SAVITRIBAI PHULE PUNE UNIVERSITY

A PRELIMINARY PROJECT REPORT ON

Energy Monitoring, Usage Optimization and Condition Monitoring System

SUBMITTED TOWARDS THE
PARTIAL FULFILLMENT OF THE REQUIREMENTS OF

BACHELOR OF ENGINEERING (Computer Engineering)

BY

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SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

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Dr. D. Y. Patil Institute of Technology
DEPARTMENT OF COMPUTER ENGINEERING

CERTIFICATE

This is to certify that the Project Entitled

Energy Monitoring, Usage Optimization and Condition Monitoring System

Submitted by

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is a bonafide work carried out by Students under the supervision of Prof. Santosh V. Chobe and it is approved for the partial fulfilment of the requirement of Savtribai Phule Pune University, Pune for the award of the degree of Bachelor of Engineering (Computer Engineering).

Prof. Santosh V. Chobe Internal Guide Dept. of Computer Engg.	Dr. Pramod Patil H.O.D Dept. of Computer Engg.

Abstract

As the supply and demand of electrical energy is challenged within the context of environmental awareness, the need to monitor and optimize power usage is of utmost importance. Electrical energy plays a critical role in our lives as it is an enabling product, an intangible necessity used to power our systems. In order to manage our energy and prevent the consequences caused by energy wastage, a need arises to develop tools to accurately measure and optimize energy usage.

Currently, energy meters available in the market can measure and indicate the energy consumption of an entire household or a business premises. However, they are expensive and do not offer measurement for individual systems, particularly high power consuming electrical appliances. Despite these meters being highly precise and accurate, they see a device level limitation of energy and condition monitoring.

The primary objective of the proposed system is to precisely monitor the energy consumed by each individual device present at a premise. The electronic module shall be a replacement for a standard household switchboard and additionally would be able to calculate and locally display the energy consumed by the devices connected to the same. A certain premise may have several switchboards installed controlling numerous devices in which case one of the many modules shall be the master module. Data from all the modules along with device identification shall be relayed to the master.

The master module in any premise shall be able to communicate along with application software that would be the heart of the system. The application software shall provide an advanced graphical user interface to the user from where the user shall be able to not only control the many modules, but also view energy consumption of the appliances connected in various formats (graphical, numerical, etc.). The software extensively can be a part of the building management system. It will receive energy consumption data from the electronic modules and over period of time analyse the data to understand the variations in energy consumption of a particular device. The learning so far acquired by the software shall be used by the same to monitor the condition of a probable failing device, a device that may be under maintenance or a

device that is completely non-operational. It will also learn the usage of a particular device and generate a projected energy meter bill for the user and by extension, an energy usage plan.

Acknowledgments

It gives us great pleasure in presenting the preliminary project report on ***'Energy Monitoring, Usage Optimization and Condition Monitoring System'****.*

We would like to take this opportunity to thank our internal guide ***Prof. Santosh V. Chobe*** *for giving us all the help and guidance we needed. We are really grateful to him for his kind support. His valuable suggestions were very helpful.*

We are also grateful to ***Dr. Pramod Patil****, Head of Computer Engineering Department, Dr. D. Y. Patil Institute of Technology for his indispensable support and suggestions.*

In the end our special thanks to ***Mr. Makarand Deshmukh*** *for providing various resources such as laboratory with all needed software platforms, continuous Internet connection, for Our Project.*

Lavesh Jain
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(B.E. Computer Engg.)

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1.2 PROJECT OPTION

Industry sponsored project

1.3 INTERNAL GUIDE

Prof. Santosh V. Chobe

1.4 SPONSORSHIP AND EXTERNAL GUIDE

Mr. Makarand Deshmukh
General Electric(GE)

1.5 TECHNICAL KEYWORDS (AS PER ACM KEYWORDS)

1. Hardware - Microcontroller
    (a) MicroProgramming
    (b) Semiconductor Memories
    (c) Input/Output Devices
2. Software
    (a) Data Analysis
    (b) Machine Learning
    (c) Predictive Modselling
    (d) Client/Server

1.6 PROBLEM STATEMENT

To develop a product that should monitor energy consumption of each device and facilitate the user in energy conservation by analysing previous data set and providing the user with an interactive module to optimize usage. The system should be able to detect early failure of devices by analysing stored data.

1.7 ABSTRACT

As the supply and demand of electrical energy is challenged within the context of environmental awareness, the need to monitor and optimize power usage is of utmost importance. The primary objective of the proposed system is to precisely monitor the energy consumed by each individual device present at a premise. The electronic module shall be a replacement for a standard household switchboard. The module shall be able to communicate with application software that would be the heart of the system. The application software shall provide an advanced graphical user interface to the user from where the user shall be able to not only control the many modules, but also view energy consumption of the appliances connected in various formats (graphical, numerical, etc.). The software extensively can be a part of the building management system. It will receive energy consumption data from the electronic modules and over period of time analyse the data to understand the variations in energy consumption of a particular device.The learning so far acquired by the software shall be used by the same to monitor the condition of a probable failing device, a device that may be under maintenance or a device that is completely non-operational. It will also learn the usage of a particular device and generate a projected energy meter bill for the user and by extension, an energy usage plan.

1.8 GOALS AND OBJECTIVES

- The primary objective of the product is to conserve energy by optimizing the usage.
- The product should monitor the system, provide remote access and automation.
- The Product should also detect early failure in devices.

1.9 RELEVANT MATHEMATICS ASSOCIATED WITH THE PROJECT

System Description:

- Input:
    1. c_ r = Current reading
    2. v_ r = Voltage reading
    3. f_ r = Frequency reading
    4. time = Time stamp
- Functions:
    1. Read()= To acquire data.
    2. Analyse()= To analyse the acquired data and predict fault in devices.
    3. Result()= To generate statistical result based on processed data.
- Output:
    1. Energy usage in monetary terms
    2. Statistical analysis of power consumption
    3. Early warning for probable failure of device

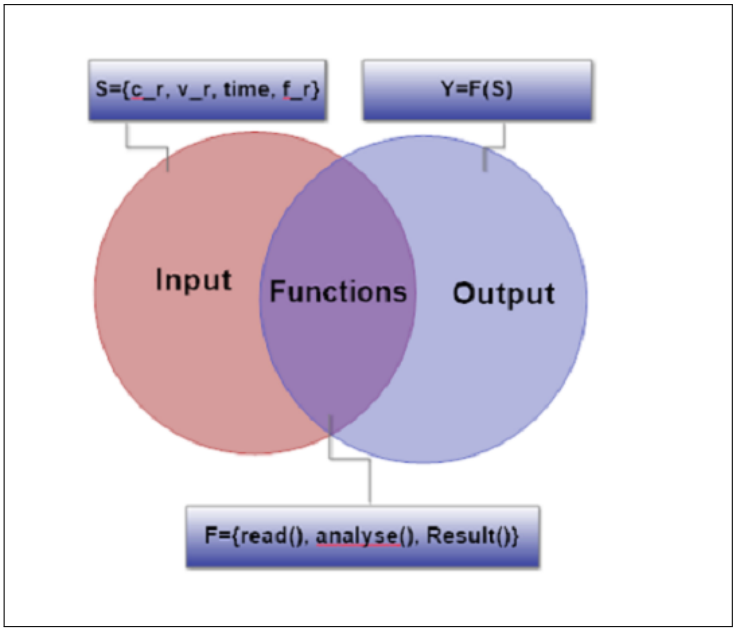

Figure 1.1: Venn Diagram

- Data Structures
    1. Trees
    2. Multi Dimensional Arrays
    3. Custom Data Structures
- Constraints
    1. Operating system and programming language compatibility.
    2. Network connectivity.
    3. Semi conductor memory.
- Success Conditions:
    1. System will accurately find the anomaly in electrical devices.
    2. It will provide the correct result in monetary terms
    3. Produce user friendly statistics

- Failure Conditions:

    1. Failure in data acquisition from the micro controller
    2. False detection of fault in devices
    3. The stored data could get corrupted
    4. Wrong calculation of result of power consumption

1.10 NAMES OF CONFERENCES / JOURNALS WHERE PAPERS CAN BE PUBLISHED

- Power and Energy Magazine, IEEE
- Journal of Computation Science, Sciencedirect
- Journal of Machine Learning Research, ACM

1.11 REVIEW OF CONFERENCE/JOURNAL PAPERS SUPPORTING PROJECT IDEA

- "Smart home automation system for energy efficient housing."

    The author presents a concept and implementation of modern smart monitoring and control system for building automization.The system enable significant reduction of energy consumption by increasing energy efficiency of the building. The system deals with the monitoring energy consumption of the entire building but not for individual devices.

- "Power consumption/supply control using neural network for micro grids."

    The author proposes power consumption/ supply control using neural network with high adaptability for micro grids. It uses neural network techniques to map and predict power consumption in grids.This system works efficiently for large power devices but is less accurate for small power devices.

- "Wireless power consumption monitoring and analysis system using Winter's forecasting method."

  In this, authors have developed an appliance-level system that monitors and analyses power consumption.This system can monitor and control electrical devices very efficiently. The system limits to analyse the data acquired over time.

- "IoT based Smart Home design using power and security management."

  The author presents the design and implementation of an Ethernet-based Smart Home intelligent system for monitoring the electrical energy consumption. The system works on real time monitoring and voice control, so that the electrical devices and switches can be remotely controlled and monitored. The system provides only control over the devices, no machine learning concepts are used to analyse previous data.

- "Integrating Nonlinear Independent Component Analysis and Neural Network in Stock Price Prediction."

  As an application, the proposed method helps to identify linear, non-Gaussian, and acyclic causal models when mild nonlinearity exists in the data generation procedure. Using this method to separate daily returns of a set of stocks, we successfully identify their linear causal relations.

1.12 PLAN OF PROJECT EXECUTION

Following is the gantt chart representation of the schedule of the project.

