User Manual

xEV Simulator

Version 6.0

Supervisor: Miyasaka san

NIDEC ADVANCE TECHNOLOGY CORPORATION

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URL. https://www.nidec.com/jp/nidec-advancetechnology/

Revisions:

Version	Primary Author	Description of Version	Date completed
6.0	Roywin Joel Monteiro	Initial Release	06-09-2024
	Pratheeksha		

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1. Introduction

With the global rise of automobile electrification, it is essential to optimize the entire vehicle as a unified system. The xEV Simulator is designed to create and optimize a digital twin of the whole electric vehicle, rather than focusing solely on its individual components.

xEV Simulator is an integrated simulation tool to support the designing and analysis of xEV (electric vehicles).This tool simulates the entire electric vehicle during xEV development, incorporating the specific characteristics of the E-Axle, which includes an automotive drive motor, gear, inverter, and other components.

This function enables the tool’s users to propose, among others, motors and components that match the vehicle’s conditions and running environment, while shortening the time for motor test via detailed calculation, and improving the efficiency of the calculation-result gap analysis.

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2. Installation and Setup

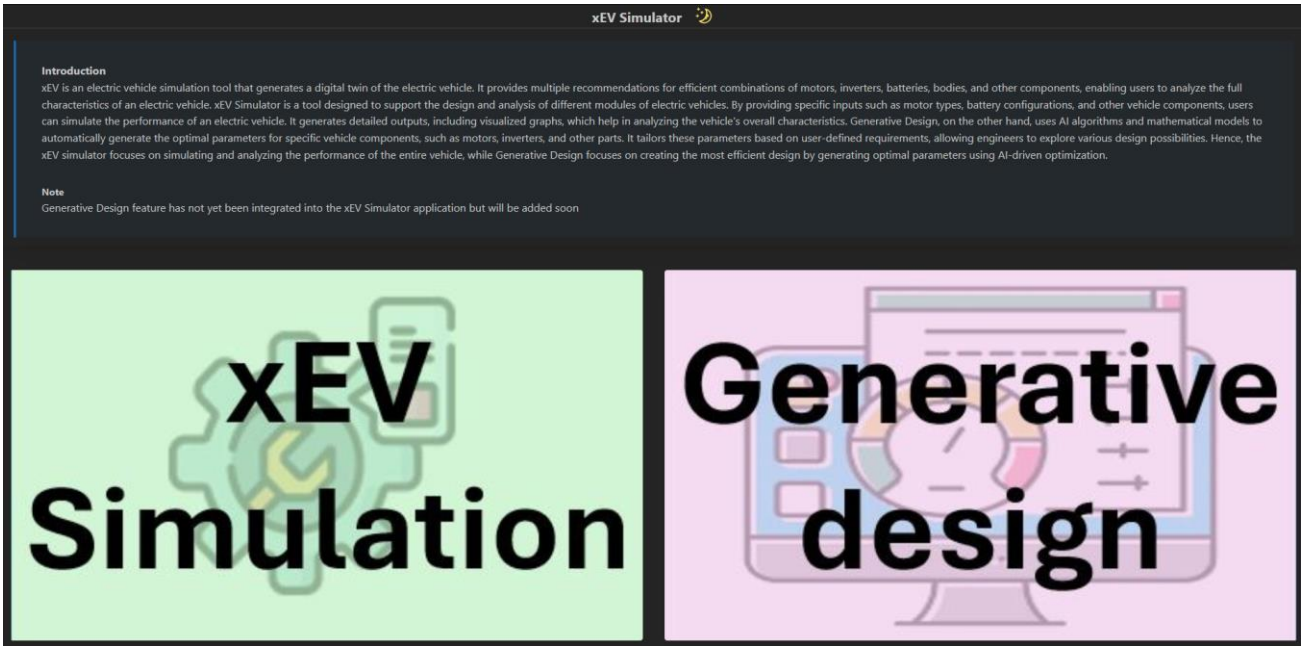
Follow these steps to run the xEV Simulator web application:

1. Extract the Zip File:
    - Extract the contents of the attached zip file
2. Navigate to the Build Directory:
    - Go to the directory: web v6.0/build/exe.win-amd64-3.12/
3. Run the Server:
    - Run the server.exe file located in the directory.
4. Open the Application in a Browser:
    - Open a web browser and go to: http://127.0.0.1:8050

3. Getting Started

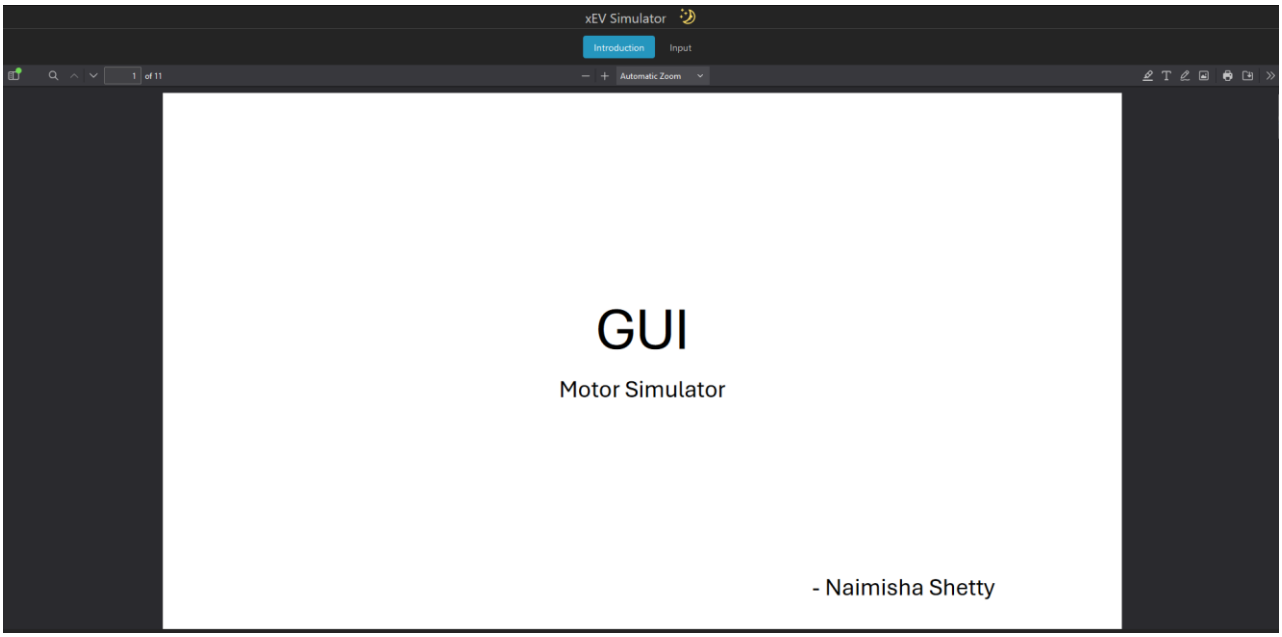
3.1 Home Page:

On this page, selecting the xEV simulator button starts the motor simulator application.



3.2 Introduction:

This page contains a Presentation for the motor simulator.

