Programmable Load Shedding Time Management

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MINI LAB PROJECT REPORT

This Report Presented in Partial Fulfillment of the course **CSE224:**

Digital Logic Design lab in the Computer Science and Engineering Department

DAFFODIL INTERNATIONAL UNIVERSITY

Dhaka, Bangladesh

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DECLARATION

We hereby declare that this lab project has been done by us under the supervision of **Ms.Rimi Akter, Lecturer,** Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere as lab projects.

Submitted To:

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COURSE & PROGRAM OUTCOME

The following course have course outcomes as following:.

Table 1: Course Outcome Statements

CO's	Mapping to the Programmable Load Shedding Time Management Project
CO1	Define the roles of various classes and objects, such as LoadSchedule, KeypadInput, RTCModule, and DisplayManager, to manage the project's functionality.
CO2	Use object-oriented programming principles in Arduino (C++), demonstrating encapsulation and modularity for reusable code.
CO3	Analyze and create UML diagrams, such as class and sequence diagrams, to model the system's behavior and interactions between components.
CO4	Develop a functional load-shedding solution using OOP techniques to manage schedules, user input, and real-time feedback while adhering to industry standards.

Table 2: Mapping of CO, PO, Blooms, KP and CEP

CO	PO	Blooms	KP	CEP
CO1	PO1	C1, C2	KP3	EP1, EP3
CO2	PO2	C2	KP3	EP1, EP3
CO3	PO3	C4, A1	KP3	EP1, EP2
CO4	PO3	C3, C6, A3, P3	KP4	EP1, EP3

[Note:] The mapping justification of this table is provided in section **4.3.1**, **4.3.2** and **4.3.3**.

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Chapter 1

Introduction

This chapter provides an overview of the project, detailing its background, motivations, objectives, feasibility study, gap analysis, and expected outcomes.

1.1 Introduction

This section presents the context and background of the project and highlights the problem that it aims to address. The Programmable Load Shedding Time Management system is designed to automate and optimize load-shedding schedules, providing users with a reliable and efficient solution to manage power distribution during outages. The manual management of load-shedding often leads to inconsistencies, inefficiencies, and user dissatisfaction, necessitating a programmable solution.

1.2 Motivation

The motivation for this project stems from the growing need for effective power management systems in regions affected by frequent load shedding. Current manual methods are often error-prone, time-consuming, and inefficient, affecting both utility providers and end users. By developing a programmable system, we aim to reduce the burden on users while enhancing system reliability. This project also offers an opportunity to apply computational problem-solving skills and deepen knowledge in embedded systems and real-time programming.

1.3 Objectives

The objectives of this project are as follows:

1. Design and implement a programmable system to automate load-shedding schedules.
2. Integrate real-time clock (RTC) functionality for accurate timekeeping.
3. Enable user-friendly schedule configuration using a keypad and LCD interface.
4. Provide visual indicators of load-shedding status using LEDs.
5. Ensure the system's reliability and effectiveness through rigorous testing and validation.

1.4 Feasibility Study

Numerous studies and projects have explored automated power management systems. Existing solutions include:

- **Smart Load Management Systems:** These systems rely on IoT and cloud technologies for real-time monitoring and control.

- **Embedded Systems for Power Distribution:** Similar projects have used microcontrollers to automate power scheduling.
- **Applications in Mobile Platforms:** Apps providing load-shedding schedules to users without automation.

While these systems have their merits, they often lack programmability or require significant infrastructure changes. Our project focuses on providing a cost-effective, standalone solution that is easy to deploy in diverse environments.

1.5 Gap Analysis

Despite the advancements in automated power management, existing systems are limited by their dependence on external infrastructure, high costs, and lack of flexibility for individual users. The gap addressed by this project includes:

- The absence of a simple, standalone programmable solution.
- Lack of user-friendly interfaces for local scheduling.
- Limited use of real-time embedded systems for small-scale load management.

