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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THANJAVUR-613 401

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 : 06 / 12 / 2022

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We express our gratitude to honourable **Dr. S. Vaidhyasubramaniam**, Vice Chancellor SASTRA University forcm the opportunity of pursuing our engineering in this esteemed in institution and carry out the project work.

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We would like to thank our friends who supported us. We would also like to thank the lab assistants for helping us with their practical expertise and for providing the necessary software tools.

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.

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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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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:**123005140

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 Need for Better Charging Scheme

1.3 *****

1.4 *****

1.5 *****

1.6 Motivation

1.7 Package Options

1.8 Example Figures and tables

1.9 Bibliography with BIBTEX

1.10 Other useful LATEX packages

CHAPTER 2

LITERATURE SURVEY

The objectives of this project are:

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-
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CHAPTER 3

METHODOLOGY

3.1 Vehicle Classification

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

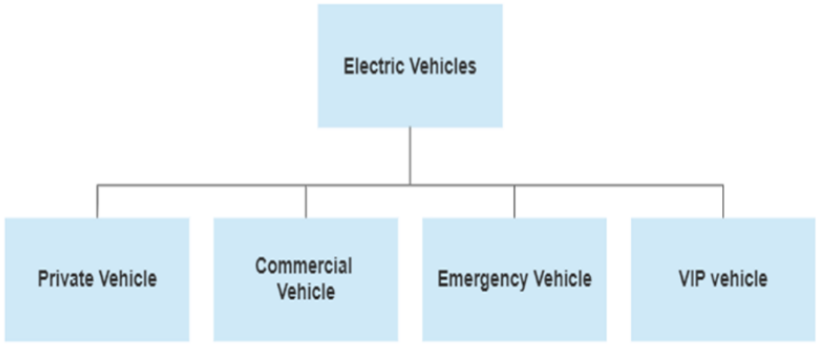

Figure 3.1: Vehicle Classification

The above classification is made by comparing the battery capacity of the vehicles from the data (1) 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 rate.