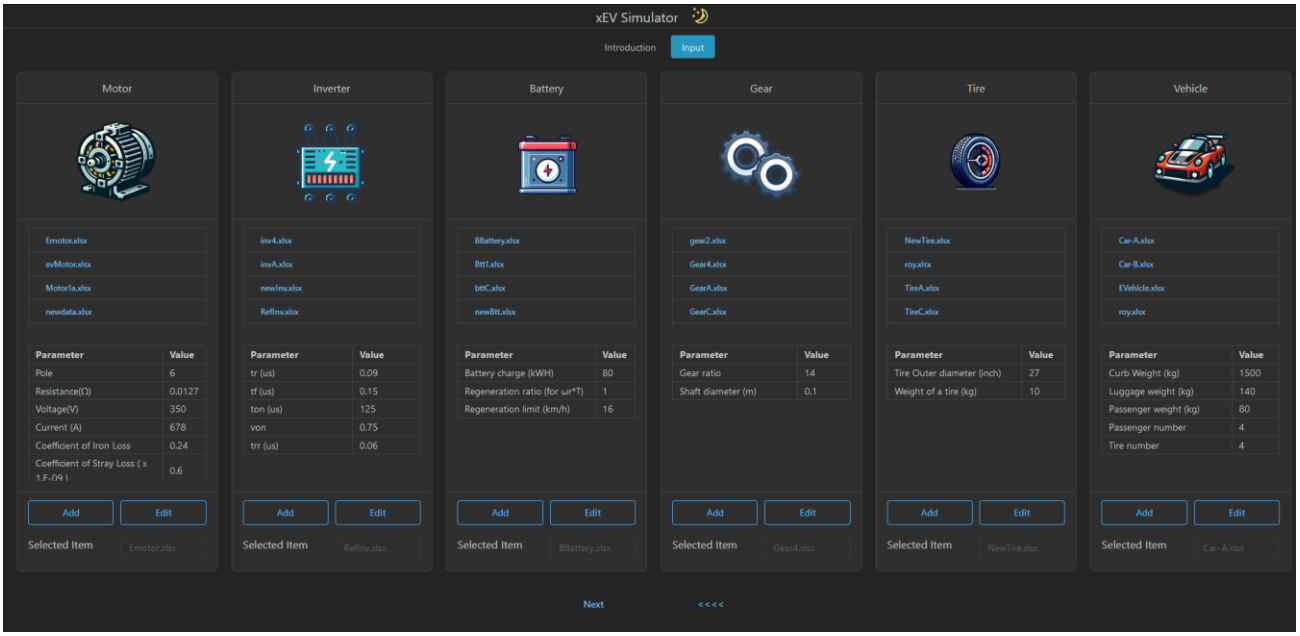


3.3 Input Tab:

The Xev software has the main tab named the Input tab.

In this tab, parameters for Motor, Inverter, Battery, Gear, Tire and Electric Vehicle on the whole has to be selected. Upon clicking Next button, the following tabs will be available:

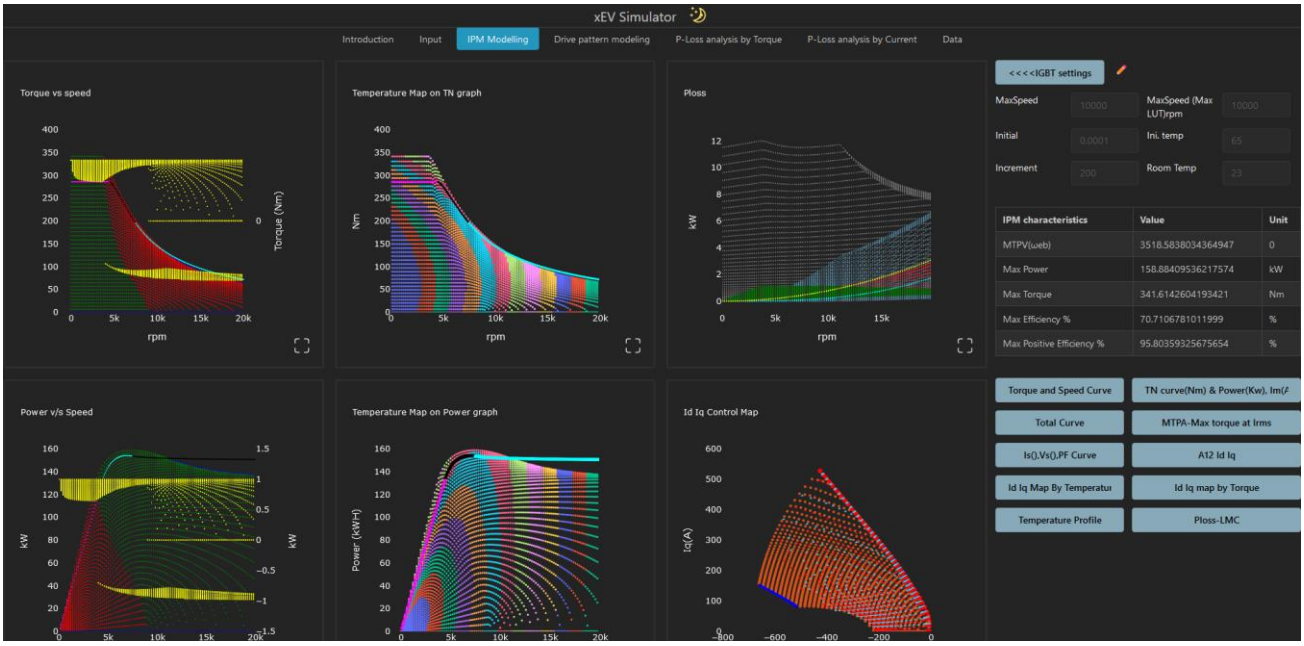
1. IPM Modeling
2. Drive Pattern
3. P-Loss Analysis by Torque
4. P-Loss Analysis by Current
5. Data