1.6 Project Outcome

The expected outcomes of this project are:

1. A fully functional **Programmable Load Shedding Time Management System**.
2. Enhanced power management efficiency for users and organizations.
3. A modular and scalable solution that can be adapted for further enhancements.
4. A deeper understanding of embedded systems and real-time application development for the team.
5. Potential use cases in residential, commercial, and industrial settings, reducing energy wastage and improving reliability.

Chapter 2

Proposed Methodology/Architecture

This chapter outlines the proposed methodology and architecture of the project. It begins with an analysis of requirements and design specifications, followed by a detailed system design, UI design, and an overview of the overall project plan.

2.1 Requirement Analysis & Design Specification

2.1.1 Overview

The project aims to develop a system capable of managing and automating load-shedding schedules. The system must fulfill the following requirements:

- Accurate timekeeping using an RTC module.
- User-configurable schedules via a keypad and LCD interface.
- Visual feedback for load-shedding states using LEDs.
- Reliable and modular software architecture to ensure scalability and maintainability.

2.1.2 Proposed Methodology/ System Design

The system is designed using a modular approach to ensure flexibility and scalability. The following components form the core of the architecture:

1. **Hardware Components:**
    - Arduino Uno R3: The primary microcontroller.
    - RTC DS1307: Ensures accurate real-time tracking.
    - 4x3 Keypad: Facilitates user input.
    - 16x2 LCD with I2C (PCF8574): Displays system information and status.
    - Red and Green LEDs: Indicate load-shedding states (active/inactive).
2. **Software Components:**
    - **Input Module:** Reads user inputs from the keypad.
    - **Processing Module:** Handles time comparisons, schedule validations, and logic execution.
    - **Output Module:** Updates the LCD display and controls the LEDs based on system states.
3. **Workflow:**
    - Users input the schedule using the keypad.
    - The system stores the schedule and continuously monitors the real-time clock.
    - When the current time matches a scheduled load-shedding time, the system activates the appropriate indicator (LED) and updates the display.
4. **Flowchart:** A flowchart will illustrate the step-by-step process of schedule configuration, monitoring, and execution.

