Coordinated system for charging and discharging for different and various electric vehicles for energy management

Report submitted to the SASTRA Deemed to be University
as the requirement for the course

EEE300: MINI PROJECT

Submitted by

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SCHOOL OF ELECTRICAL AND ELECTROINCS ENGINEERING
THANJAVUR,TAMIL NADU, INDIA-613 401

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Bonafide Certificate

This is to certify that the report titled "**Coordinated system for charging and discharging for different and various electric vehicles for energy management**" submitted as a requirement for the course, **EEE300: MINI PROJECT** for B. Tech. Electrical & Electronics Engineering programme, is a bonafide record of the work done by **Ms. Mithra Vinda Reddy K (Reg.No.123005085), Mr. Sarvesh Babu R G (Reg.No.123005132), Ms. Shwetha S (Reg.No.123005140)** during the academic year 2022-23, in the **School of Electrical and Electronics Engineering**, under my supervision.

Signature of Project Supervisor:

Name with Affliation **: Dr. Narayanan K (SAP / EEE / SEEE)**

Date **:** 31 / 03 / 2021

Project *Vivavoce* held on

Examiner-I **Examiner-II**

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Declaration

I/We declare that the report titled "**Coordinated system for charging and discharging for different and various electric vehicles for energy management**" submitted by me/us is an original work done by me/us under the guidance of **Dr. Narayanan K, SAP, School of Electrical and Electronics Engineering, SASTRA Deemed to be University** during the academic year 2022-23, in the **School of Electrical and Electronics Engineering**. The work is original and wherever We have used materials from other sources, I/We have given due credit and cited them in the text of the report. This report has not formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title to any candidate of any University.

Signature of the candidate(s) :

Name of the candidate(s) : **Mithra Vinda Reddy K**
: **Sarvesh Babu R G**
: **Shwetha S**

Date : 09 / 12 / 2022

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And finally, we would like to acknowledge the appreciation and support that our parents provided to ensure we faced minimal obstacles throughout the project.

ABSTRACT

This work proposes a method for charging and discharging the batteries in Electric Vehicles (EV). The classification of Electric vehicles is Private Vehicle, Commercial Vehicle, Emergency Vehicle, VIP Vehicle based on the battery capacity and vehicle's usage.

The State of Charge (SoC) of each vehicle is calculated for every twenty minutes and compared with the threshold limits of SoC. The Distance traveled and the time for which it is connected to the grid is fixed for each vehicle type. The ideal pattern has been established by comparing the charging pattern with the scheduled Real Time Pricing (RTP) for every 20-minute block. Here 20-minute blocks are considered because the time required for full charge varies from vehicle to vehicle. The pattern has been formulated in such a way that discharging occurs when the cost is higher (peak hours), charging occurs when the cost is low (off peak hours). Few blocks are left idle when charging or discharging is not feasible because of violation of threshold limits. The total price has been calculated for each vehicle for a span of 24 hours after the charging and discharging patterns are established.

The novelty of this work is the establishment of a travel pattern for the classified types of vehicles and thereby arriving at the best charging/discharging patterns.

Specific Contribution

- Establishing the travel pattern for the classified vehicles by using the vehicle's battery capacity and how much time it takes to complete its trip.

Specific Learning

- Understood about various ranges of battery capacities of the vehicles and time to complete its trip after one time charging.

Signature of the Guide **Student Reg. No:**123005085

Name of the Guide: Dr. Narayanan K (SAP/EEE/SEEE) **Name:**Mithra Vinda Reddy K

ABSTRACT

This work proposes a method for charging and discharging the batteries in Electric Vehicles (EV). The classification of Electric vehicles is Private Vehicle, Commercial Vehicle, Emergency Vehicle, VIP Vehicle based on the battery capacity and vehicle's usage.