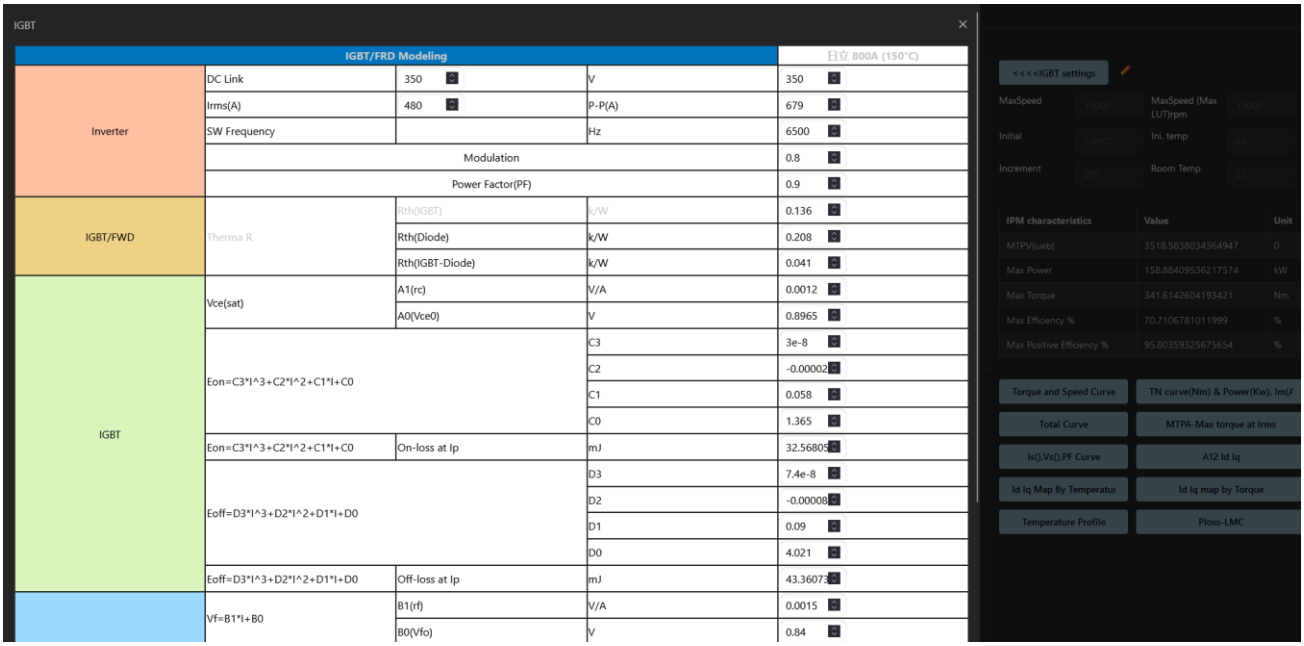
3.3.1 Digital Twin:

3.4 IPM Tab:

IPM Modeling tab simulates the Interior Permanent Magnet Synchronous motor (IPMSM) by incorporating the control strategies specific to IPMSM. Major graphs of this tab include the torque vs speed, power vs speed and id-iq current maps. Within these graphs we can observe the different regions of the control namely MTPA(Maximum Torque per Ampere), MTPV(Maximum torque per voltage) and CPSR(Constant Power Speed Range). From these graphs we c obtain the maximum torque and power obtainable. Additionally, we can observe the temperature profile for different operating points of the torque vs speed and power vs speed graphs. This tab calculates the losses occurring within the motor and inverter for different speeds of operation. These motor losses include the copper loss, stray loss, iron loss friction loss windage loss. These losses are calculated based on the current map. By knowing these losses, efficiency of the system can be found.



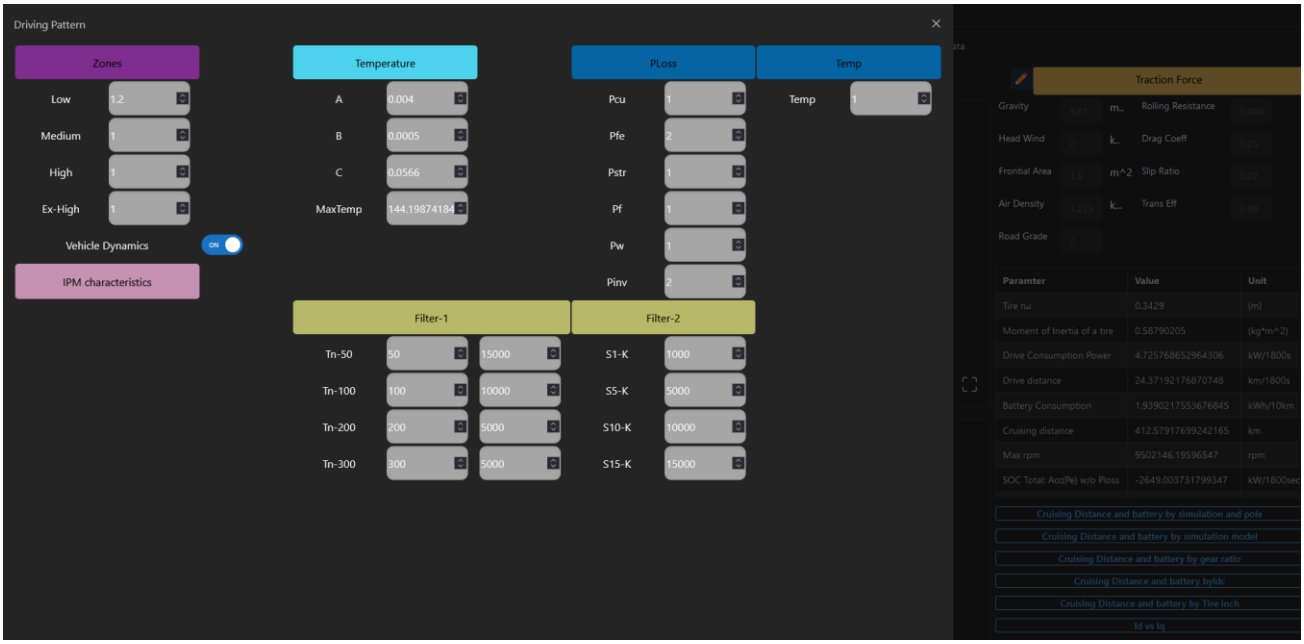
3.4.1 IGBT:


IGBT
IGBT/FRD Modeling
Inverter
DC Link
350
V
350
Irms(A)
480
P-P(A)
679
SW Frequency
Hz
6500
Modulation
0.8
Power Factor(PF)
0.9
IGBT/FWD
Therma R
Rth(IGBT)
k/W
0.136
Rth(Diode)
k/W
0.208
Rth(IGBT-Diode)
k/W
0.041
IGBT
Vce(sat)
A1(rc)
V/A
0.0012
A0(Vce0)
V
0.8965
Eon=C3*I^3+C2*I^2+C1*I+C0
C3
3e-8
C2
-0.00002
C1
0.058
C0
1.365
Eon=C3*I^3+C2*I^2+C1*I+C0
On-loss at Ip
mJ
32.56805
Eoff=D3*I^3+D2*I^2+D1*I+D0
D3
7.4e-8
D2
-0.00008
D1
0.09
D0
4.021
Eoff=D3*I^3+D2*I^2+D1*I+D0
Off-loss at Ip
mJ
43.36073
Vf=B1*I+B0
B1(rf)
V/A
0.0015
B0(Vfo)
V
0.84
<<<<IGBT settings
MaxSpeed
MaxSpeed (Max LUT)rpm
Initial
Ini. temp
Increment
Room Temp
IPM characteristics
Value
Unit
MTPV(ueb)
3518.5838034364947
0
Max Power
158.88409536217574
kW
Max Torque
341.6142604193421
Nm
Max Efficiency %
70.7106781011999
%
Max Positive Efficiency %
95.80359325675654
%
Torque and Speed Curve
TN curve(Nm) & Power(Kw), Im(A
Total Curve
MTPA-Max torque at Irms
Is().Vs().PF Curve
A12 Id Iq
Id Iq Map By Temperatur
Id Iq map by Torque
Temperature Profile
Ploss-LMC

3.5 Drive Pattern Modelling Tab:

The drive pattern tab simulates the vehicle dynamics by using the standard drive cycles namely WLTC (World Wide Harmonic Light Vehicle Test Cycle), CLTC(China Light-duty vehicle Test Cycle), NEDC(New European Driving Cycle) and FTP75(Federal Test Procedure). The power consumption at each point of the drive pattern is found. These points are added up to find the total energy consumption for the particular drive cycle selected. From this data, we obtain the battery power consumption per 10 km. By knowing the battery capacity that is provided as input, we can determine the cruising distance. The losses occurring in the motor and inverter are calculated in this tab, similar to that done in IPM tab, but this time accounting for the vehicle dynamics. Based on these losses, the efficiency is determined. The losses are depicted using a pie chart for better understanding. The drive pattern tab also comprises of the torque vs speed and power vs speed plots. The efficiency for different points on these graphs can be visualized. Other important graphs of this tab include the variation of cruising distance and battery consumption as a function of pole pairs, gear ratio, battery current and tire inch. The id-iq current maps are also included.