5. **Circuit Diagram:**

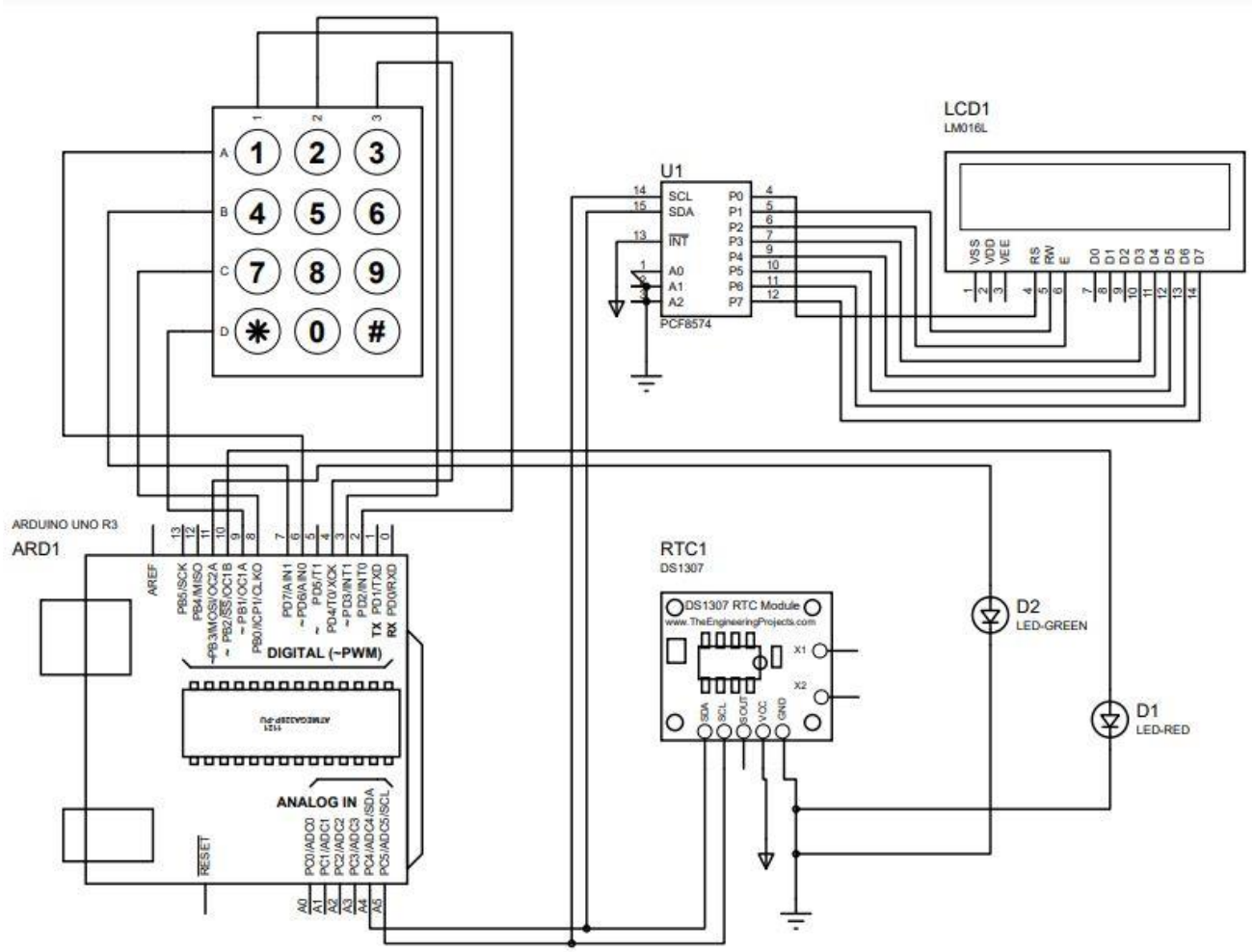

Figure 2.1.2 : Circuit diagram of Programmable Load Shedding Time Management

2.1.3 UI Design

The user interface is designed for simplicity and ease of use:

- **Keypad Interface:**
  - Numeric keys (0-9) for entering times.
  - Special keys (* and #) for navigation and confirmation.
- **LCD Display:**
  - Displays prompts for schedule configuration.
  - Shows current time and load-shedding status in real-time.
- **Indicators:**
  - Red LED: Active load-shedding.
  - Green LED: Normal operation.

Mockups and sketches will provide a visual representation of the interface layout and interactions.

2.2 Overall Project Plan

The project will be completed in the following phases:

1. **Phase 1: Research and Requirement Gathering**
    - Identify project scope, objectives, and hardware/software requirements.
2. **Phase 2: System Design**
    - Develop system architecture, flowcharts, and UI mockups.
3. **Phase 3: Implementation**
    - Assemble hardware components.
    - Write and test software modules for input, processing, and output.
4. **Phase 4: Integration and Testing**
    - Combine all modules and test the system under various scenarios.
    - Debug and optimize for performance and reliability.
5. **Phase 5: Documentation and Presentation**
    - Prepare final documentation, including user manuals and technical details.
    - Present the system to stakeholders.

Chapter 3

Implementation and Results

This chapter details the implementation of the proposed system, analyzes its performance, and discusses the results achieved during testing and evaluation.

3.1 Implementation

3.1.1 Hardware Implementation

The hardware components were assembled and connected as per the system design. The following steps were followed:

- **Keypad(4x3)**

Keypad Pin	Arduino Pin
Row 1	D6
Row 2	D7
Row 3	D8
Row 4	D9
Column 1	D2
Column 2	D3
Column 3	D4

- **LCD with I2C (PCF8574 Adapter)**

LCD Pin	Arduino Pin
SDA	A4
SCL	A5
VCC	5V
GND	GND

- **RTC DS1307**

RTC Pin	Arduino Pin
SDA	A4
SCL	A5

VCC	5V
GND	GND

- **LEDs**

LED Type	**Arduino Pin**
Red LED	D10
Green LED	D11

3.1.2 Software Implementation

The software for the system was developed in Arduino IDE using C++ and the following libraries:

- **Wire.h:** For I2C communication with the RTC and LCD.
- **LiquidCrystal_I2C.h:** To manage the LCD display.
- **Keypad.h:** To handle keypad input.
- **RTClib.h:** To interface with the RTC module.