The State of Charge (SoC) of each vehicle is calculated for every twenty minutes and compared with the threshold limits of SoC. The Distance traveled and the time for which it is connected to the grid is fixed for each vehicle type. The ideal pattern has been established by comparing the charging pattern with the scheduled Real Time Pricing (RTP) for every 20-minute block. Here 20-minute blocks are considered because the time required for full charge varies from vehicle to vehicle. The pattern has been formulated in such a way that discharging occurs when the cost is higher (peak hours), charging occurs when the cost is low (off peak hours). Few blocks are left idle when charging or discharging is not feasible because of violation of threshold limits. The total price has been calculated for each vehicle for a span of 24 hours after the charging and discharging patterns are established.

The novelty of this work is the establishment of a travel pattern for the classified types of vehicles and thereby arriving at the best charging/discharging patterns.

Specific Contribution

- Charging/Discharging Pattern formulation for the classified Electric Vehicles by comparing it with the Real time pricing.

Specific Learning

- Understood about various types of Electric Vehicles, time required for them to charge and discharge.
- Understood about Real Time Pricing (RTP) and its benefits when incorporated with charging schemes.

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Name of the Guide: Dr. Narayanan K (SAP/EEE/SEEE) **Name:**Sarvesh Babu R G

ABSTRACT

This work proposes a method for charging and discharging the batteries in Electric Vehicles (EV). The classification of Electric vehicles is Private Vehicle, Commercial Vehicle, Emergency Vehicle, VIP Vehicle based on the battery capacity and vehicle's usage.

The State of Charge (SoC) of each vehicle is calculated for every twenty minutes and compared with the threshold limits of SoC. The Distance traveled and the time for which it is connected to the grid is fixed for each vehicle type. The ideal pattern has been established by comparing the charging pattern with the scheduled Real Time Pricing (RTP) for every 20-minute block. Here 20-minute blocks are considered because the time required for full charge varies from vehicle to vehicle. The pattern has been formulated in such a way that discharging occurs when the cost is higher (peak hours), charging occurs when the cost is low (off peak hours). Few blocks are left idle when charging or discharging is not feasible because of violation of threshold limits. The total price has been calculated for each vehicle for a span of 24 hours after the charging and discharging patterns are established.

The novelty of this work is the establishment of a travel pattern for the classified types of vehicles and thereby arriving at the best charging/discharging patterns.

Specific Contribution

- The vehicles have been classified into different categories based on the usage and the battery capacity. The classifications are Private Vehicle, Commercial Vehicle, Emergency Vehicle, VIP Vehicle.

Specific Learning

- Understood about Electric Vehicles and its parameters like Charging, Discharging and State of charge.
- Understood that Electric vehicles have different battery capacity and time required for full charge depends on the type of vehicle.

Signature of the Guide **Student Reg. No:**121005206

Name of the Guide: Dr. Narayanan K (SAP/EEE/SEEE) **Name:** Shwetha S

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ABBREVIATIONS

EV	Electric Vehicle
RTP	Real Time Price

NOTATIONS

$SoC_{(y)}$	State of Charge in present hour
$SoC_{(y-1)}$	State of Charge in previous hour
ηc	Charging Efficiency
ηd	Discharging Efficiency
∂y	Time Interval
$SoC_{Threshold}$	Threshold limit for State of Charge
Ch_t	Energy delivered at time t
RTP	Real Time Price Array
T_n	Cost of nth iteration

CHAPTER 1

INTRODUCTION

1.1 Electric Vehicle

With the increase in Pollution , fuel demand, global warming and many other socio-economic issues ,one could say Electric Vehicles will be the future means of transport.

1.2 *****

1.3 *****

1.4 *****

1.5 *****

1.6 Motivation

This document provides a simple template of how the provided `iitmdiss.cls` LaTeX class is to be used. Also provided are several useful tips to do various things that might be of use when you write your thesis.

Before reading any further please note that you are strongly advised against changing any of the formatting options used in the class provided in this directory, unless you are absolutely sure that it does not violate the IITM formatting guidelines. *Please do not change the margins or the spacing.* If you do change the formatting you are on your own (don't blame me if you need to reprint your entire thesis). In the case that you do change the formatting despite these warnings, the least I ask is that you do not redistribute your style files to your friends (or enemies).

