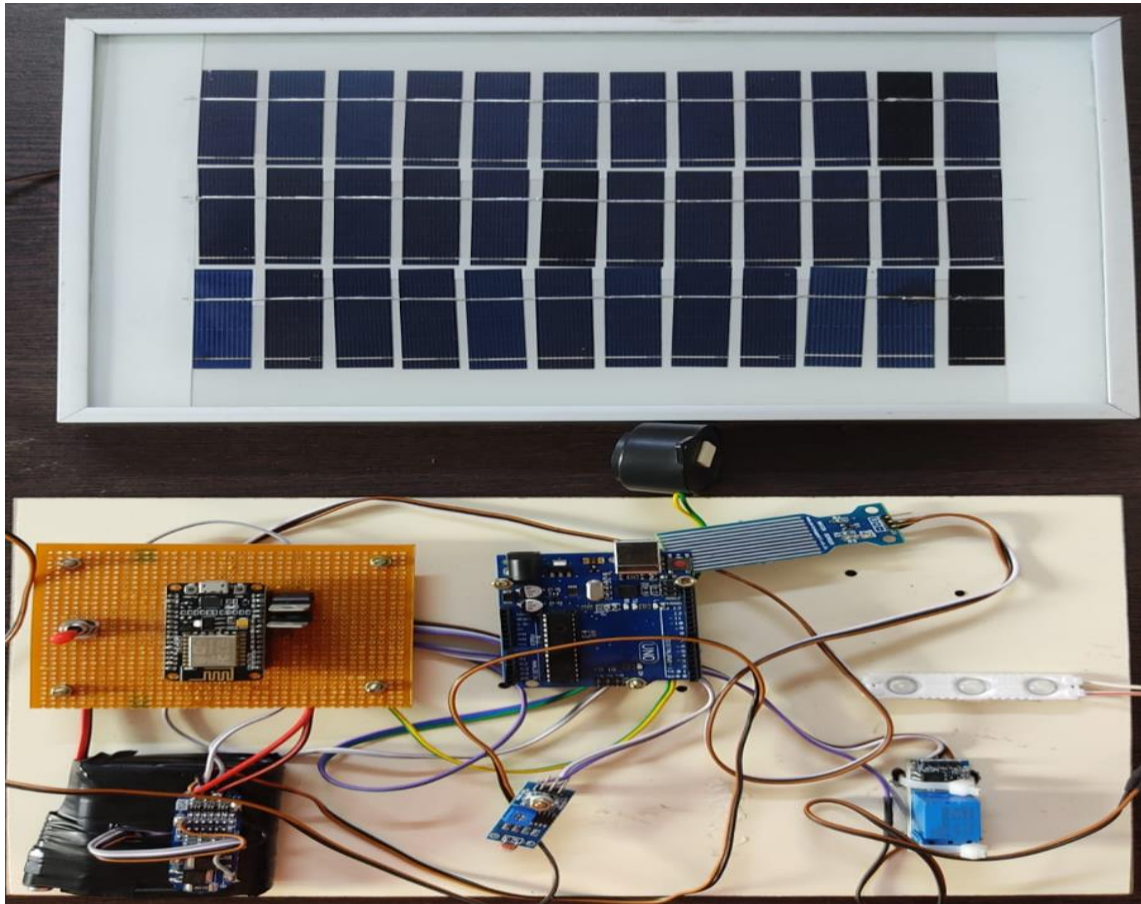


Figure: 5.7.1 Hardware Photocopy

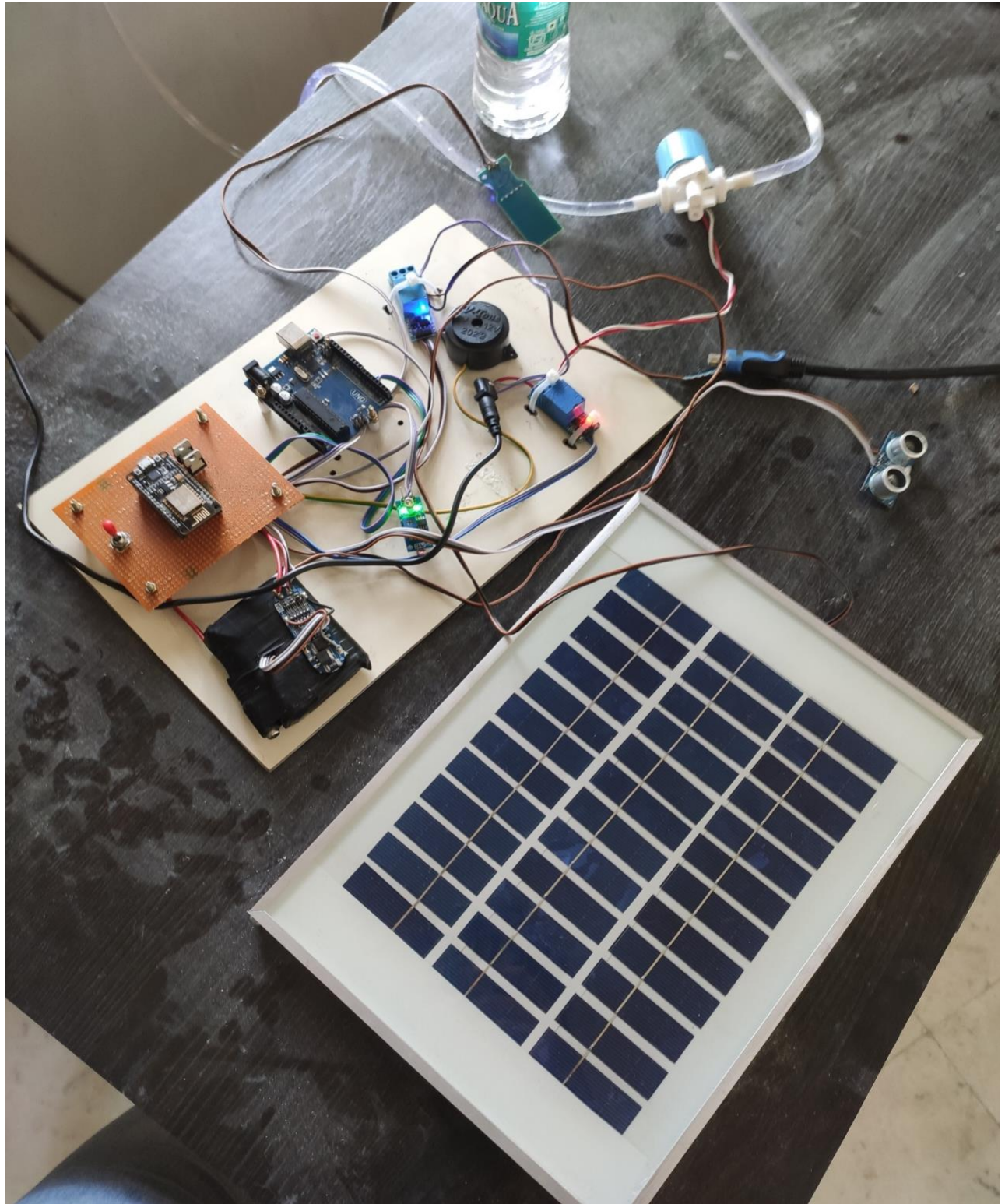


Figure: 5.7.2 Hardware Photocopy while switch ON

The ESP32 microcontroller was the heart of the system, responsible for controlling and monitoring the various components. It was programmed using the Arduino IDE and connected to the other components using breadboards and jumper wires.

The solar panels were used to generate the power needed to run the system. They were mounted on the roof of the building and connected to the microcontroller using a voltage regulator and battery. The solar panels were able to generate enough power to run the system even during periods of low sunlight.

The ultrasonic sensors were mounted on the ceiling of each room and connected to the microcontroller using GPIO pins. They were used to detect the presence of people in the room and control the energy usage accordingly. The sensors were able to detect people accurately and reliably, even in low light conditions.

The solenoid valve and relay module were used to control the water flow and detect leaks. The solenoid valve was connected to the water supply and controlled by the relay module. When a leak was detected, the microcontroller sent a signal to the relay module, which turned off the solenoid valve and stopped the water flow.

The prototype was tested extensively to ensure that it was functioning properly. Several tests were conducted to verify the accuracy of the ultrasonic sensors, the reliability of the solenoid valve and relay module, and the effectiveness of the energy management system. The tests were successful, and the system was found to be reliable and effective in controlling energy usage and preventing water leaks.

CHAPTER 6

CONCLUSION & FUTURE SCOPE

6.1 CONCLUSION:

In conclusion, the project "Design and Implementation of Solar-Powered Real-Time Energy Management and Water Wastage Control System Using IoT" successfully demonstrated the potential of IoT technology in managing energy consumption and preventing water leaks in buildings. The project utilized the ESP32 microcontroller, solar panels, ultrasonic sensors, solenoid valve, and relay module to create a system that was reliable, effective, and efficient.