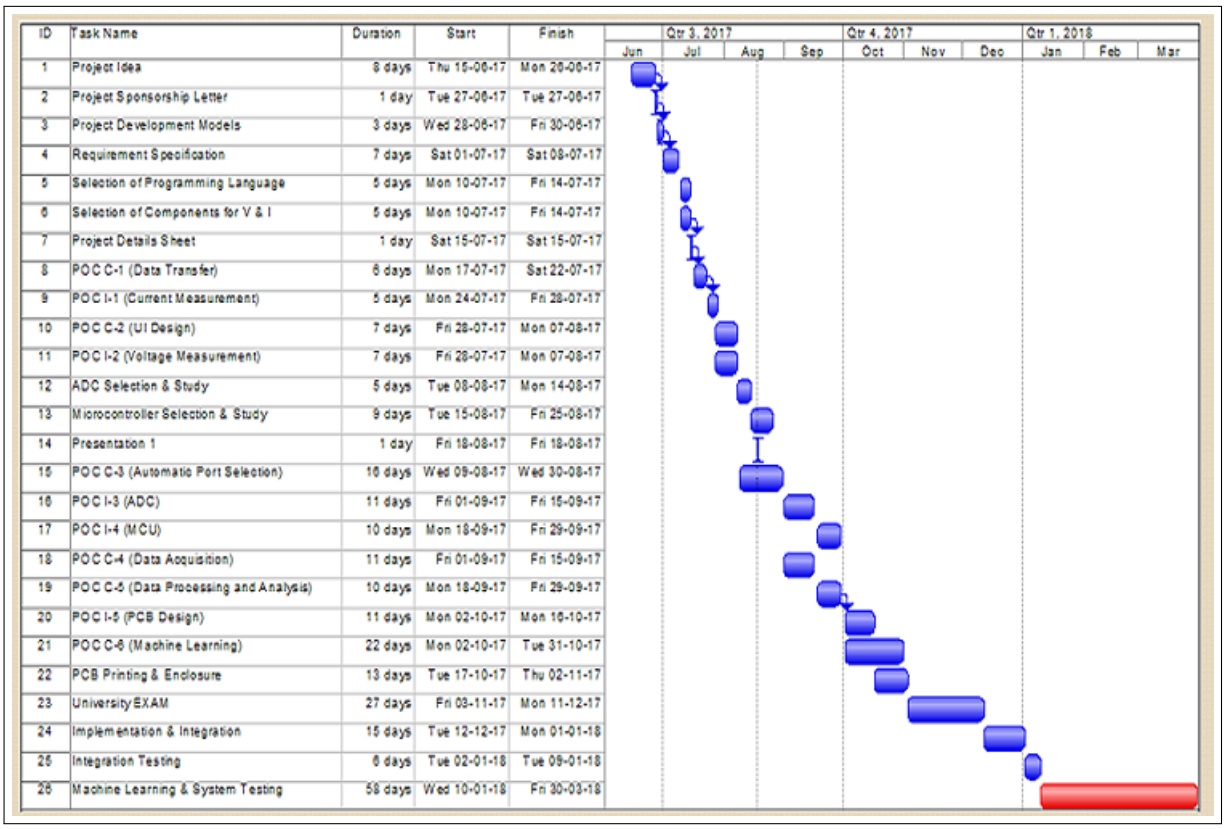

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Figure 1.2: Gantt Chart

CHAPTER 2

TECHNICAL KEYWORDS

2.1 AREA OF PROJECT

The area of project is energy conservation which consists of electrical as well as computational aspects.

2.2 TECHNICAL KEYWORDS

1. Hardware - Microcontroller
    (a) MicroProgramming
    (b) Semiconductor Memories
    (c) Input/Output Devices
2. Software
    (a) Data Analysis
    (b) Machine Learning
    (c) Predictive Modelling
    (d) Client/Server

CHAPTER 3

INTRODUCTION

3.1 PROJECT IDEA

Current power measurement systems are accurate at a certain level but cannot exactly pin point the faulty device and also cannot precisely measure the consumption reading of individual device. Hence this idea is put forth to precisely measure the energy consumption of each electrical device and provide more accurate results.

3.2 MOTIVATION OF THE PROJECT

In developing country like India, Energy conservation is a major issue. To conserve the energy first we nead to measure and monitor the energy consumption but we often feel the lack of technology to do so. Therefore a need arises to have a system which can literate the mass public about their energy consumption and provide measures to reduce their energy consumption for the betterment of each individual and to the country as a whole.

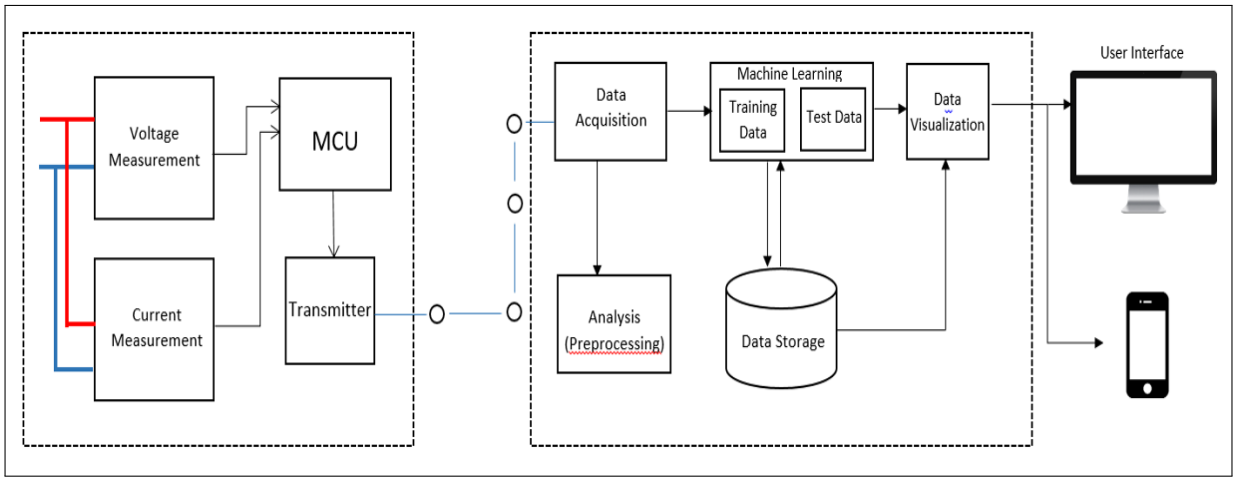

Figure 3.1: Block Diagram

3.3 LITERATURE SURVEY

1. Skeledzija, Niksa, et al. “Smart home automation system for energy efficient housing.” Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2014 37th International Convention on. IEEE, 2014.

The author presents a concept and implementation of modern smart monitoring and control system for building automization.The system enable significant reduction of energy consumption by increasing energy efficiency of the building. The system deals with the monitoring energy consumption of the entire building but not for individual devices.

2. Kaneko, Tsunashi, Shohei Shimizu, and Hiromitsu Ohmori. "Power consumption/supply control using neural network for micro grids." ICCAS-SICE, 2009. IEEE, 2009.

   The author proposes power consumption/ supply control using neural network with high adaptability for micro grids. It uses neural network techniques to map and predict power consumption in grids.This system works efficiently for large power devices but is less accurate for small power devices.

3. Enriquez, Dominic Joseph R., et al. "Wireless power consumption monitoring and analysis system using Winter's forecasting method." TENCON 2015-2015 IEEE Region 10 Conference. IEEE, 2015.

   In this, authors have developed an appliance-level system that monitors and analyses power consumption.This system can monitor and control electrical devices very efficiently. The system limits to analyse the data acquired over time.

4. Gupta, Punit, and Jasmeet Chhabra. "IoT based Smart Home design using power and security management." Innovation and Challenges in Cyber Security (ICICCS-INBUSH), 2016 International Conference on. IEEE, 2016.

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are used to analyse previous data.

5. Chi-Jie Lu, Chih-Chou Chiu, Jung-Li Yang“Integrating Nonlinear Independent Component Analysis and Neural Network in Stock Price Prediction.”, Proceedings of 22nd International Conference on Industrial, Engineering and other Applications of Applied Intelligent Systems, June 24-27, 2009, Tainan

   As an application, the proposed method helps to identify linear, non-Gaussian, and acyclic causal models when mild nonlinearity exists in the data generation procedure. Using this method to separate daily returns of a set of stocks, we successfully identify their linear causal relations.

CHAPTER 4

PROBLEM DEFINITION AND SCOPE

4.1 PROBLEM STATEMENT

To develop a product that should monitor energy consumption of each device and facilitate the user in energy conservation by analysing previous data set and providing the user with an interactive module to optimize usage. The system should be able to detect early failure of devices by analysing stored data.

4.1.1 Goals and objectives

Goal and Objectives:

- The primary objective of the product is to conserve energy by optimizing the usage.
- The product should monitor the system, provide remote access and automation.
- The Product should also detect early failure in devices.

4.1.2 Statement of scope

- The system will have input from the micro controller with a fixed size data frame which will consist of current, voltage and power readings , checksum and the frequency readings.
- The system should ignore any other data coming from the micro controller(will be treated as noise). The validation of the input from micro controller will be done by checksum and size of data frame.
- The provided data will be used in the implemented machine learning algorithm to analyse the data and provide optimal results by applying various techniques.

4.2 SOFTWARE CONTEXT

- Th proposed system will be fully automated, The software will act as the major control unit of the system. It will analyse the acquired data, implement Machine Learning algorithms and provide a interactive user interface.

4.3 MAJOR CONSTRAINTS

- Data should be acquired by the system from the micro controller in proper format.
- Data should not cause over fitting but should be sufficient for the system to learn.
- The implemented machine learning algorithm must be intelligent enough to analyse the data correctly.
- The testing of data should be done on numerous data so as to male the algorithm learn better.

4.4 METHODOLOGIES OF PROBLEM SOLVING AND EFFICIENCY ISSUES

- Various Machine Learning algorithms have their advantages and disadvantages and will have their respective performance parameters.
- The result can be stored in forms of snapshots as well as statical data structures. Snapshots will have memory constraint and statistics will need different algorithms.
- Efficiency can be checked by considering the time-space complexity.

4.5 OUTCOME

- The outcome of the project will be a ready to launch market product which is compatible for both households and commercial places where energy conservation is very crucial.

4.6 APPLICATIONS

- The System can be applied to household circuitry.
- The proposed system can be implemented in industrial areas where energy conservation is crucial need.

4.7 HARDWARE RESOURCES REQUIRED

Sr. No.	Parameter	Minimum Requirement	Justification
1	CPU Speed	2 GHz	Data acquisition
2	RAM	3 GB	storage and processing
3	Memory Disk	4 GB	Data Storage

Table 4.1: Hardware Requirements

4.8 SOFTWARE RESOURCES REQUIRED

Platform :

1. Operating System: Windows 7/8.1/10
2. IDE: Will be provided along with the system
3. Programming Language:Python, C#

CHAPTER 5

PROJECT PLAN

5.1 PROJECT ESTIMATES

5.1.1 Reconciled Estimates

5.1.1.1 Cost Estimate

The wages for the developer will be based on the number of hours required to build the project.

5.1.1.2 Time Estimates

The man hours required to design the circuitry and the programming of the machine learning algorithm and the user interface can be considered in time estimation.

5.2 RISK MANAGEMENT W.R.T. NP HARD ANALYSIS

The proposed problem statement is NP-Complete. The data acquisition can be done in polynomial time and the data can also be processed in polynomial time at constant time intervals. Here the problem can be generated as well as solved in polynomial time and hence the proposed problem is NP-Complete class problem.

5.2.1 Risk Identification

For risks identification, review of scope document, requirements specifications and schedule is done. Answers to questionnaire revealed some risks. Each risk is categorized as per the categories mentioned in [1]. Please refer table 9.1 for all the risks. You can refereed following risk identification questionnaire.