It is also a good idea to take a quick look at the formatting guidelines. Your office or advisor should have a copy. If they don't, pester them, they really should have the formatting guidelines readily available somewhere.

To compile your sources run the following from the command line:

```
% latex thesis.tex
% bibtex thesis
% latex thesis.tex
% latex thesis.tex
```

Modify this suitably for your sources.

To generate PDF's with the links from the `hyperref` package use the following command:

```
% dvipdfm -o thesis.pdf thesis.dvi
```

1.7 Package Options

Use this thesis as a basic template to format your thesis. The `iitmdiss` class can be used by simply using something like this:

```
\documentclass[PhD]{iitmdiss}
```

To change the title page for different degrees just change the option from `PhD` to one of `MS`, `MTech` or `BTech`. The dual degree pages are not supported yet but should be quite easy to add. The title page formatting really depends on how large or small your thesis title is. Consequently it might require some hand tuning. Edit your version of `iitmdiss.cls` suitably to do this. I recommend that this be done once your title is final.

To write a synopsis simply use the `synopsis.tex` file as a simple template. The synopsis option turns this on and can be used as shown below.

```
\documentclass[PhD,synopsis]{iitmdiss}
```

Once again the title page may require some small amount of fine tuning. This is again easily done by editing the class file.

This sample file uses the `hyperref` package that makes all labels and references clickable in both the generated DVI and PDF files. These are very useful when reading the document online and do not affect the output when the files are printed.

1.8 Example Figures and tables

Fig. 1.1 shows a simple figure for illustration along with a long caption. The formatting of the caption text is automatically single spaced and indented. Table 1.1 shows a sample table with the caption placed correctly. The caption for this should always be placed before the table as shown in the example.

1.9 Bibliography with BIBTEX

I strongly recommend that you use BIBTEX to automatically generate your bibliography. It makes managing your references much easier. It is an excellent way to organize your references and reuse them. You can use one set of entries for your references and cite them in your thesis, papers and reports. If you haven't used it anytime before please invest some time learning how to use it.

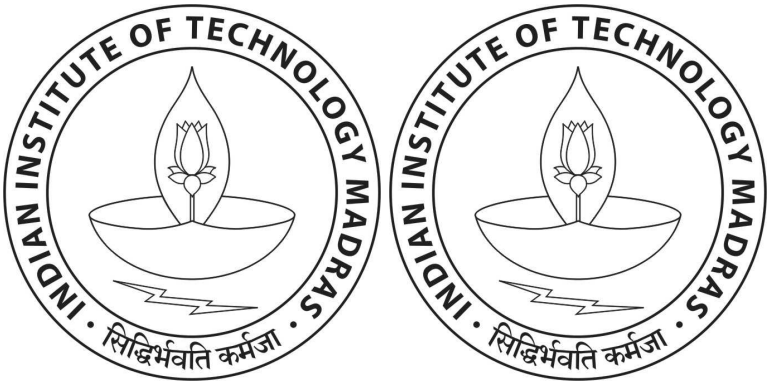


Figure 1.1: Two IITM logos in a row. This is also an illustration of a very long figure caption that wraps around two two lines. Notice that the caption is single-spaced.

Table 1.1: A sample table with a table caption placed appropriately. This caption is also very long and is single-spaced. Also notice how the text is aligned.

x	x^2
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64

I've included a simple example BIBTEX file along in this directory called `refs.bib`. The `iitmdiss.cls` class package which is used in this thesis and for the synopsis uses the `natbib` package to format the references along with a customized bibliography style provided as the `iitm.bst` file in the directory containing `thesis.tex`. Documentation for the `natbib` package should be available in your distribution of LATEX. Basically, to cite the author along with the author name and year use `\cite{key}` where `key` is the citation key for your bibliography entry. You can also use `\citet{key}` to get the same effect. To make the citation without the author name in the main text but inside the parenthesis use `\citep{key}`. The following paragraph shows how citations can be used in text effectively.