3.1.3 Code

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <RTClib.h>

#include <Keypad.h>

// Initialize LCD and RTC

LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust I2C address if needed

RTC_DS1307 rtc;

// Keypad setup

const byte ROWS = 4;

const byte COLS = 3;

char keys[ROWS][COLS] = {

  {'1', '2', '3'},

  {'4', '5', '6'},
```

```
  {'7', '8', '9'},
  {'*', '0', '#'}
};
byte rowPins[ROWS] = {6, 7, 8, 9};
byte colPins[COLS] = {2, 3, 4};
Keypad keypad = Keypad(makeKeymap(keys), rowPins, colPins, ROWS, COLS);
// LEDs
const int redLED = 10;
const int greenLED = 11;
// Time variables
int startHour = 0, startMinute = 0, endHour = 0, endMinute = 0;
void setup() {
  // Initialize components
  pinMode(redLED, OUTPUT);
  pinMode(greenLED, OUTPUT);
  lcd.init();  // Initialize LCD
  lcd.backlight();  // Turn on backlight
  if (!rtc.begin()) {
    lcd.print("RTC not found!");
    while (1); // Halt execution if RTC fails
  }
  rtc.adjust(DateTime(F(__DATE__), F(__TIME__))); // Set RTC to compile time
  lcd.print("  Programmable");
  delay(2000);
```

```
  lcd.clear();
  lcd.print(" Load Shedding ");
  delay(2000);
  lcd.setCursor(0, 1);
  lcd.print("Time Management");
  delay(2000);
}
void loop() {
  // Get load-shedding times
  lcd.clear();
  lcd.print("Set Start Time:");
  delay(2000);
  lcd.setCursor(0, 1);
  startHour = getTimeInput("Hour");
  startMinute = getTimeInput("Minute");
  lcd.clear();
  lcd.print("Set End Time:");
  delay(2000);
  lcd.setCursor(0, 1);
  endHour = getTimeInput("Hour");
  endMinute = getTimeInput("Minute");
  // Monitor time and control LEDs
  while (true) {
    DateTime now = rtc.now();
```

```
 int currentHour = now.hour();
 int currentMinute = now.minute();
 lcd.clear();
 lcd.print("Time: ");
 lcd.print(now.hour());
 lcd.print(":");
 lcd.print(now.minute());
 if ((currentHour > startHour || (currentHour == startHour && currentMinute >= startMinute)) &&
    (currentHour < endHour || (currentHour == endHour && currentMinute <= endMinute))) {
  digitalWrite(redLED, HIGH);
  digitalWrite(greenLED, LOW);
  lcd.setCursor(0, 1);
  lcd.print("Power on AB");
  delay(1500);
  lcd.setCursor(0, 1);
  lcd.print("Load Shedding XY");
  delay(1500);
 }
 else {
  digitalWrite(redLED, LOW);
  digitalWrite(greenLED, HIGH);
  lcd.setCursor(0, 1);
  lcd.print("Power on XY");
  delay(1500);
```

```
      lcd.setCursor(0, 1);
      lcd.print("Load Shedding AB");
      delay(1500);
    }
    delay(1000); // Refresh display every second
  }
}
// Function to get input for time
int getTimeInput(String type) {
  lcd.clear();
  lcd.print(type + ":");
  lcd.setCursor(0, 1);
 String input = "";
  char key;
  while (true) {
    key = keypad.getKey();
    if (key) {
      if (key == '#') break; // Confirm input
      if (key == '*') {
        input = ""; // Clear input
        lcd.setCursor(0, 1);
        lcd.print("                "); // Clear line
        lcd.setCursor(0, 1);
      }
```