3.3 Charging/Discharging Pattern

3.4 Proposed Algorithm

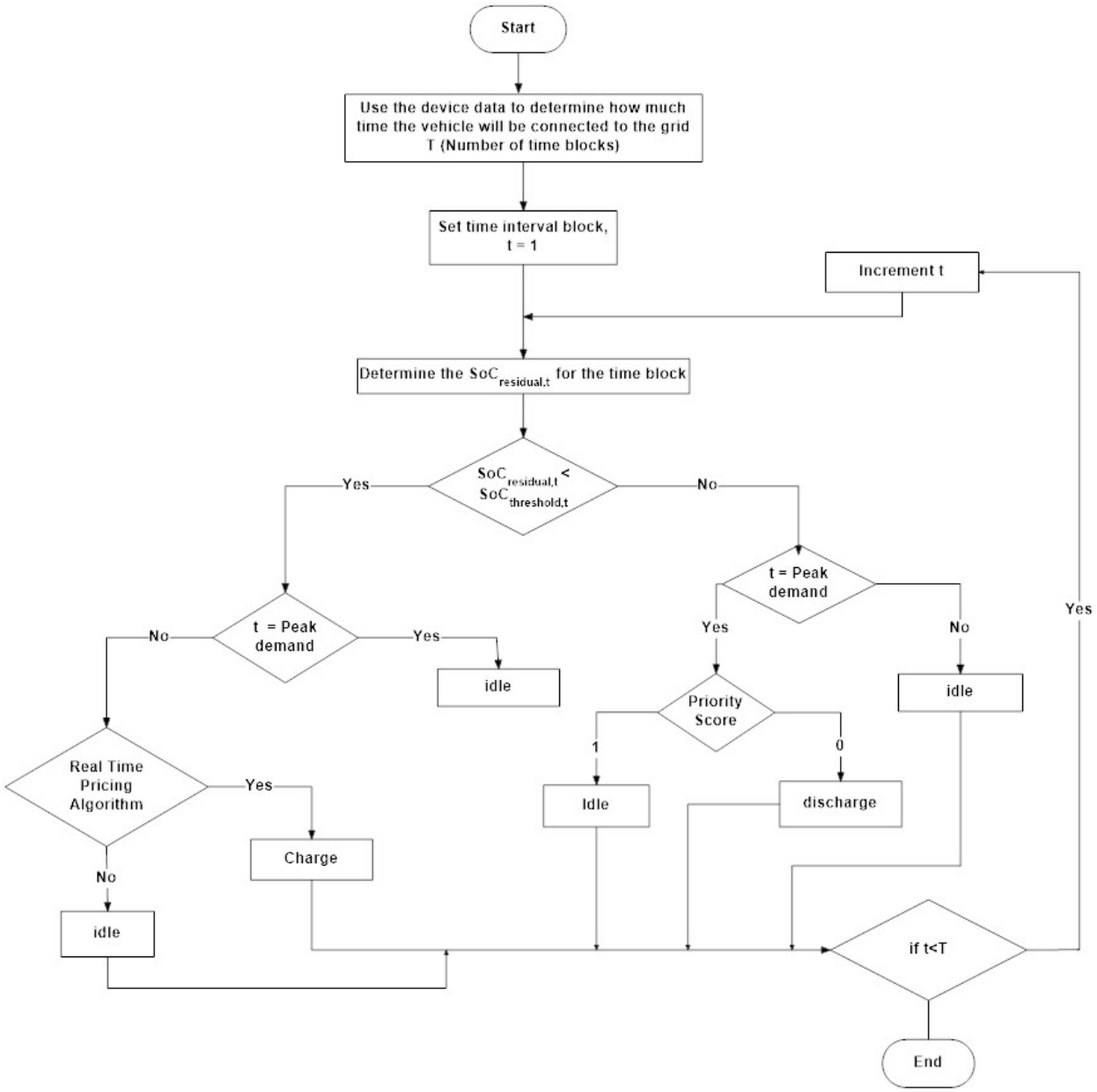

Figure 3.2: Proposed Algorithm for determining Charging/Discharging Pattern

CHAPTER 4

Mathematical Modelling

4.1 SoC Calculation

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

$$SoC_{min} \leq SoC \leq SoC_{max}$$

$$SoC_y = SoC_{y-1} + P_{batt}(y) \times \partial y \times \eta c$$

$$SoC_y = SoC_{y-1} - P_{batt}(y) \times \partial y \times \eta d$$

$$P_{batt}(y) = SoC_y \times E$$

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

5.2 Voltage Magnitude Graphs for Different Scenarios

5.3 *****

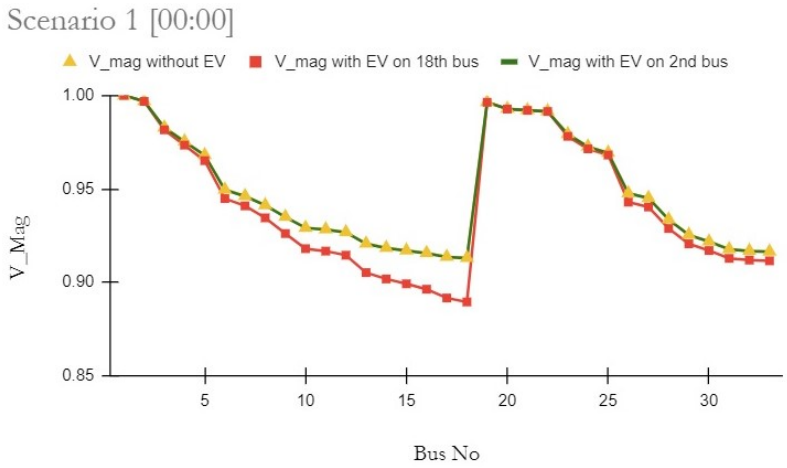

Figure 5.1: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 1 - case 1

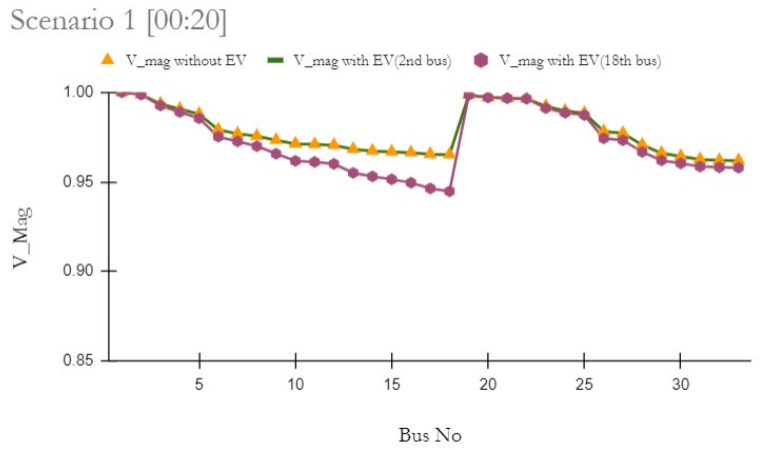

Figure 5.2: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 1 - case 2