More information on BIBTEX is available in the book by **?**. There are many references **??** that explain how to use BIBTEX. Read the `natbib` package documentation for more details on how to cite things differently.

Here are other references for example. **?** presents a Python based visualization system called MayaVi in a conference paper. **?** illustrates a journal article with multiple authors. Python **?** is a programming language and is cited here to show how to cite something that is best identified with a URL.

1.10 Other useful LATEX packages

The following packages might be useful when writing your thesis.

- It is very useful to include line numbers in your document. That way, it is very easy for people to suggest corrections to your text. I recommend the use of the `lineno` package for this purpose. This is not a standard package but can be obtained on the internet. The directory containing this file should contain a lineno directory that includes the package along with documentation for it.
- The `listings` package should be available with your distribution of LATEX. This package is very useful when one needs to list source code or pseudo-code.
- For special figure captions the `ccaption` package may be useful. This is specially useful if one has a figure that spans more than two pages and you need to use the same figure number.
- The notation page can be entered manually or automatically generated using the `nomencl` package.

More details on how to use these specific packages are available along with the documentation of the respective packages.

CHAPTER 2

LITERATURE SURVEY

The objectives of this project are:

-
-
-

CHAPTER 3

METHODOLOGY

3.1 Vehicle Classification

Electric vehicles have been classified primarily into four major categories as shown in Figure 3.1

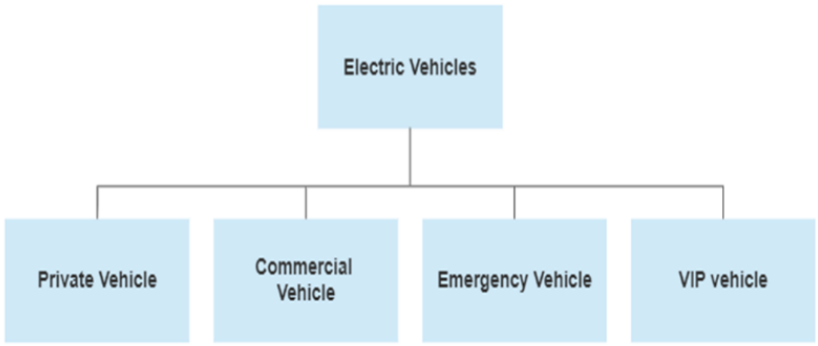


Figure 3.1: Vehicle Classification

The above classification is made by comparing the battery capacity of the vehicles from the data taken with the battery capacity of the similar kind of vehicles in the market.

Private vehicles are further classified into E-bikes and E-cars with average battery capacity of 400Wh to 500 Wh and 40 kWh to 100 Kwh respectively. Commercial vehicles are classified into E-Truck and E-Bus with an average battery capacity of 100 KWh and 60 to 548 KWh respectively. Emergency vehicles have a battery capacity of around 105 KWh and VIP vehicles have around 90 KWh to 200 KWh.

3.2 Travel Pattern Establishment

Travel pattern for three main vehicle subcategories of the above mentioned vehicle categories namely E-car, E-Truck and E-Bus are now taken and travel patterns of the same have been established by using the Battery capacity, Time taken to full charge, Time period of the vehicle when it is connected to the grid , charging rate and discharging rateLee et al. (2019).

3.3 Charging/Discharging pattern Establishment

CHAPTER 4

Mathematical Modelling

4.1 SoC Calculation

The SoC of the vehicle is calculated from the following equations:

$\text{SoC}_{min} \leq SoC \leq SoC_{max}$ (4.1)

$\text{SoC}_y = SoC_{y-1} + P_{batt}(y) \times \partial y \times \eta c$ (4.2)

$\text{SoC}_y = SoC_{y-1} - P_{batt}(y) \times \partial y \times \eta d$ (4.3)

$\text{P}_{batt}(y) = SoC_y \times E$ (4.4)

Initial Power = Generation - Load

SoC limits:

SoC_{min} and SoC_{max} are the maximum and minimum SoC of the EV respectively. This constraint allows the SoC to vary between predefined minimum and maximum SoC.