1. Have top software and customer managers formally committed to support the project? No
2. Are end-users enthusiastically committed to the project and the system/product to be built? Yes
3. Are requirements fully understood by the software engineering team and its customers? Yes
4. Have customers been involved fully in the definition of requirements? Yes

5. Do end-users have realistic expectations? Yes
6. Does the software engineering team have the right mix of skills? Yes
7. Are project requirements stable? Yes
8. Is the number of people on the project team adequate to do the job? Yes
9. Do all customer/user constituencies agree on the importance of the project and on the requirements for the system/product to be built? Yes

5.2.2 Risk Analysis

The risks for the Project can be analyzed within the constraints of time and quality

ID	Risk Description	Probability	Impact		
			Schedule	Quality	Overall
1	Description 1	Low	Low	High	High
2	Description 2	Low	Low	High	High

Table 5.1: Risk Table

Probability	Value	Description
High	Probability of occurrence is	$> 75\%$
Medium	Probability of occurrence is	$26 - 75\%$
Low	Probability of occurrence is	$< 25\%$

Table 5.2: Risk Probability definitions [1]

Impact	Value	Description
Very high	$> 10\%$	Schedule impact or Unacceptable quality
High	$5 - 10\%$	Schedule impact or Some parts of the project have low quality
Medium	$< 5\%$	Schedule impact or Barely noticeable degradation in quality Low Impact on schedule or Quality can be incorporated

Table 5.3: Risk Impact definitions [1]

5.2.3 Overview of Risk Mitigation, Monitoring, Management

Following are the details for each risk.

Risk ID	1
Risk Description	Network failure
Category	Development Environment.
Source	Software requirement Specification document.
Probability	Low
Impact	High
Response	Mitigate
Strategy	Alternative Bluetooth connectivity
Risk Status	Occurred

Risk ID	2
Risk Description	Stored data corrupt
Category	Requirements
Source	Software Design Specification documentation review.
Probability	Low
Impact	Medium
Response	Mitigate
Strategy	Back up data
Risk Status	Identified

5.3 PROJECT SCHEDULE

5.3.1 Project task set

- Task 1: Requirement specification and Designing
- Task 2: Programming algorithms
- Task 3: Testing the algorithms
- Task 4: Integrating the software and hardware

5.3.2 Timeline Chart

Following is the gnant chart representation of the schedule of the project.

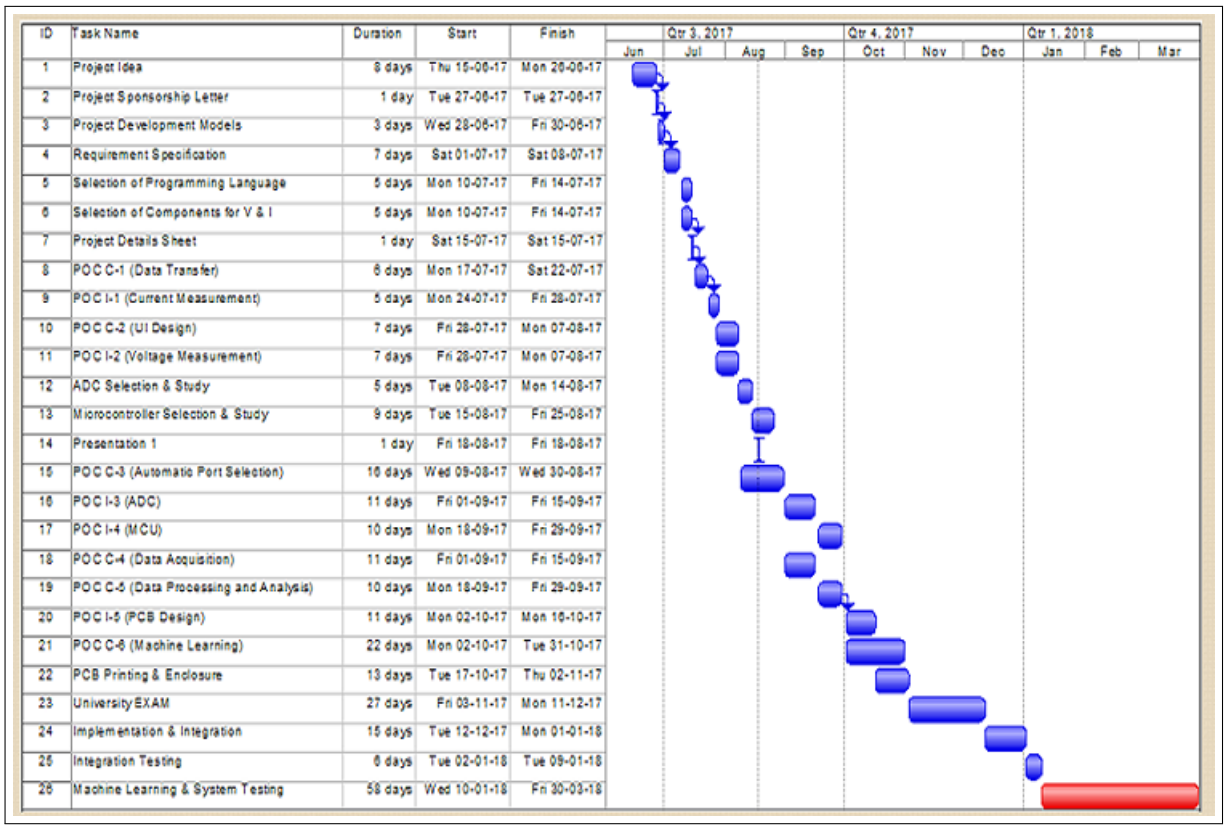

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Figure 5.1: Timeline Chart

5.4 TEAM ORGANIZATION

Tasks are assigned to the hardware and software team and after every week both the teams meet to discuss the problems and progress so far along with the weekly meeting of internal and external guide.

5.4.1 Team structure

The hardware part of the project is handled by the Instrumentation Team.
The software part of the project is handled by the Computer Team.

5.4.2 Management reporting and communication

Assessment is done by internal as well as external guide. Various lab assignments and reports are submitted to the guides timely for records.

CHAPTER 6

SOFTWARE REQUIREMENT SPECIFICATION

6.1 INTRODUCTION

6.1.1 Purpose and Scope of Document

The SRS covers the requirement specification, the objectives an the methodology.

6.1.2 Overview of responsibilities of Developer

- The developer should keep the data intact
- The developer should be able to deliver results
- The developer should make upgrades in the system and make necessary changes in the code over the period of time.

6.2 USAGE SCENARIO

The system should be developed with mind set of implementing in household as well as industrial areas.

6.2.1 User profiles

- Sensors: Sense the current and other parameters
- User: Enter the valid details of the products
- System: Analyse the data and produce the results

6.2.2 Use Cases

All Use Cases for the software are presented. Description of all main Use cases using use case template is provided.

Sr No.	Use Case	Description	Actors	Assumptions
1	Use Case 1	Data transmission	System and Hardware	data frame is fixed

Table 6.1: Use Cases

6.2.3 Use Case View

Use Case Diagram. Example is given below

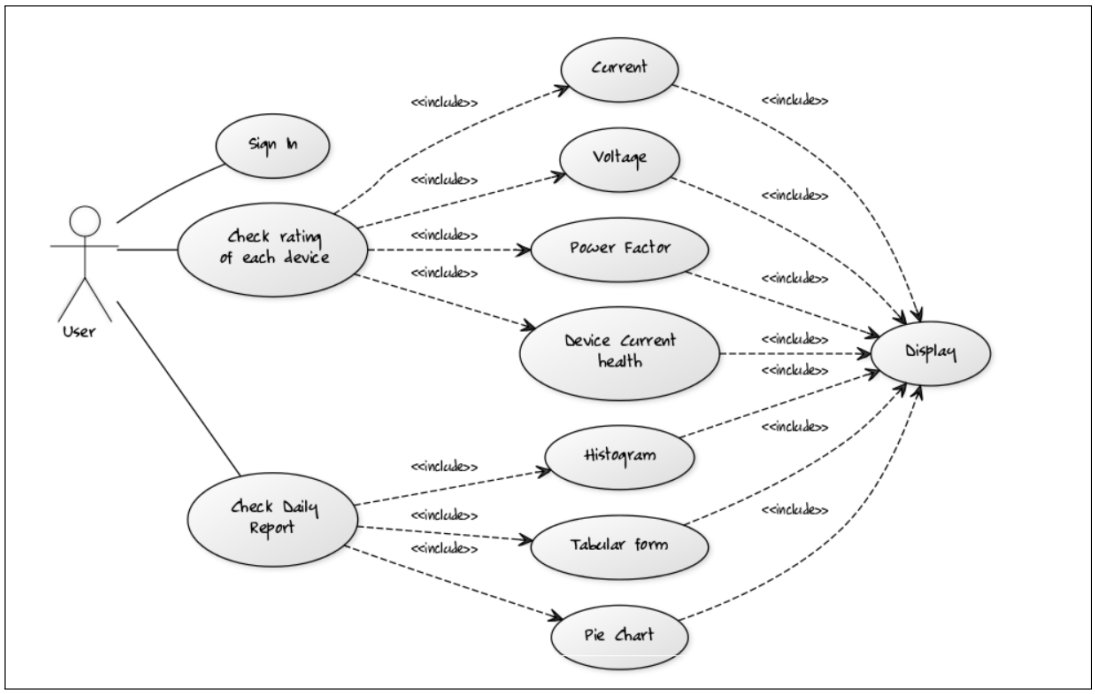


Figure 6.1: Use case diagram

6.3 DATA MODEL AND DESCRIPTION

6.3.1 Data Description

- Software will handle the data acquisition.
- Software will store the data.
- Software will produce results and display them timely.
- Storage is needed for storing csv file and processing of trees.

6.4 FUNCTIONAL MODEL AND DESCRIPTION

- Data acquisition: To acquire data from micro controller.
- Data storage: Storing the time snapshot of the data and providing data for machine learning algorithms.

- Data analysis: To implement Machine Learning algorithms on the provided data.
- User Interface: To provide the user interface.

6.4.1 Activity Diagram:

The Activity diagram represents the steps taken.

Figure 6.2: Activity diagram

6.4.2 Non Functional Requirements:

- Interface Requirements: Provide statistical analysis
- Performance Requirements: Provide exact flaw in the circuitry
- Software module is not resusable as it is key encrypted.
- It can be available on the system with stored data.

6.4.3 Software Interface Description

- A compatible OS should be available.
- The user should enter the valid details of the device
- It should provide statistical analysis.
- The system should provide data history.

CHAPTER 7

DETAILED DESIGN DOCUMENT USING APPENDIX A AND B

7.1 INTRODUCTION

This document specifies the design that is used to solve the problem of Product.