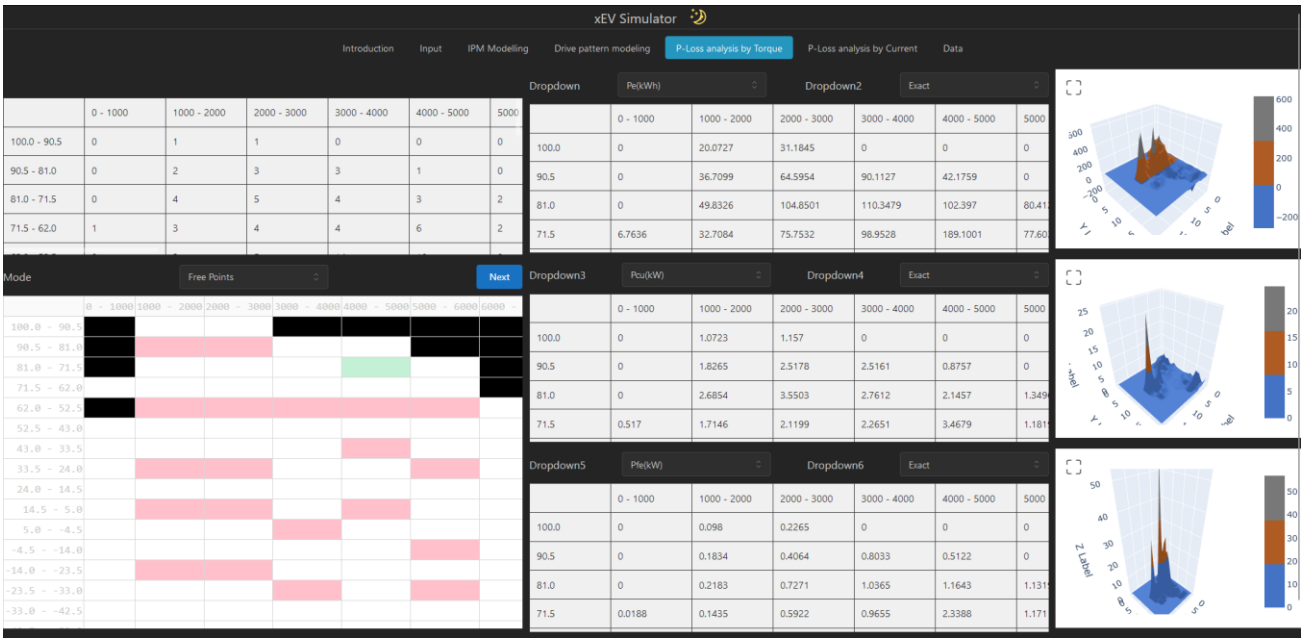
3.5.1 Parameter Settings:



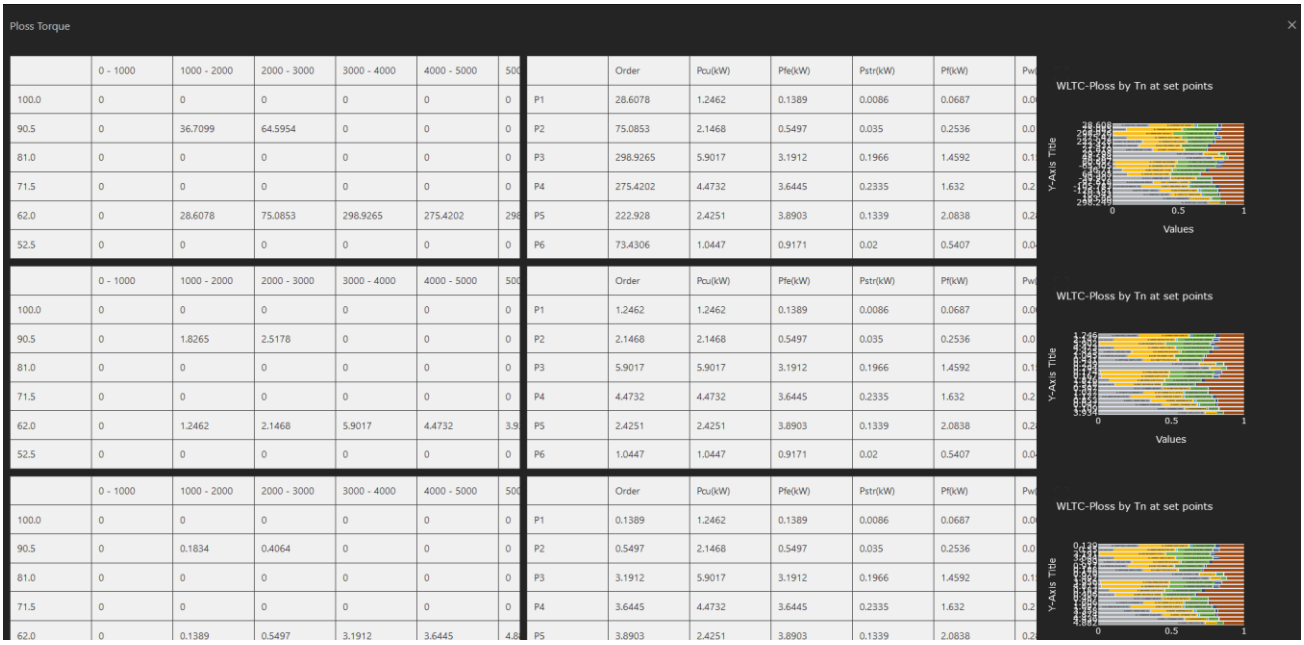
3.6 Ploss Analysis by Torque:

This tab has the frequency map table. The column header specifies the torque range and the row header specifies the speed range. The torque array calculated on the basis of the drive pattern, is divided into sets of ranges. This table specifies the number of points present in the torque and speed range. If no point lies in a particular torque and speed range, the corresponding cell holds the value, 0.