4.2 Best Pattern for charging

The charging pattern is determined by comparing the Energy required to the Real Time Price and by identifying the minimum of it.

$$T_n = \sum_{i=1}^{24} (Ch_t \times [1 \parallel 0 \parallel -1]) * Rtp_i$$

4.3 Maximum Power required by EV

Maximum Power demand occurs when all the three vehicles loads are high and the time block of maximum demand is identified.

$$P_{t(total)} = P_{t(car)} + P_{t(truck)} + P_{t(bus)}$$

$$P_{t(total)} = \text{argmax } \pi_i^{24} * P_{t(total)}$$

CHAPTER 5

RESULTS & DISCUSSION

5.1 Tabulations

SCENARIO	Case 1 - (00:00)		Case 2 - (00:20)		Case 3 - (00:40)	
	Power Loss when Ev in Bus 2 (W)	Power Loss when Ev in Bus 18 (W)	Power Loss when Ev in Bus 2 (W)	Power Loss when Ev in Bus 18 (W)	Power Loss when Ev in Bus 2 (W)	Power Loss when Ev in Bus 18 (W)
SCENARIO-1	204.1038	253.746	65.7725	78.4603	204.1038	253.746
SCENARIO-2	189.8325	236.9117	178.9671	222.4681	189.8325	236.9117

Table 5.1: Power Loss when Ev connected in different busses in 33 bus system for two load profile scenarios

Scenario	Best price	Hour
Case 1 - (00:00)	- $1.71	12:00
Case 2 - (00:20)	- $2.0988	01:20
Case 3 - (00:40)	- $1.584	01:40

Table 5.2: Best pricing for Car during various connection time

Scenario	Best price	Hour
Case 1 - (00:00)	- $2.579304	05:00
Case 2 - (00:20)	- $1.003062667	04:20
Case 3 - (00:40)	- $2.110840667	04:40

Table 5.3: Best pricing for Truck during various connection time

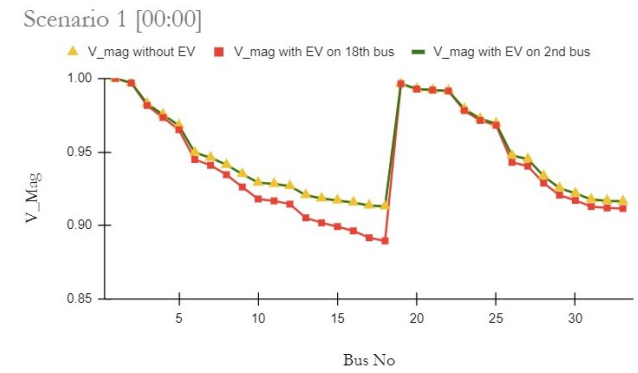
Scenario	Best price	Hour
Case 1 - (00:00)	- $0.4791666667	12:00
Case 2 - (00:20)	- $1.25	20:20
Case 3 - (00:40)	- $0.6958333333	11:40

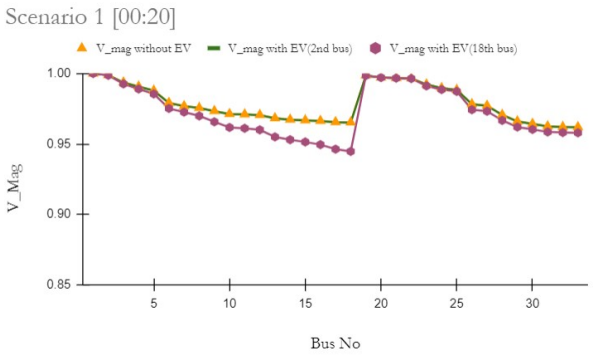
Table 5.4: Best pricing for Bus during various connection time