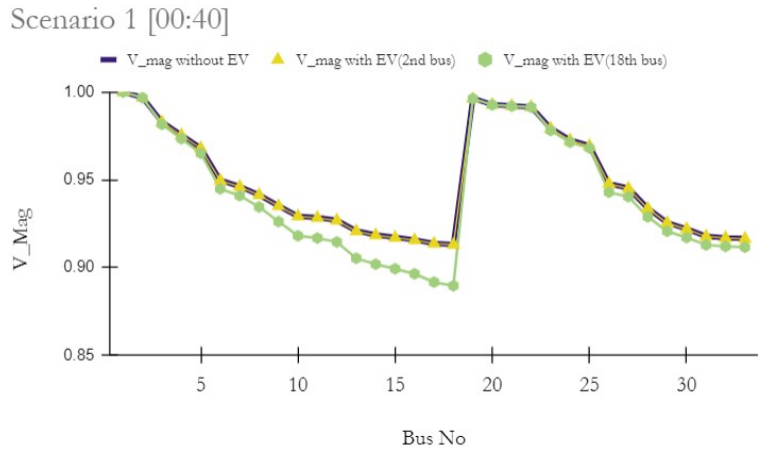

Figure 5.3: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 1 - case 3

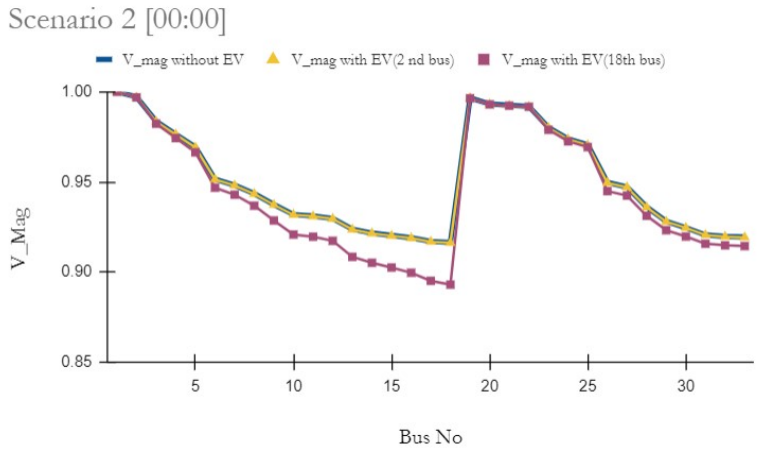

Figure 5.4: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 2 - case 1

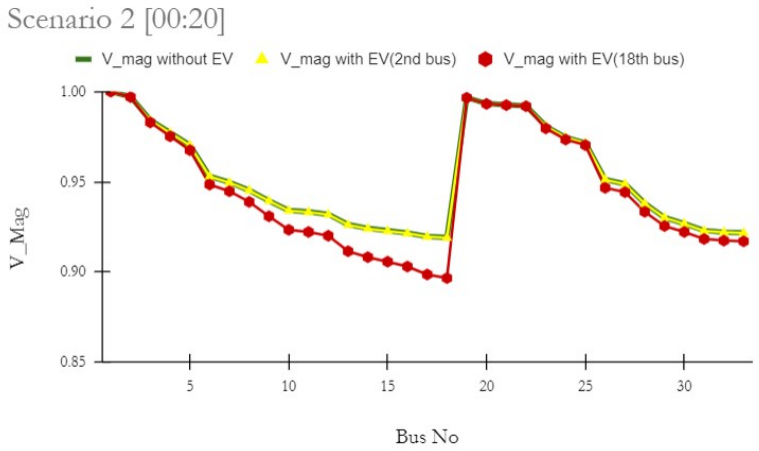

Figure 5.5: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 2 - case 2

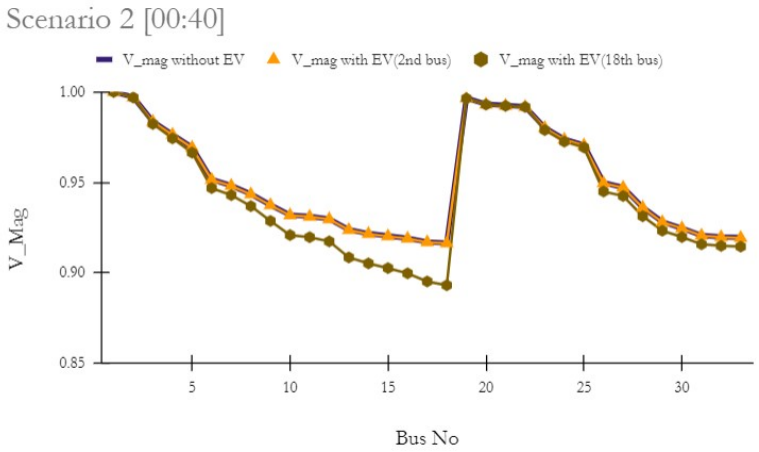

Figure 5.6: Voltage loss plot when EV is connected in Bus 2 and 18 of a 33 Bus system - Scenario 2 - case 3

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

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.

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

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REFERENCES

[1] Zachary J. Lee, Tongxin Li, and Steven H. Low. 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, June 2019.

SIMILARITY CHECK REPORT