Below this table, there is a table named “Free points”. In this table,10 positive and 10 negative points have to be selected by checking 20 cells of the table. After selection of these cells, we need to click on the next button available below this table. This will enable 3 tables to appear on the right side of the tab. The column headers and row headers for these tables remain the same as for the frequency map table. The column headers being Torque range and row headers being speed range. These tables are prob=vided with drop down where we can select different parameters which include motor power (Pe), motor power with regeneration (Pe with regeneration) having the units of kW/s and kWh each, temperature (Temp), efficiency (n=Pe/Pbatt) and the loss values which include copper loss, iron loss, stray loss, friction loss, windage loss, inverter loss and the total loss (Pcu, , Pfe, Pstr, Pf, Pw, Pinv, sum Ploss) The table will hold the values corresponding to the parameter that is selected using the drop down. If Pcu is selected, each cell will hold the sum of copper loss for the points present in the torque and speed range corresponding to this cell. There is another dropdown provided for each of the 3 tables. This dropdown contains the average and exact fields. Suppose that a particular cell has no numerical value, then by selecting average this cell will hold the value of 0. If exact field is selected the cell will hold the value named “nan” which signifies that this cell would be omitted for plotting. It should be noted that all the 6 dropdowns must be selected in order to click the next button again. By clicking the next button we can visualize the bar chart of these tables.



3.6.1 Ploss Analysis by Torque Next:



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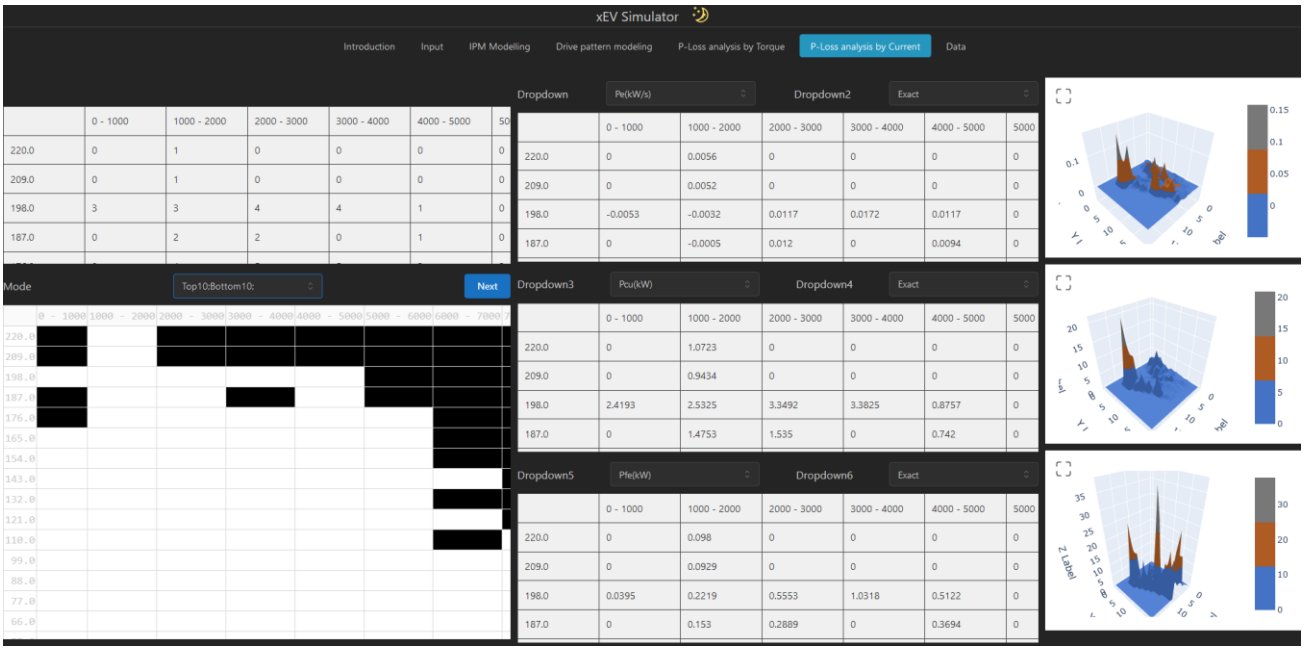
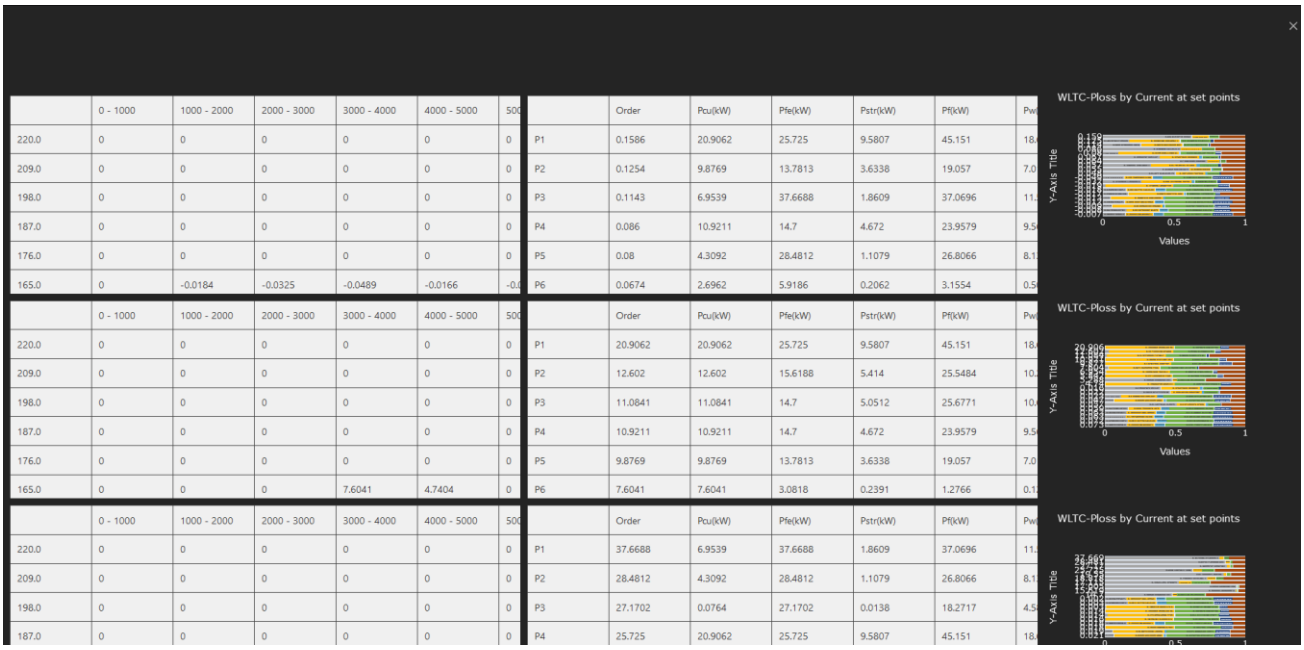
3.7 Ploss Analysis by Current:

This tab is similar to the Ploss Analysis by current tab with only difference being the column header for the table is current. This current refers to the peak stator phase current of the motor.



3.7.1 Ploss Analysis by Current Next:



3.8 Data Tab

This tab consists of several graphs which could be used for comparative analysis.

The first graph of this tab is the battery consumption vs battery capacity graph. This graph is used to compare the value of battery capacity and the battery consumption that our simulated model offers, along with that offered by other models. The other two graphs, present on the first row of the tab are similar to the first graph but are specific to the CLTC and WLTC drive cycles. They are battery consumption for cltc cycle vs battery capacity and battery consumption for wltc cycle vs battery capacity graphs. The battery consumption per 10 km is considered in all the 3 graphs. Next is the graph of loss vs speed in rpm. This graph has two curves which indicate the power loss of our motor model and that of Nissan Leaf.