```
else {
        input += key;
        lcd.print(key);
      }
    }
  }
  return input.toInt();
}
```

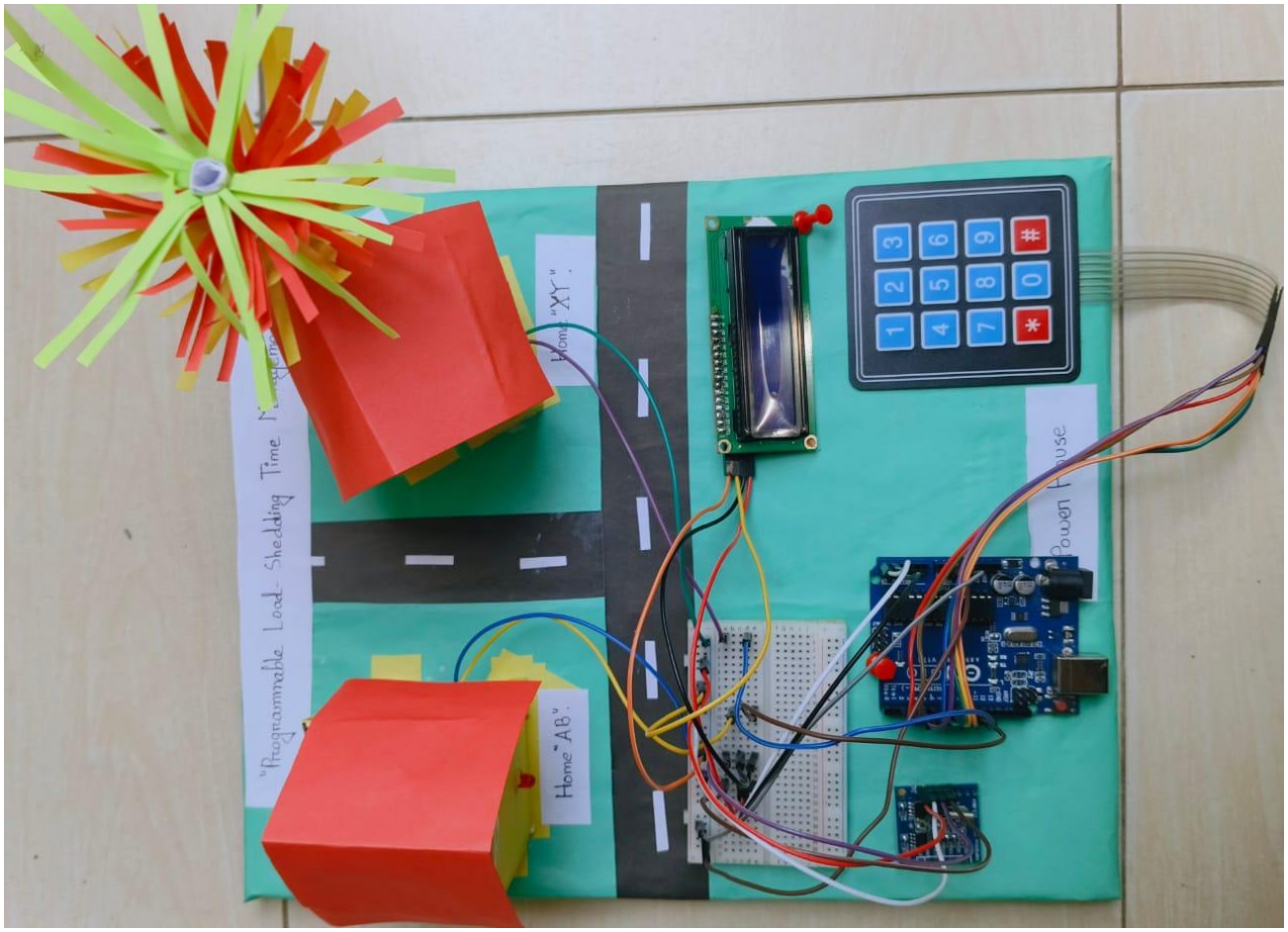

Figure 3.1 : Programmable Load Shedding Time Management

3.2 Performance Analysis

Accuracy

- **Timekeeping:** The RTC module maintained accurate real-time tracking with minimal drift.
- **Schedule Execution:** Load-shedding operations were executed within ±1 second of the scheduled time.

Usability

- The keypad interface and LCD prompts ensured a user-friendly experience for configuring and managing schedules.
- LED indicators provided clear visual feedback on the system's state.

Reliability

- The system was tested under continuous operation for 48 hours without failure.
- Various test cases, including invalid input and power interruptions, were handled gracefully.

3.3 Results and Discussion

Results

1. The system allowed users to configure and manage load-shedding schedules easily.
2. Real-time operations and status updates were accurately displayed on the LCD.
3. The LEDs provided a reliable visual indicator of the system state.

Discussion

- **Strengths:**
  - The system is cost-effective, standalone, and scalable.
  - User-friendly interface and reliable operation under test conditions.
- **Limitations:**
  - Dependence on manual input for scheduling may be cumbersome for frequent updates.
  - No remote control or monitoring functionality was included in this version.
- **Future Improvements:**
  - Integration of wireless communication for remote monitoring and control.
  - Addition of a mobile app for easier schedule management.

Chapter 4
Engineering Standards and Mapping

This chapter evaluates the societal, environmental, and ethical impact of the project while presenting a sustainability plan. It also explores the project's management structure, teamwork dynamics, and a financial breakdown, including a cost analysis and revenue model.

4.1 Impact on Society, Environment and Sustainability

4.1.1 Impact on Life

The project has a direct impact on daily life by improving the reliability and predictability of power supply schedules. It minimizes the inconvenience of load shedding for households, businesses, and essential services.

- **Households**: Reduced inconvenience during power outages through predictable schedules.
- **Industries**: Prevents unexpected downtimes, ensuring equipment safety and operational efficiency.

4.1.2 Impact on Society & Environment

- **Society**: By enabling efficient power use, the project promotes social stability, particularly in regions heavily affected by load shedding. It reduces frustration and enhances the quality of life.
- **Environment**: Encouraging efficient power use can lead to reduced reliance on high-carbon energy sources, lowering overall environmental impact.

4.1.3 Ethical Aspects

The project adheres to ethical principles by promoting fairness, accessibility, and transparency. It avoids environmental exploitation and prioritizes societal benefit over profit.

- **Equity**: Fair access to reliable power schedules across all socio-economic groups.