7.2 ARCHITECTURAL DESIGN

A description of the program architecture is presented. Subsystem design or Block diagram of how the data is acquired and processed in python along with ML and the final results.

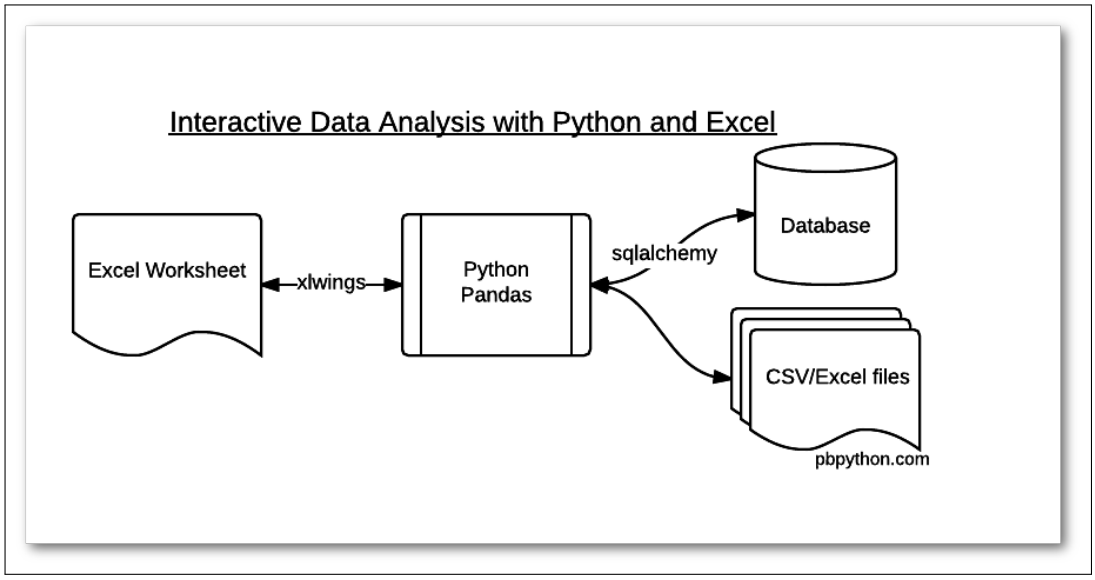


Figure 7.1: Architecture diagram

CHAPTER 8

PROJECT IMPLEMENTATION

8.1 INTRODUCTION

The project is implemented in two sections the Hardware section and the Software section. The hardware section includes microcontroller along with voltage and current measurement circuits. The acquired analog signals are first processed, converted into digital form and transmitted to the microcontroller. Here, the data received is calibrated according to various parameters (peak to peak voltage). The finished data is then encapsulated into a data frame along with time stamp and stored on to the on board memory for further processing.

The data packets are then transmitted to the software application for detailed analysis and prediction. The acquired data is passed through different prediction algorithms(linear regression, decision trees) for predicting the health of the connected electrical device. The software also warns the user about the malfunctioning of the device well in advance. The software acts as a remote monitoring and control system for the product and provide remote access to the the electric switch board.

8.2 TOOLS AND TECHNOLOGIES USED

1. Microcontroller- TM4C123G LaunchPad

The TM4C123G LaunchPad Evaluation Kit is a low-cost evaluation platform for ARM Cortex-M4F based microcontrollers from Texas Instruments. The design of the TM4C123G LaunchPad highlights the TM4C123GH6PM microcontroller with a USB 2.0 device interface and hibernation module.

There are many I/O pins that have multi-personality. This means that they can be easily configured as digital inputs or outputs, analog inputs and outputs or other functions, allowing a great variety of applications, are just the multiple serial ports have the ability to interface with more items such as test cards or other communication modules, etc.

The ARM Cortex-M4F Based MCU TM4C123G LaunchPad Evaluation Kit (EK-TM4C123GXL) offers these features:

- 80MHz 32-bit ARM Cortex-M4-based microcontrollers CPU
- 256KB Flash, 32KB SRAM, 2KB EEPROM
- Two Controller Area Network (CAN) modules
- USB 2.0 Host/Device/OTG + PHY
- Dual 12-bit 2MSPS ADCs, motion control PWMs
- 8 UART, 6 I2C, 4 SPI
- On-board In-Circuit Debug Interface (ICDI)

2. Code Composer Studio

Code Composer Studio is an integrated development environment (IDE) that supports TI's Microcontroller and Embedded Processors portfolio. Code Composer Studio comprises a suite of tools used to develop and debug embedded applications. It includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features.

The intuitive IDE provides a single user interface taking you through each step of the application development flow.Code Composer Studio combines the advantages of the Eclipse software framework with advanced embedded debug capabilities from TI resulting in a compelling feature-rich development environment for embedded developers.

3. PyCharm

PyCharm is an Integrated Development Environment (IDE) used in computer programming, specifically for the Python language. It is developed by the Czech company JetBrains. It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and supports web development. PyCharm is cross-platform, with Windows, macOS and Linux versions.

PyCharm has following Features:

- Coding assistance and analysis, with code completion, syntax and error highlighting, linter integration, and quick fixes
- Project and code navigation
- Python refactoring: including rename, extract method, introduce variable
- Integrated Python debugger
- Integrated unit testing, with line-by-line code coverage
- Google App Engine Python development

8.3 METHODOLOGIES/ALGORITHM DETAILS

We will be using the different prediction and decision algorithms in order to process the data acquired from the hardware's memory unit. The data acquired is formatted data.

As we found that the power consumption of electric device increases linearly due to the wear and tear of its components. Thus the linear regression model is used to predict the future power consumption of the devices and inform the user about the possible date of failure of the device.

There may arise situations where the device power consumption may suddenly decrease or increase due to some reason other the linear decomposition of the device, decision algorithms are used here to find the problem and inform user about the sudden change in power consumption which need to be looked.

8.3.1 Linear Regression Model

Linear regression is a basic and commonly used type of predictive analysis. In linear regression, the relationships are modeled using linear predictor functions whose unknown model parameters are estimated from the data. The goal is prediction, or forecasting, or error reduction, linear regression can be used to fit a predictive model

to an observed data set of y and X values. The variable we are predicting is called the criterion variable and is referred to as Y. The variable we are basing our predictions on is called the predictor variable and is referred to as X. When there is only one predictor variable, the prediction method is called simple regression.

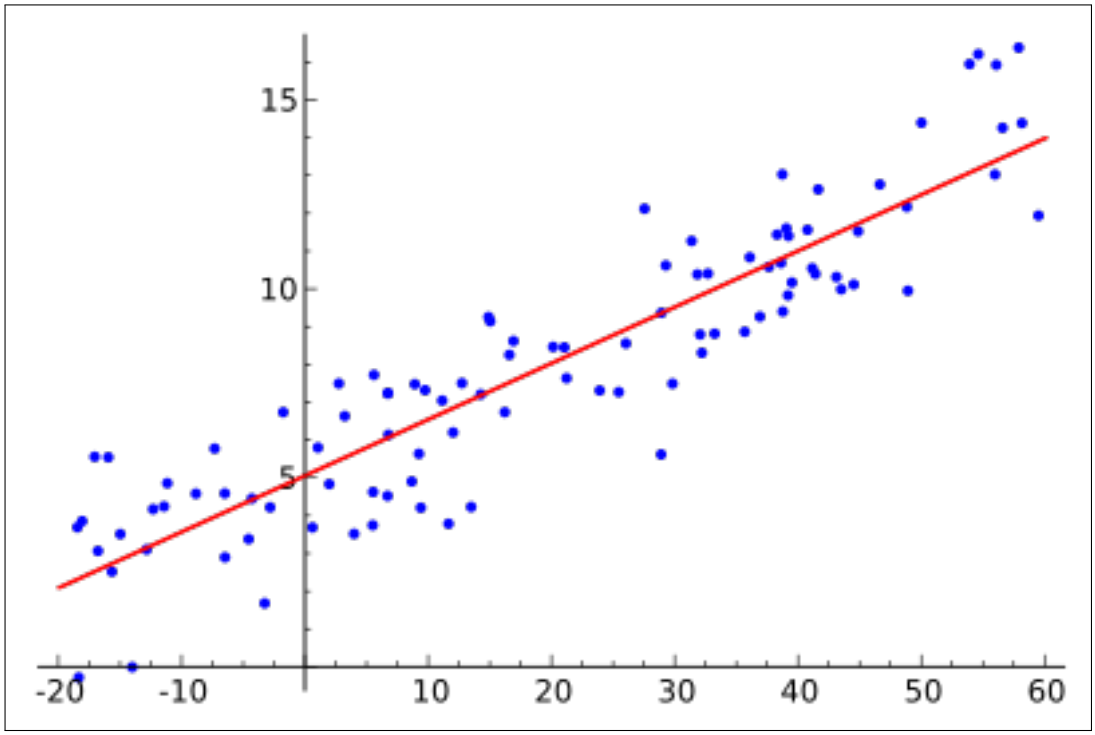


Figure 8.1: Linear Regression

8.3.2 Decision Tree

A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility.A decision tree is drawn upside down with its root at the top. In decision analysis, a decision tree and the closely related influence diagram are used as a visual and analytical decision support tool, where the expected values (or expected utility) of competing alternatives are calculated.Decision trees can also be seen as generative models of induction rules from empirical data. An optimal decision tree is then defined as a tree that accounts for most of the data, while minimizing the number of levels