Other two graphs are corresponding to the WLTC drive cycle. They are the first two graphs present in the second row of the data tab.

The first graph plots the power loss values due to 4 factors namely Aerodynamic drag (M1), Rolling resistance (M2), Drivetrain losses (M3) and Accessory power loss (M4). The power loss due to these 4 factors are found for the 4 phases of the WLTC drive cycle namely low, medium, high and extra-high. Hence from this graph, we can obtain the total loss corresponding to the WLTC drive cycle.

The second graph shows the electrical power (Pe), electrical torque (Tn), Reactance torque (in percentage), efficiency (in percentage) corresponding to M1, M2, M3 and M4.

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4. Detailed Functionality

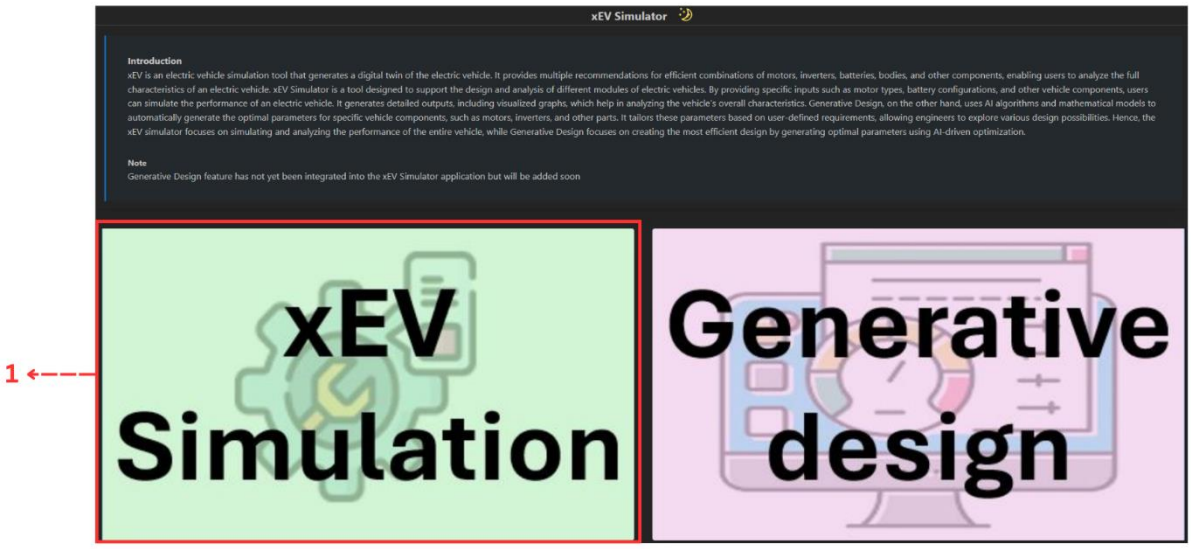

Figure 1 : Home Page

In Figure 1:

1 - xEV Simulator Button

Click button 1 to proceed with xEV simulator Application

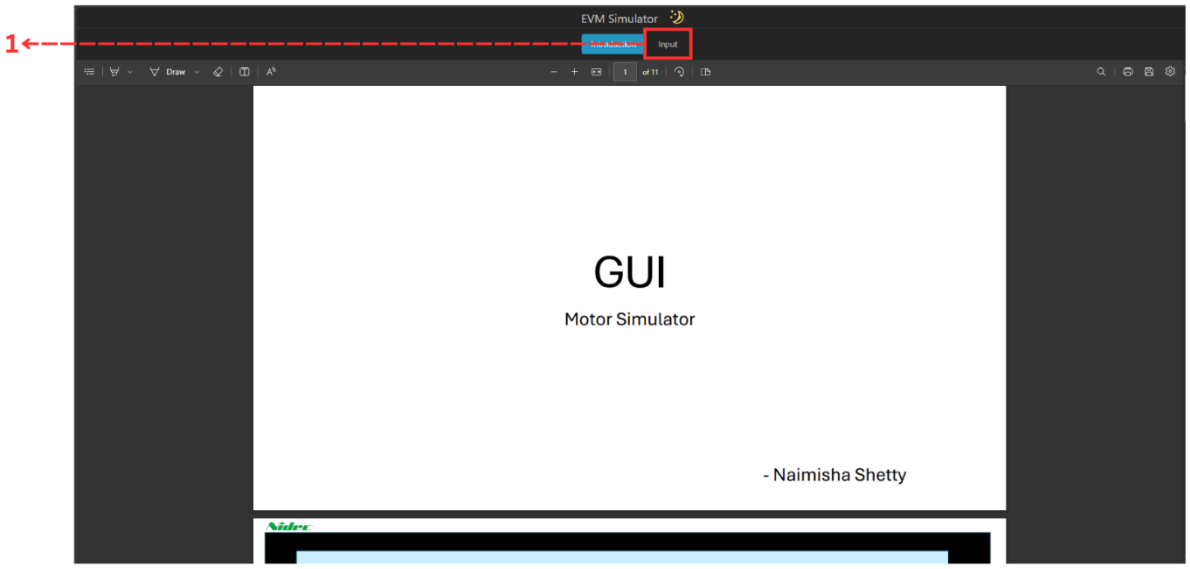

Figure 2 : Introduction Tab

In Figure 2:

1 - Input Tab Navigation

Click on 1 to navigate to input tab

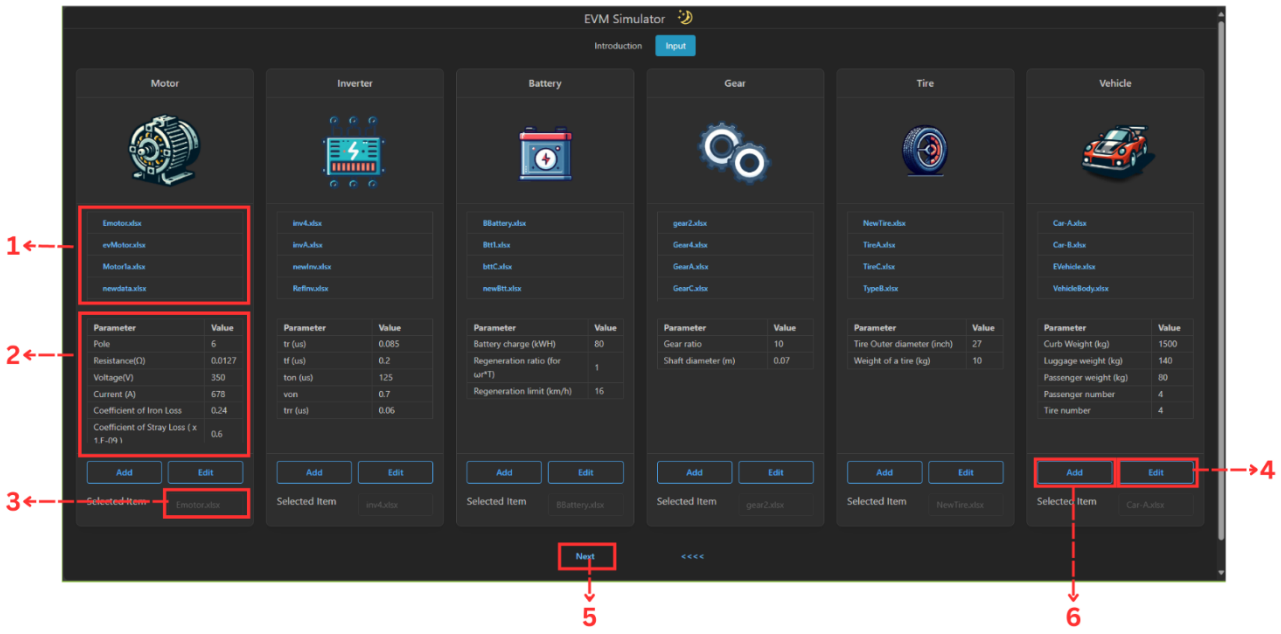

Figure 3 : Input Tab

In Figure 3 :