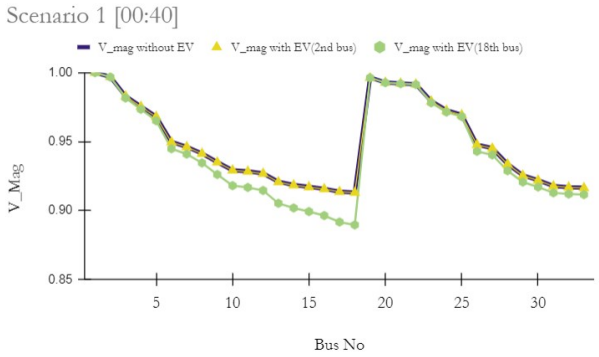
SCENARIO	HOURLY	20MINS	40 MINS
SCENARIO 1	13^{th}	6^{th}	13^{th}
SCENARIO 2	19^{th}	6^{th}	19^{th}

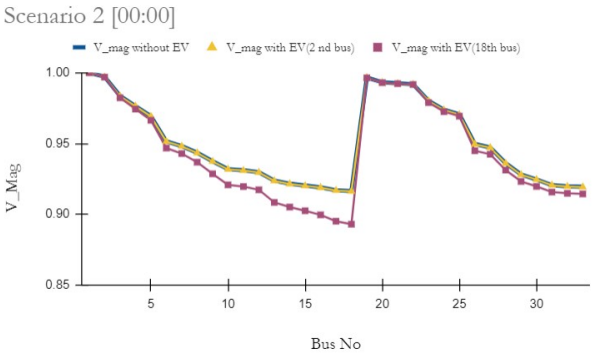
Table 5.5: Hour at which the EV Load is maximum

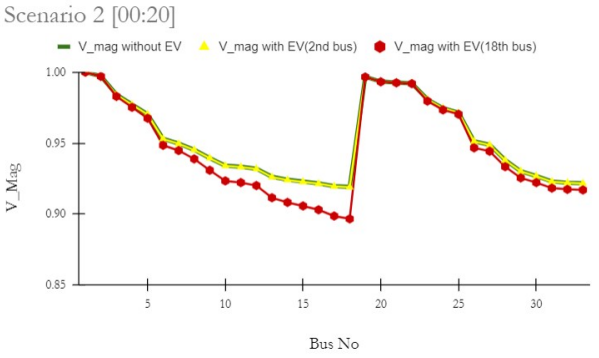
5.2 Voltage Magnitude Graphs for Different Scenarios

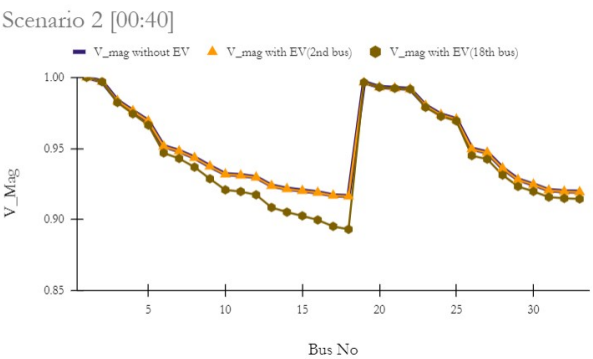












5.3 *****

CHAPTER 6

CONCLUSIONS AND FURTHER WORK

A LaTeX class along with a simple template thesis are provided here. These can be used to easily write a thesis suitable for submission at IIT-Madras. The class provides options to format PhD, MS, M.Tech. and B.Tech. thesis. It also allows one to write a synopsis using the same class file. Also provided is a BIBTeX style file that formats all bibliography entries as per the IITM format.

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Name of the Guide: Dr. Narayanan K (SAP/EEE/SEEE) **Name:**Mithra Vinda Reddy K

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REFERENCES

Lee, Z. J., T. Li, and S. H. Low (2019, June). ACN-Data: Analysis and Applications of an Open EV Charging Dataset. In *Proceedings of the Tenth International Conference on Future Energy Systems*, e-Energy '19.

PUBLICATIONS

1. Authors.... Title... *Journal*, Volume, Page, (year).

APPENDIX A

FIRST SET DATA

APPENDIX B

SECOND SET DATA

SIMILARITY CHECK REPORT