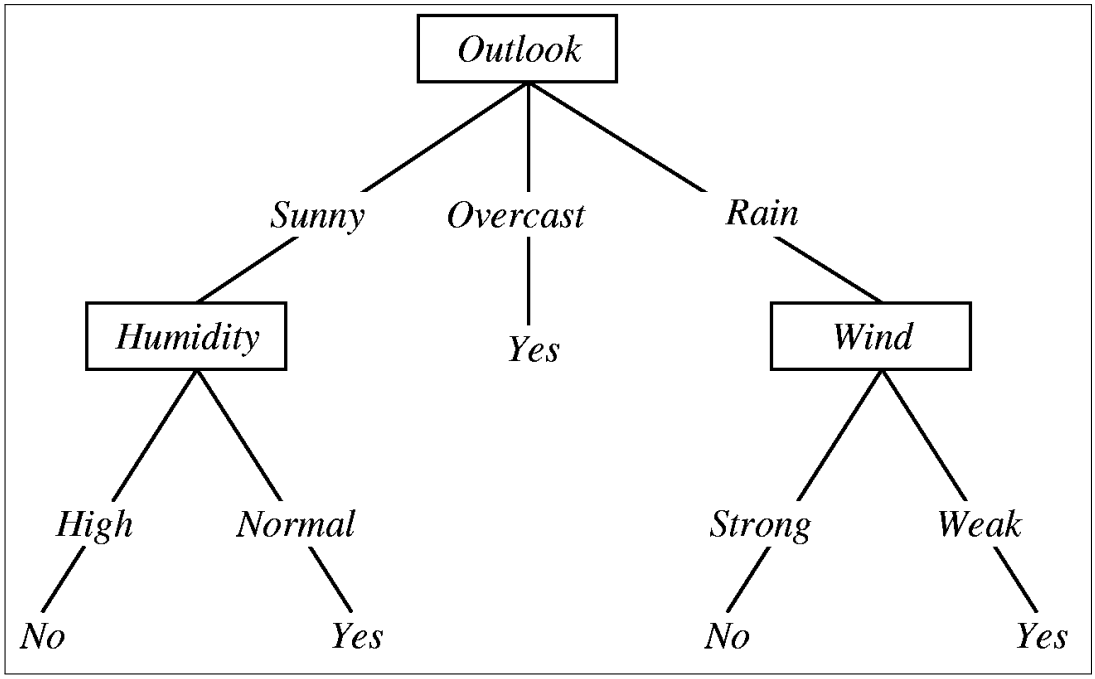


Figure 8.2: Decision Trees

8.3.3 Algorithm

1. Set the threshold value for each device.
2. Read the Training data set from CSV file and store it in data frame.
3. Process the data.
4. If: The deviation in data is more than expected
5. Then: Display appropriate message.
6. Convert data frame object into 1-dimensional array.
7. Fit the data in linear regression model.
8. Create 2D array to store predicted data.
9. for x in range(startDay,endDay):
10. store the predicted value of current for each day.
11. end for
12. Open a new CSV file.
13. Store the predicted values in CSV file.
14. Process the predicted values.
15. If: Current value greater than threshold.
16. Then: Display 'Device maintenance message.'
17. Else: Display 'Device condition is good.'

8.4 VERIFICATION AND VALIDATION FOR ACCEPTANCE

CHAPTER 9

SOFTWARE TESTING

9.1 TYPE OF TESTING USED

unit testing/integration testing/ system testing

Test	Input	Expected Values	Actual Values	Error
	(mv)	(Amp)	(Amp)	
ReadCurrent(CH0)	185 mv	1.0	1.0	0
ReadCurrent(CH0)	92.5 mv	0.5	0.49	2
ReadCurrent(CH0)	370 mv	2	2.1	5

Table 9.1: Risk Table

9.2 TEST CASES AND TEST RESULTS

for each type of testing done.

CHAPTER 10

RESULTS

10.1 SCREEN SHOTS

10.1.1 CSV Input file

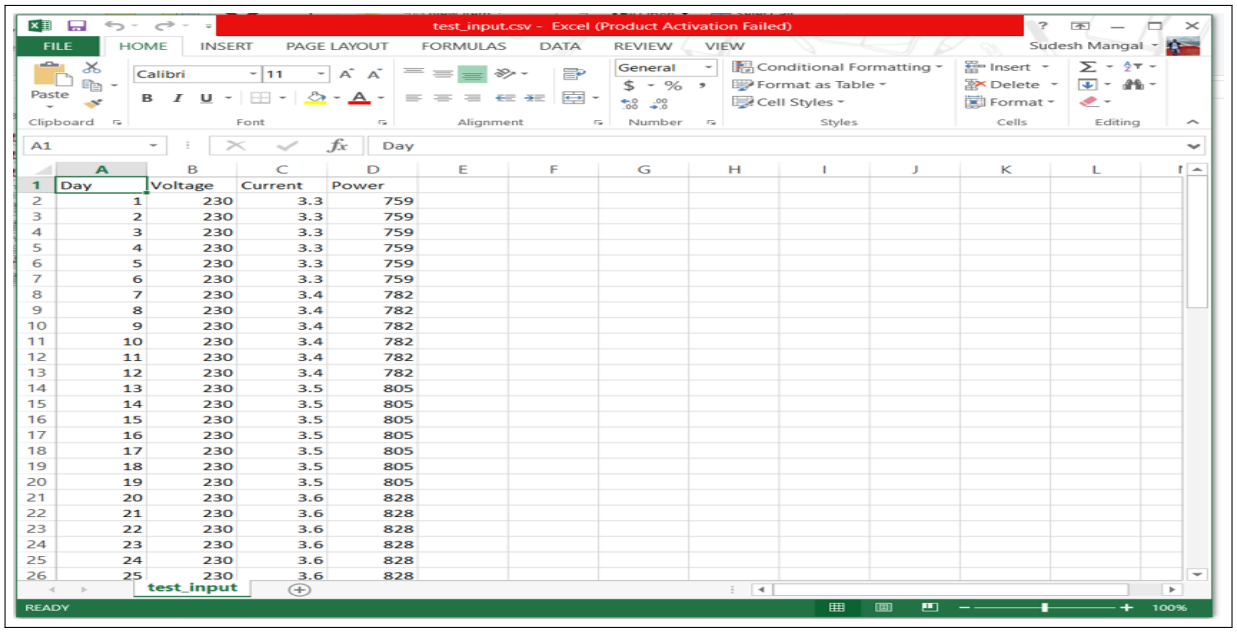


Figure 10.1: Input data

10.1.2 CSV Output file

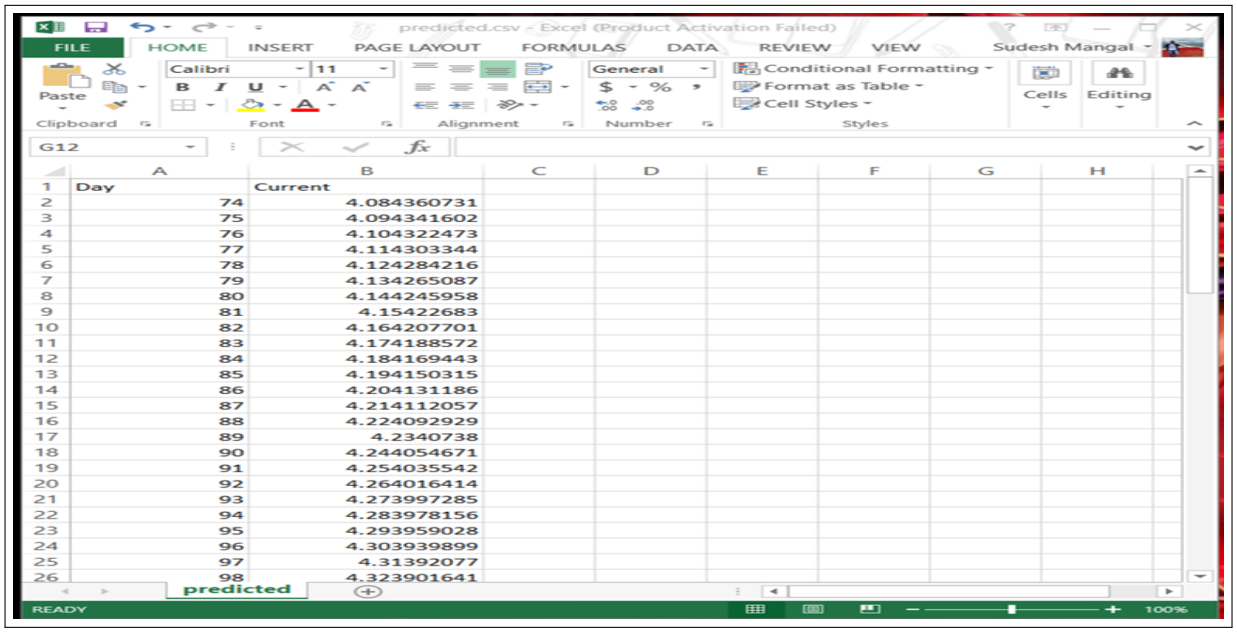


Figure 10.2: Input data

10.2 OUTPUTS

Outputs / Snap shots of the results

CHAPTER 11

DEPLOYMENT AND MAINTENANCE

11.1 INSTALLATION AND UN-INSTALLATION

11.2 USER HELP

CHAPTER 12

SUMMARY AND CONCLUSION

Conclusion

The proposed system will significantly reduce energy consumption manifolds, by precisely monitoring the power consumption and optimizing energy usage. The system will assist in early detection of the failure in electrical devices. The proposed product is a energy monitoring and optimizing device that can be easily employed in the current household structures. It should be able to precisely find the faulty device and designed such as to help and guide the consumer for better automation experience.

CHAPTER 13

REFERENCES

[1] Roger S. Pressman. *Software Engineering (3rd Ed.): A Practitioner's Approach*. McGraw-Hill, Inc., New York, NY, USA, 1992.

[2] Parag Kulkarni. *Knowledge Innovation Strategy*. Bloomsbury Publication, Pune, 2015.

[3] P.K. Sinha. *Electronic Health Record*. IEEE Press Wiley.

[4] McKinsey. Big data: The next frontier for innovation, competition,and productivity. Technical report.

[5] Digital competition:http://www.mckinsey.com/insights.

[6] Government website to support entrepreneurs:http://msme.gov.in/mob/home.aspx.

ANNEXURE A

LABORATORY ASSIGNMENTS ON PROJECT ANALYSIS OF ALGORITHMIC DESIGN

- To develop the problem under consideration and justify feasibilty using concepts of knowledge canvas and IDEA Matrix.

  Refer [2] for IDEA Matrix and Knowledge canvas model. Case studies are given in this book. IDEA Matrix is represented in the following form. Knowledge canvas represents about identification of opportunity for product. Feasibility is represented w.r.t. business perspective.