1- File list

2- Selected File content

3- Selected file name

4- Edit button

5- Next Button

6- Add button

Click on button 1 to select input file for all parameters. On 2 you can view the selected file contents. On 3 you can view the selected file name. Click on 4 to edit the file contents. Click on 6 to add a new file. After selecting files for each parameter click on 5 to display all the tabs for selected parameters.

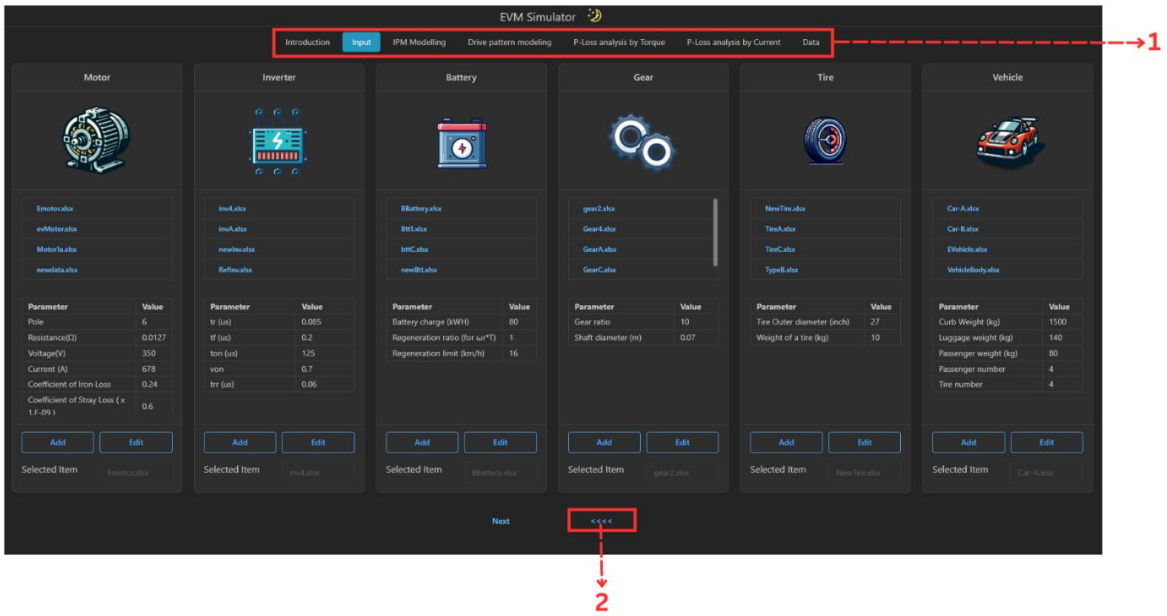

Figure 4 : Input Tab

In Figure 4

1 - Tab navigation

2 - Digital Twin button

Select the required tab by using 1. Click on button 3 to view Digital Twin tab.

Figure 5 : Digital Twin

In Figure 5

1 - DTnum Dropdown

2 - Close button

Select the required value in drop down 1 which will result in the change of values in standard deviation for speed and torque based on 6 methods.

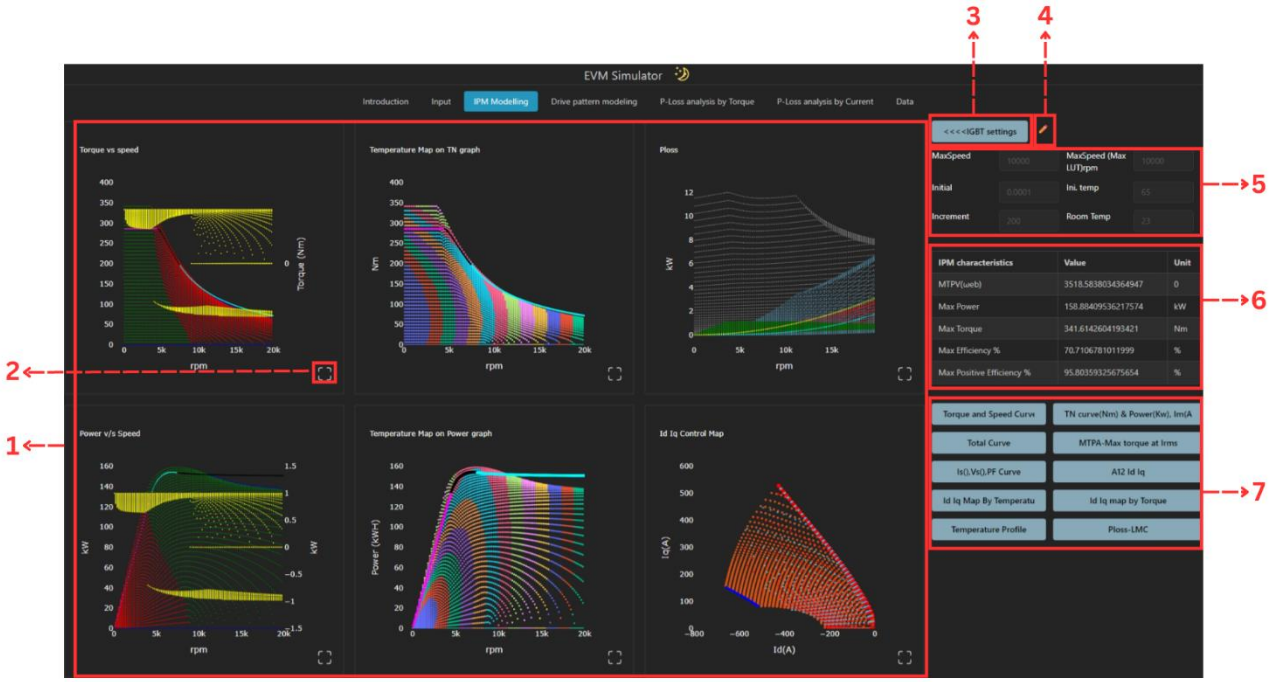

Figure 6 : IPM Modelling Tab

In Figure 6 :

1 – IPM Modelling graphs

2 - enlarge button

3 - IGBT settings button

4 - Edit/Confirm button

5 - Input Parameters

6 - Output Parameters

7 - Secondary graphs

On frame 1 you can view all the primary IPM graphs. On clicking 2 you can enlarge individual graphs. On clicking 3 you can view IGBT settings. Click 4 to edit input parameters on table 5. On 6 you can view the resulting output parameters. Select individual buttons on 7 to display secondary graphs one by one.