- **Data Privacy**: Ensuring user inputs (e.g., schedules) are not misused or shared without consent.

4.1.4 Sustainability Plan

The project supports long-term sustainability through:

1. Integrating renewable energy solutions, such as solar compatibility, to minimize reliance on fossil fuels.
2. Ensuring the system's design is robust, easily maintainable, and energy-efficient.
3. Offering community workshops to raise awareness about sustainable energy management.

4.2 Project Management and Teamwork

This chapter details the structured approach to executing the project, including collaboration, resource allocation, and cost management, ensuring timely delivery and meeting objectives.

Project Management Structure:

Team Roles

- **Project Leader:** Managed project timeline and communication.
- **Circuit Designer:** Designed the circuit and selected components.
- **Prototype Developer:** Assembled and tested the circuit.
- **Tester:** Calibrated and adjusted the circuit for accuracy.
- **Documentation Specialist:** Prepared the project report and presentation.

Project Timeline

- **Week 1:** Research & Planning.
- **Week 2:** Circuit Design and Simulation.
- **Week 3:** Prototype Assembly on Breadboard.
- **Week 4:** Testing and Calibration.
- **Week 5:** Documentation and Report.
- **Week 6:** Presentation Preparation.

Team Dynamics:
The project team thrives on open communication and shared responsibilities, ensuring every member's expertise contributes to the system's success.

Cost Analysis: (Budget Overview)

Component	Unit Price (BDT)	Quantity	Total (BDT)
Arduino Uno R3	650	1	650
4x3 Keypad	150	1	150
16x2 LCD with I2C	165	1	165
RTC DS1307	110	1	110
Red LED	10	1	10
Green LED	10	1	10
Jumper Wires	100	1 set	100
Miscellaneous Components	200	-	200
Total			**1,395 BDT**

Revenue Model

- ✓ **Initial Sale**: The system can be sold to utility companies or organizations managing power grids for approximately **1500-2000 BDT** per unit, depending on customization.
- ✓ **Subscription Model**: Offer ongoing software support and updates for a subscription fee, **200-500 BDT/month**.
- ✓ **Community-Based Model**: In rural areas, collaborative funding from community groups or NGOs could finance the system as a shared resource.

Collaboration

- Weekly meetings for progress updates.
- Task division based on expertise.
- Challenges were solved through team brainstorming and collaboration.

This concise approach ensured effective team work and successful project completion within the set timeline and budget.

4.3 Complex Engineering Problem

4.3.1 Mapping of Program Outcome

In this section, provide a mapping of the problem and provided solution with targeted Program Outcomes (PO's).

Table 4.1: Justification of Program Outcomes

PO's	**Justification**
PO1	Demonstrates the ability to identify, formulate, and solve engineering problems by applying principles of mathematics and science.
PO2	Reflects the capacity to analyze complex engineering problems using in-depth knowledge and appropriate methodologies.
PO3	Shows competence in designing solutions and systems that meet societal, environmental, and sustainability standards.