I	D	E	A
INCREASE: Accuracy in measurement of Energy consumed by devices present in house or industry.	DRIVE: Get power consumed by each individual device and store it.	EDUCATE: The user to log-in to the system using Login details and enter the ratings of the device.	ACCELERATE: The rate of data analysis for measurement of energy consumption.
IMPROVE: Rather than calculating the power consumed by entire house we calculate power consumed by individual device.	DELIVER: The increase in power consumption of device over the period.	EVALUATE: The power consumption of device and detect early failure of device.	ASSOCIATE: Innovative techniques for automation.
INGNORE: Data readings generated due to leakage current	DECREASE: The Energy consumption of the user.	ELASTICITY: The data can be stored for 3-4 days on the device before the connection to system is made.	AVOID: Power consumed due to leakage current

Figure A.1: Idea Matrix

ANNEXURE B

LABORATORY ASSIGNMENTS ON PROJECT QUALITY AND RELIABILITY TESTING OF PROJECT DESIGN

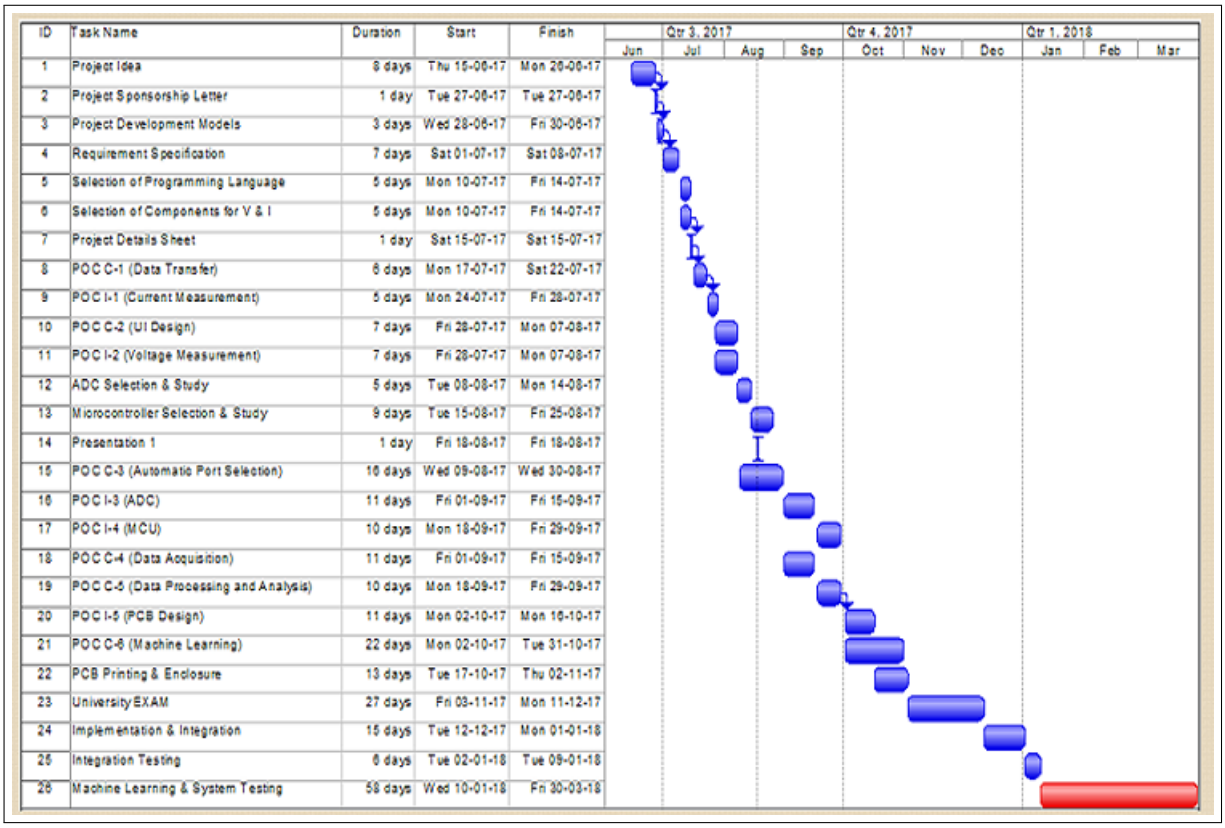
It should include assignments such as

- Use of divide and conquer strategies to exploit distributed/parallel/concurrent processing of the above to identify object, morphisms, overloading in functions (if any), and functional relations and any other dependencies (as per requirements). It can include Venn diagram, state diagram, function relations, i/o relations; use this to derive objects, morphism, overloading
- Use of above to draw functional dependency graphs and relevant Software modeling methods, techniques including UML diagrams or other necessities using appropriate tools.
- Testing of project problem statement using generated test data (using mathematical models, GUI, Function testing principles, if any) selection and appropriate use of testing tools, testing of UML diagram's reliability. Write also test cases [Black box testing] for each identified functions. You can use Mathematica or equivalent open source tool for generating test data.
- Additional assignments by the guide. If project type as Entreprenaur, Refer [3],[4],[5], [6]

ANNEXURE C

PROJECT PLANNER

The following is the representation of the project schedule.

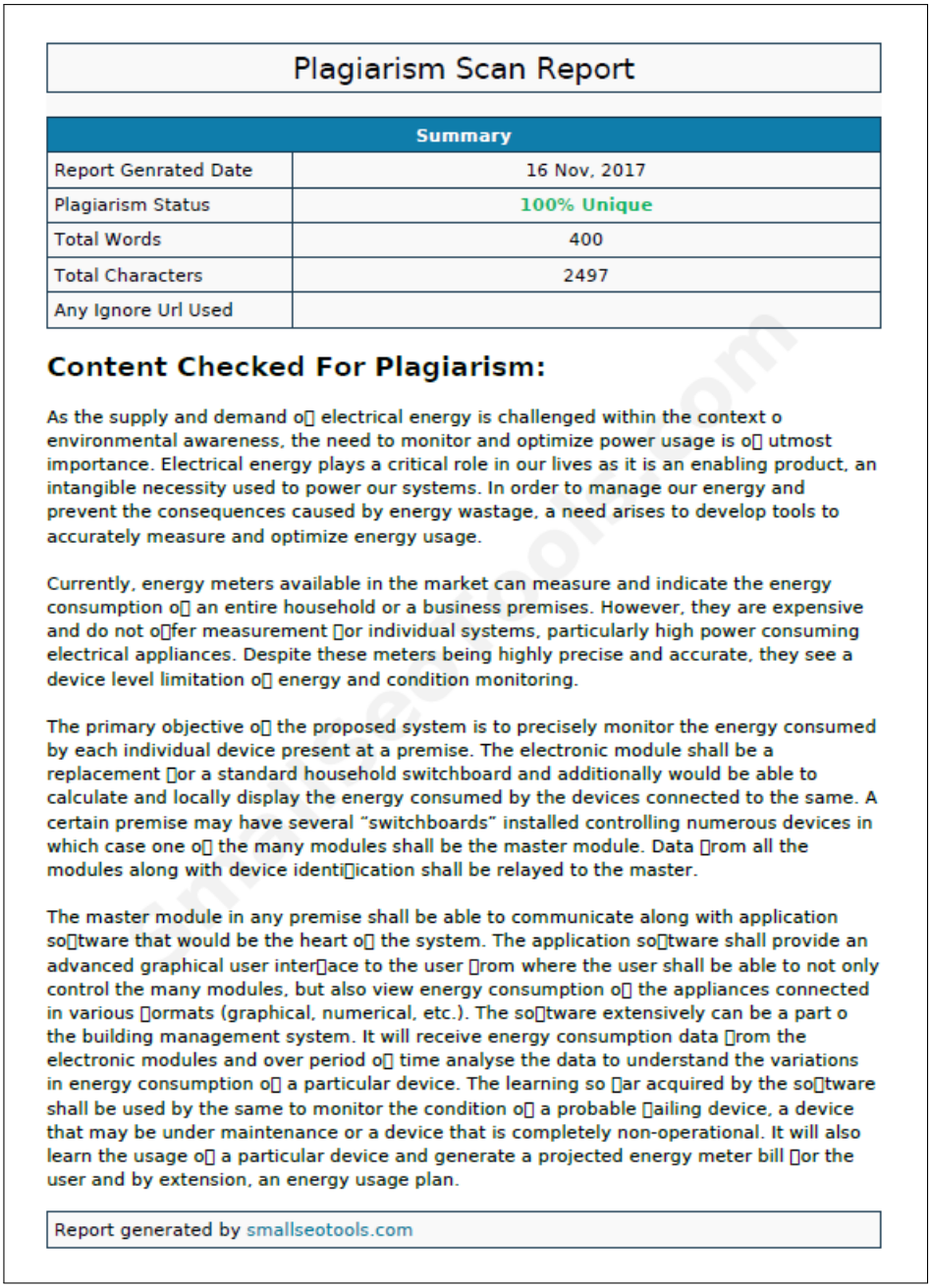


ID	Task Name	Duration	Start	Finish
1	Project Idea	8 days	Thu 15-06-17	Mon 26-06-17
2	Project Sponsorship Letter	1 day	Tue 27-06-17	Tue 27-06-17
3	Project Development Models	3 days	Wed 28-06-17	Fri 30-06-17
4	Requirement Specification	7 days	Sat 01-07-17	Sat 08-07-17
5	Selection of Programming Language	5 days	Mon 10-07-17	Fri 14-07-17
6	Selection of Components for V & I	5 days	Mon 10-07-17	Fri 14-07-17
7	Project Details Sheet	1 day	Sat 15-07-17	Sat 15-07-17
8	POC C-1 (Data Transfer)	6 days	Mon 17-07-17	Sat 22-07-17
9	POC I-1 (Current Measurement)	5 days	Mon 24-07-17	Fri 28-07-17
10	POC C-2 (UI Design)	7 days	Fri 28-07-17	Mon 07-08-17
11	POC I-2 (Voltage Measurement)	7 days	Fri 28-07-17	Mon 07-08-17
12	ADC Selection & Study	5 days	Tue 08-08-17	Mon 14-08-17
13	Microcontroller Selection & Study	9 days	Tue 15-08-17	Fri 25-08-17
14	Presentation 1	1 day	Fri 18-08-17	Fri 18-08-17
15	POC C-3 (Automatic Port Selection)	16 days	Wed 09-08-17	Wed 30-08-17
16	POC I-3 (ADC)	11 days	Fri 01-09-17	Fri 15-09-17
17	POC I-4 (MCU)	10 days	Mon 18-09-17	Fri 29-09-17
18	POC C-4 (Data Acquisition)	11 days	Fri 01-09-17	Fri 15-09-17
19	POC C-5 (Data Processing and Analysis)	10 days	Mon 18-09-17	Fri 29-09-17
20	POC I-5 (PCB Design)	11 days	Mon 02-10-17	Mon 16-10-17
21	POC C-6 (Machine Learning)	22 days	Mon 02-10-17	Tue 31-10-17
22	PCB Printing & Enclosure	13 days	Tue 17-10-17	Thu 02-11-17
23	University EXAM	27 days	Fri 03-11-17	Mon 11-12-17
24	Implementation & Integration	15 days	Tue 12-12-17	Mon 01-01-18
25	Integration Testing	6 days	Tue 02-01-18	Tue 09-01-18
26	Machine Learning & System Testing	58 days	Wed 10-01-18	Fri 30-03-18

Figure C.1: Project Schedule

ANNEXURE D

PLAGIARISM REPORT



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	400
Total Characters	2497
Any Ignore Url Used	

Content Checked For Plagiarism:

As the supply and demand o electrical energy is challenged within the context o environmental awareness, the need to monitor and optimize power usage is o utmost importance. Electrical energy plays a critical role in our lives as it is an enabling product, an intangible necessity used to power our systems. In order to manage our energy and prevent the consequences caused by energy wastage, a need arises to develop tools to accurately measure and optimize energy usage.