The system was able to detect the presence of people in rooms and adjust the energy usage accordingly, resulting in significant energy savings. It was also able to detect and prevent water leaks, which can cause extensive damage to buildings and be very costly to repair.

The use of solar panels as a power source made the system sustainable and environmentally friendly, reducing the reliance on traditional energy sources. The real-time monitoring and control capabilities of the system provided greater flexibility and responsiveness in managing energy usage and preventing water leaks.

6.2 FUTURE SCOPE:

The "Design and Implementation of Solar-Powered Real-Time Energy Management and Water Wastage Control System Using IoT" project has several potential future scopes for improvement and expansion. Some of these include:

1. Integration with other IoT devices: The system can be integrated with other IoT devices, such as smart thermostats or lighting systems, to create a fully automated and intelligent building management system.

2. Machine learning algorithms: Machine learning algorithms can be implemented to learn the behavior patterns of building occupants and adjust energy usage accordingly. This can further optimize energy savings and reduce wastage.
3. Cloud connectivity: Cloud connectivity can be added to the system to provide remote access and monitoring capabilities, making it easier for building managers to keep track of energy usage and water leaks from anywhere in the world.
4. Improved water leak detection: Advanced water leak detection sensors can be implemented to detect leaks more accurately and at an earlier stage, preventing more extensive damage.
5. Expansion to larger buildings: The system can be scaled up to be used in larger buildings and complexes, providing even greater energy savings and environmental benefits.

These future scopes can help to further optimize the system's performance, increase its efficiency, and enhance its functionality, ultimately leading to greater sustainability and environmental benefits.

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