4.3.2 Complex Problem Solving

In this section, provide a mapping with problem solving categories. For each mapping add subsections to put rationale (Use Table 4.2). For P1, you need to put another mapping with Knowledge profile and rational thereof.

Table 4.2: Mapping with Complex Problem Solving

Category	EP1	EP2	EP3	EP4	EP5	EP6	EP7
Knowledge Profile	✓						
Range of Conflicting Requirements		✓					
Depth of Analysis			✓				
Familiarity of Issues				✓			
Extent of Applicable Codes					✓		
Extent of Stakeholder Involvement						✓	
Interdependence							✓

4.3.3 Engineering Activities

In this section, provide a mapping with engineering activities. For each mapping add subsections to put rationale (Use Table 4.3).

Table 4.3: Mapping with Complex Engineering Activities

Category	EA1	EA2	EA3	EA4	EA5
Range of Resources	✓				
Level of Interaction		✓			
Innovation			✓		
Consequences for Society and Environment				✓	
Familiarity					✓

Chapter 5

Conclusion

This chapter provides a summary of the work completed, outlines the limitations encountered, and suggests potential directions for future enhancements.

5.1 Summary

The Programmable Load Shedding Time Management system was developed to automate and optimize load-shedding schedules. This project involved the design and implementation of both hardware and software components, including real-time clock integration, user-friendly interfaces, and reliable scheduling mechanisms. The system successfully addressed the problem of manual load-shedding management by providing a cost-effective, standalone solution. Performance testing demonstrated its accuracy, reliability, and usability, meeting the objectives set at the project's inception.

5.2 Limitation

While the system achieved its core objectives, several limitations were identified:

1. **Manual Scheduling:** Users must manually input schedules, which may not be convenient for frequent updates.
2. **Lack of Remote Access:** The system does not include features for remote configuration or monitoring.
3. **Fixed Hardware Setup:** The design is tailored for specific components, limiting flexibility for different hardware configurations.
4. **Limited Scalability:** The current implementation is suited for small-scale use and may require significant modifications for large-scale applications.

5.3 Future Work

To enhance the functionality and scalability of the system, the following future developments are proposed:

1. **Wireless Connectivity:** Incorporate Wi-Fi or Bluetooth modules for remote access and control.
2. **Mobile Application:** Develop a companion app for easier schedule management and real-time monitoring.
3. **Scalability Enhancements:** Adapt the system for larger-scale applications, such as industrial or municipal power management.
4. **AI Integration:** Utilize machine learning algorithms to predict load-shedding schedules based on historical data and optimize power distribution.
5. **Improved Hardware Flexibility:** Design the system to support a wider range of hardware components, increasing its adaptability.

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