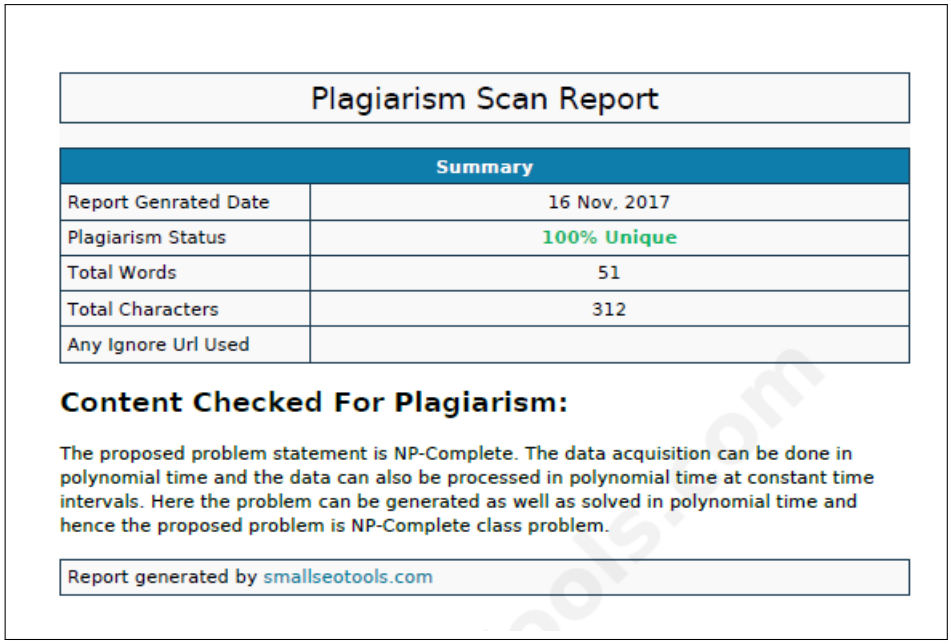
Currently, energy meters available in the market can measure and indicate the energy consumption o an entire household or a business premises. However, they are expensive and do not o fer measurement or individual systems, particularly high power consuming electrical appliances. Despite these meters being highly precise and accurate, they see a device level limitation o energy and condition monitoring.

The primary objective o the proposed system is to precisely monitor the energy consumed by each individual device present at a premise. The electronic module shall be a replacement or a standard household switchboard and additionally would be able to calculate and locally display the energy consumed by the devices connected to the same. A certain premise may have several "switchboards" installed controlling numerous devices in which case one o the many modules shall be the master module. Data rom all the modules along with device identi ication shall be relayed to the master.

The master module in any premise shall be able to communicate along with application so tware that would be the heart o the system. The application so tware shall provide an advanced graphical user inter ace to the user rom where the user shall be able to not only control the many modules, but also view energy consumption o the appliances connected in various ormats (graphical, numerical, etc.). The so tware extensively can be a part o the building management system. It will receive energy consumption data rom the electronic modules and over period o time analyse the data to understand the variations in energy consumption o a particular device. The learning so ar acquired by the so tware shall be used by the same to monitor the condition o a probable ailing device, a device that may be under maintenance or a device that is completely non-operational. It will also learn the usage o a particular device and generate a projected energy meter bill or the user and by extension, an energy usage plan.

Report generated by smallseotools.com

Figure D.1: Plagiarism Report 1



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	51
Total Characters	312
Any Ignore Url Used	

Content Checked For Plagiarism:

The proposed problem statement is NP-Complete. The data acquisition can be done in polynomial time and the data can also be processed in polynomial time at constant time intervals. Here the problem can be generated as well as solved in polynomial time and hence the proposed problem is NP-Complete class problem.

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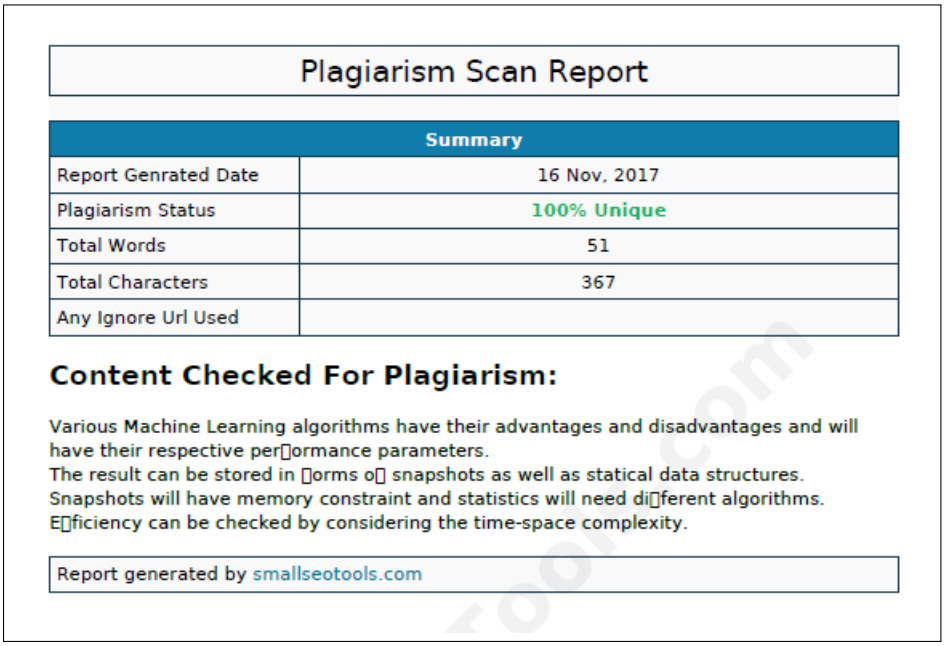
Figure D.2: Plagiarism Report 2



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	51
Total Characters	367
Any Ignore Url Used	

Content Checked For Plagiarism:

Various Machine Learning algorithms have their advantages and disadvantages and will have their respective per□ormance parameters.
The result can be stored in □orms o□ snapshots as well as statical data structures. Snapshots will have memory constraint and statistics will need di□ferent algorithms. E□ficiency can be checked by considering the time-space complexity.

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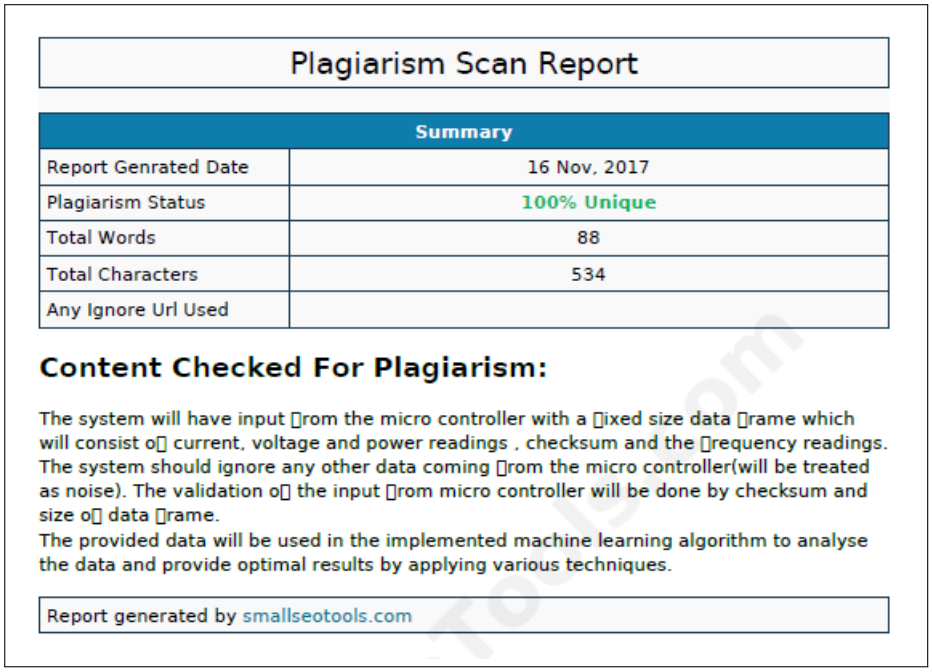
Figure D.3: Plagiarism Report 3



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	88
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Any Ignore Url Used	

Content Checked For Plagiarism:

The system will have input □rom the micro controller with a □ixed size data □rame which will consist o□ current, voltage and power readings , checksum and the □requency readings. The system should ignore any other data coming □rom the micro controller(will be treated as noise). The validation o□ the input □rom micro controller will be done by checksum and size o□ data □rame.
The provided data will be used in the implemented machine learning algorithm to analyse the data and provide optimal results by applying various techniques.

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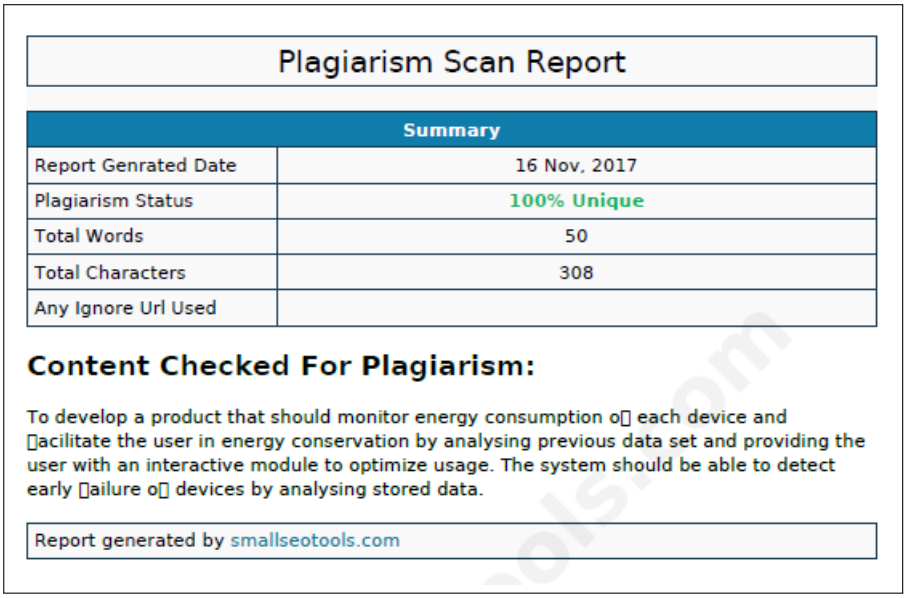
Figure D.4: Plagiarism Report 4



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	50
Total Characters	308
Any Ignore Url Used	

Content Checked For Plagiarism:

To develop a product that should monitor energy consumption o□ each device and □acilitate the user in energy conservation by analysing previous data set and providing the user with an interactive module to optimize usage. The system should be able to detect early □ailure o□ devices by analysing stored data.

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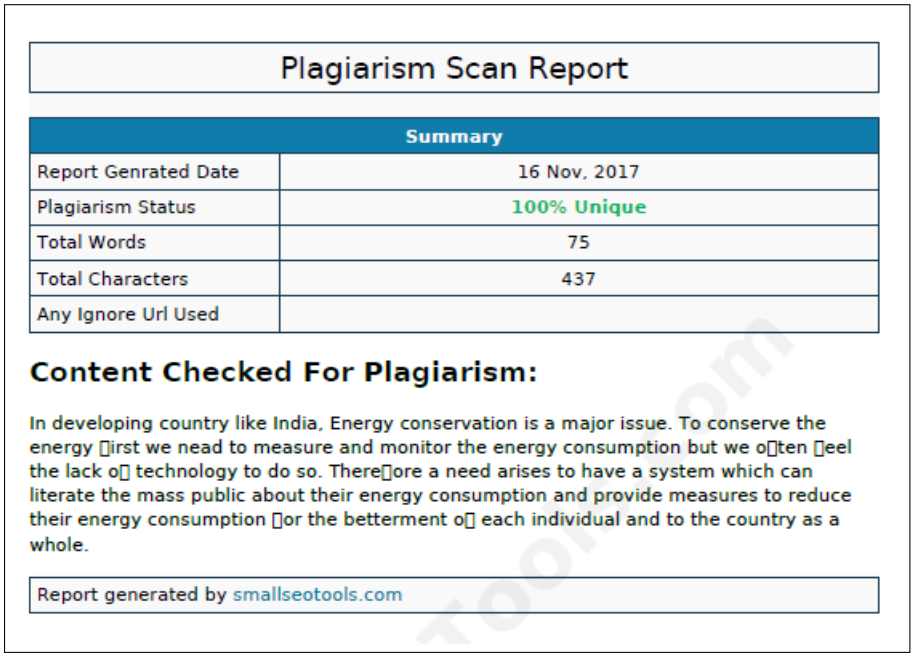
Figure D.5: Plagiarism Report 5



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
Total Words	75
Total Characters	437
Any Ignore Url Used	

Content Checked For Plagiarism:

In developing country like India, Energy conservation is a major issue. To conserve the energy □irst we nead to measure and monitor the energy consumption but we o□ten □eel the lack o□ technology to do so. There□ore a need arises to have a system which can literate the mass public about their energy consumption and provide measures to reduce their energy consumption □or the betterment o□ each individual and to the country as a whole.

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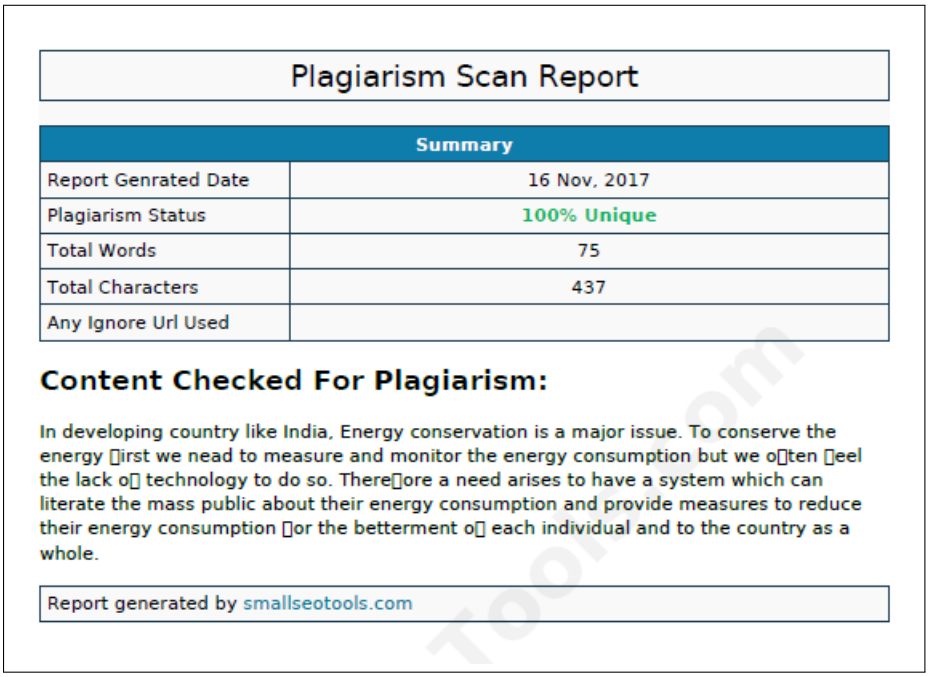
Figure D.6: Plagiarism Report 6



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
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Total Words	75
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Any Ignore Url Used	

Content Checked For Plagiarism:

In developing country like India, Energy conservation is a major issue. To conserve the energy □irst we nead to measure and monitor the energy consumption but we o□ten □eel the lack o□ technology to do so. There□ore a need arises to have a system which can literate the mass public about their energy consumption and provide measures to reduce their energy consumption □or the betterment o□ each individual and to the country as a whole.

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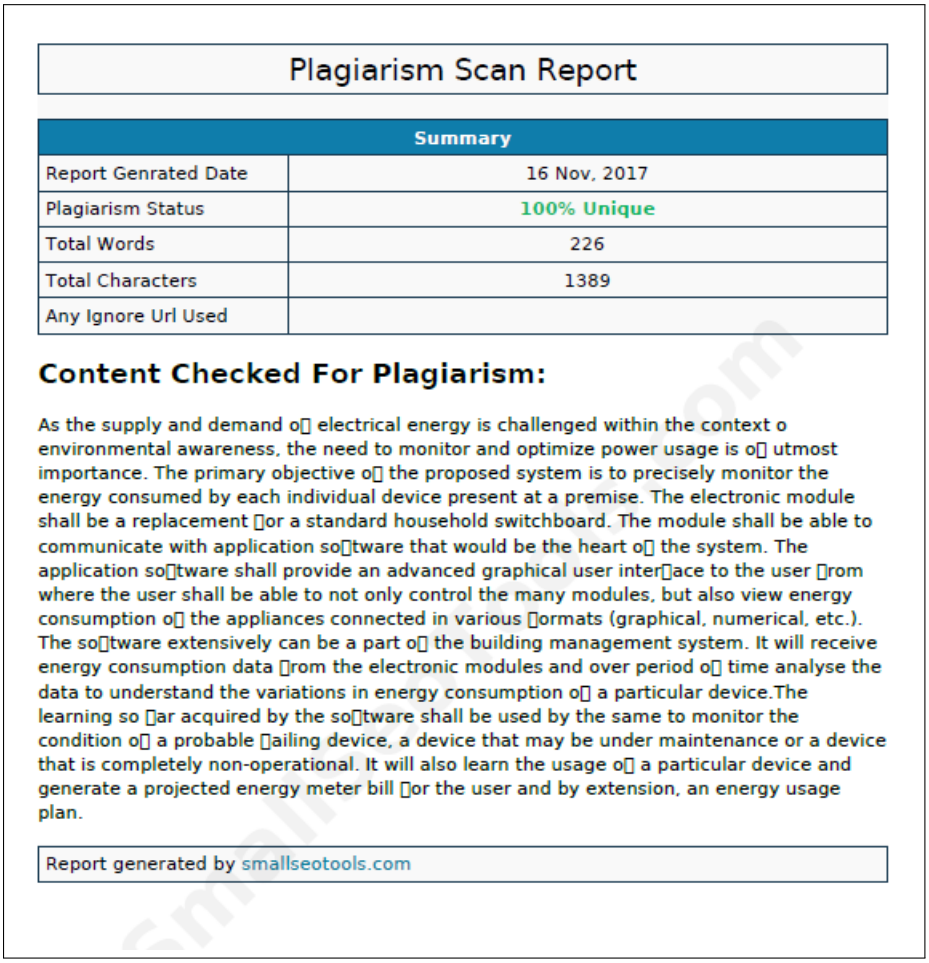
Figure D.7: Plagiarism Report 7



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
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Any Ignore Url Used	

Content Checked For Plagiarism:

As the supply and demand o electrical energy is challenged within the context o environmental awareness, the need to monitor and optimize power usage is o utmost importance. The primary objective o the proposed system is to precisely monitor the energy consumed by each individual device present at a premise. The electronic module shall be a replacement or a standard household switchboard. The module shall be able to communicate with application so tware that would be the heart o the system. The application so tware shall provide an advanced graphical user inter ace to the user rom where the user shall be able to not only control the many modules, but also view energy consumption o the appliances connected in various ormats (graphical, numerical, etc.). The so tware extensively can be a part o the building management system. It will receive energy consumption data rom the electronic modules and over period o time analyse the data to understand the variations in energy consumption o a particular device.The learning so far acquired by the so tware shall be used by the same to monitor the condition o a probable ailing device, a device that may be under maintenance or a device that is completely non-operational. It will also learn the usage o a particular device and generate a projected energy meter bill or the user and by extension, an energy usage plan.

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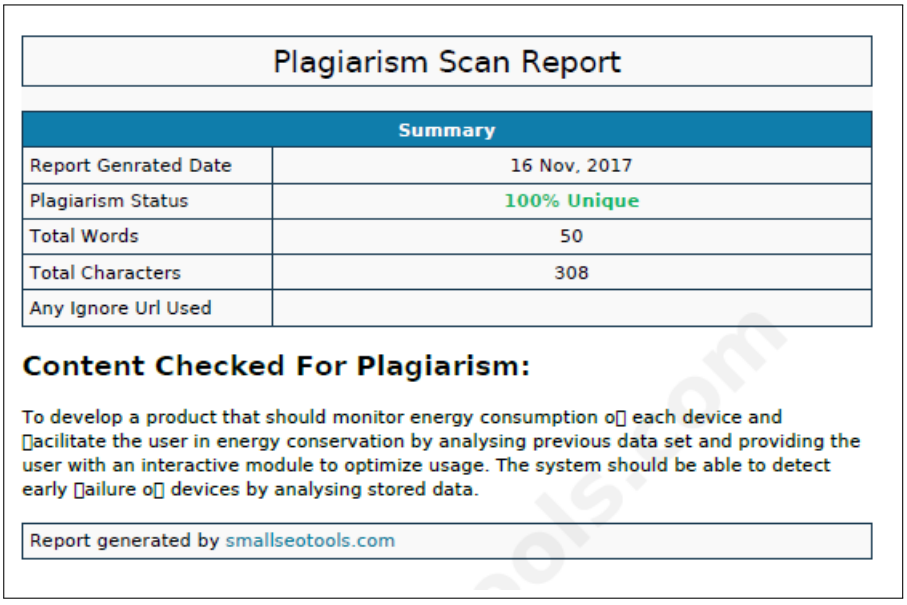
Figure D.8: Plagiarism Report 8



Plagiarism Scan Report

Summary	
Report Genrated Date	16 Nov, 2017
Plagiarism Status	100% Unique
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Any Ignore Url Used	

Content Checked For Plagiarism:

To develop a product that should monitor energy consumption o each device and acilitate the user in energy conservation by analysing previous data set and providing the user with an interactive module to optimize usage. The system should be able to detect early ailure o devices by analysing stored data.

Report generated by smallseotools.com

Figure D.9: Plagiarism Report 9