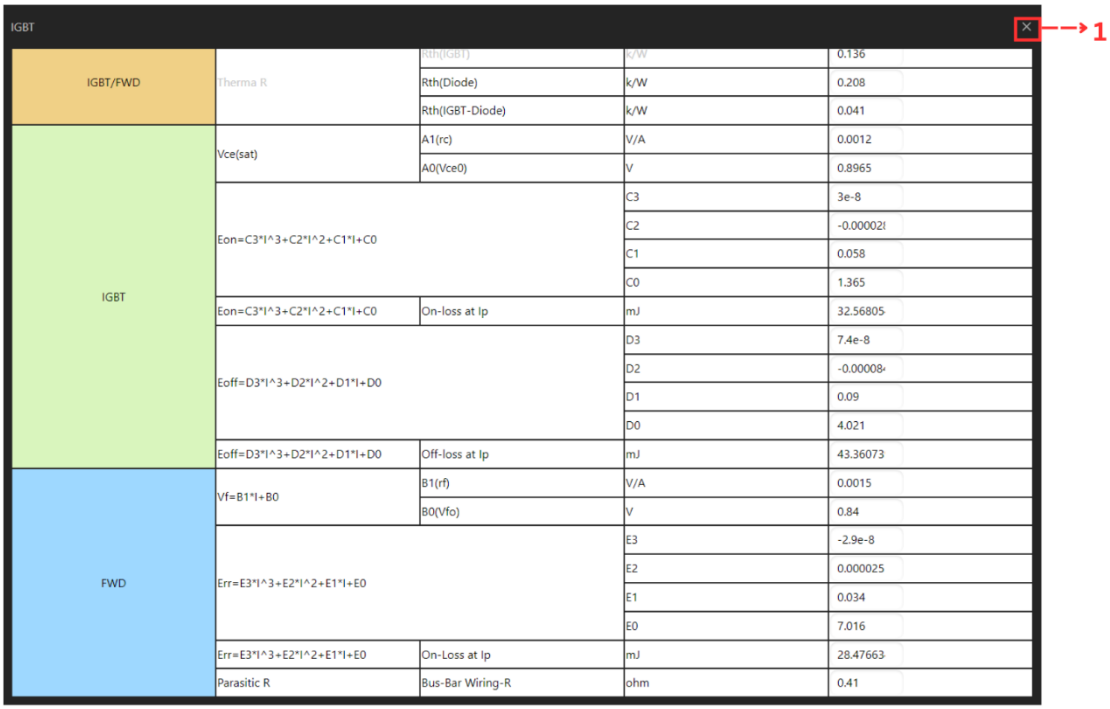

Figure 7 : IGBT Parameters

In Figure 7:

1 - Close button

select 1 to close IGFBT settings frame.

Figure 8 : Drive Pattern Modelling Tab

In Figure 8:

1 - Drive Pattern graphs

2 - enlarge button

3 - Cruising Distance graph button

4 - Cruising Pattern dropdown

5 - Parameter Setting button

6 - Edit/Confirm button

7 - Input Parametrs

8 - Output Parameters

On frame 1 you can view all the primary Drive Pattern graphs. On clicking 2 you can enlarge individual graphs. Select required buttons on 3 to display the resulting graphs. Select dropdown 4 to change drive pattern graphs based on the selected dropdown. Click on 5 to view parameter settings. Click on 6 to edit input paramters on 7. Resulting output paramters will be displayed on 8

Figure 9 : Parameter Setting

In Figure 9:

1 - Close button

select 1 to close Parameter Setting frame.

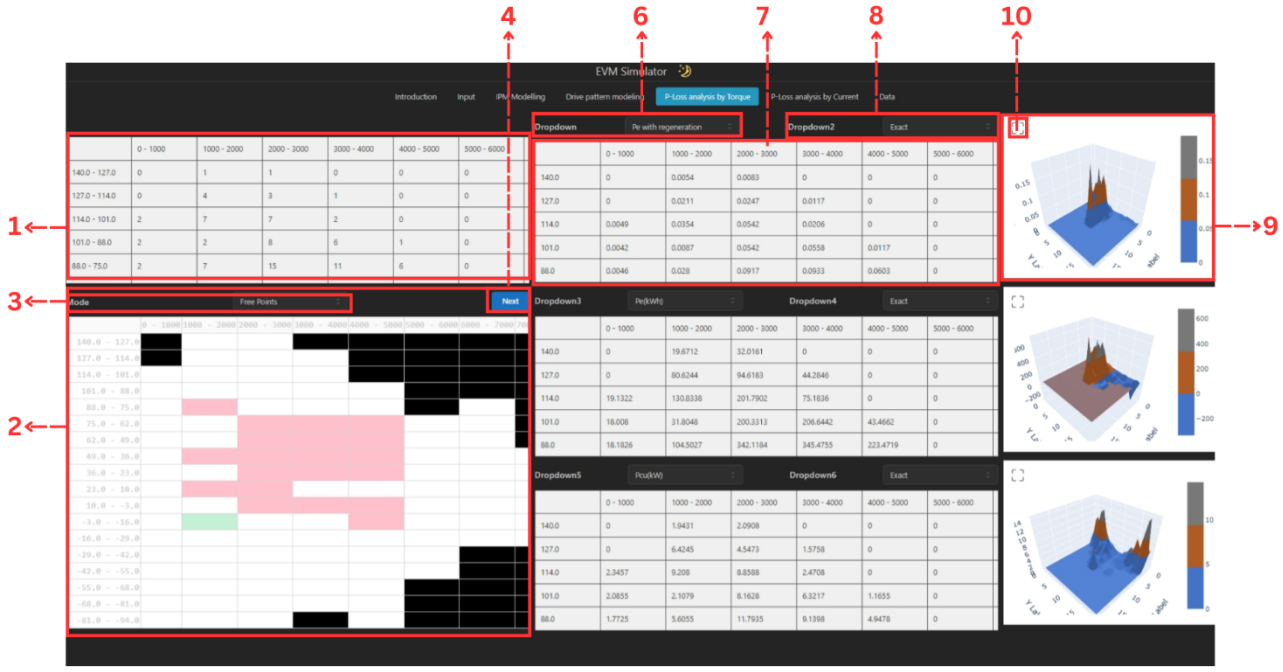

Figure 10 : Ploss Analysis by Torque Tab

In Figure 10:

1 - Tn Frequency table

2 - Tn Free points table

3 - Mode dropdown

4 - Next button

6 - Loss Dropdown

7 - Loss table

8 - Exact/Average drop down

9 - Loss graphs

Tn frequency table is displayed on 1. Select 20 points on table 2 when dropdown 3 is set at free points or set dropdown 3 to Top10: Bottom10. Click on dropdown 6 to view all loss options, after selecting three different loss options. Click on button 4 to view the resultant output tab. Select dropdown 8 to alter the loss tables between exact and average setting. View the resulting graphs in frame 9.

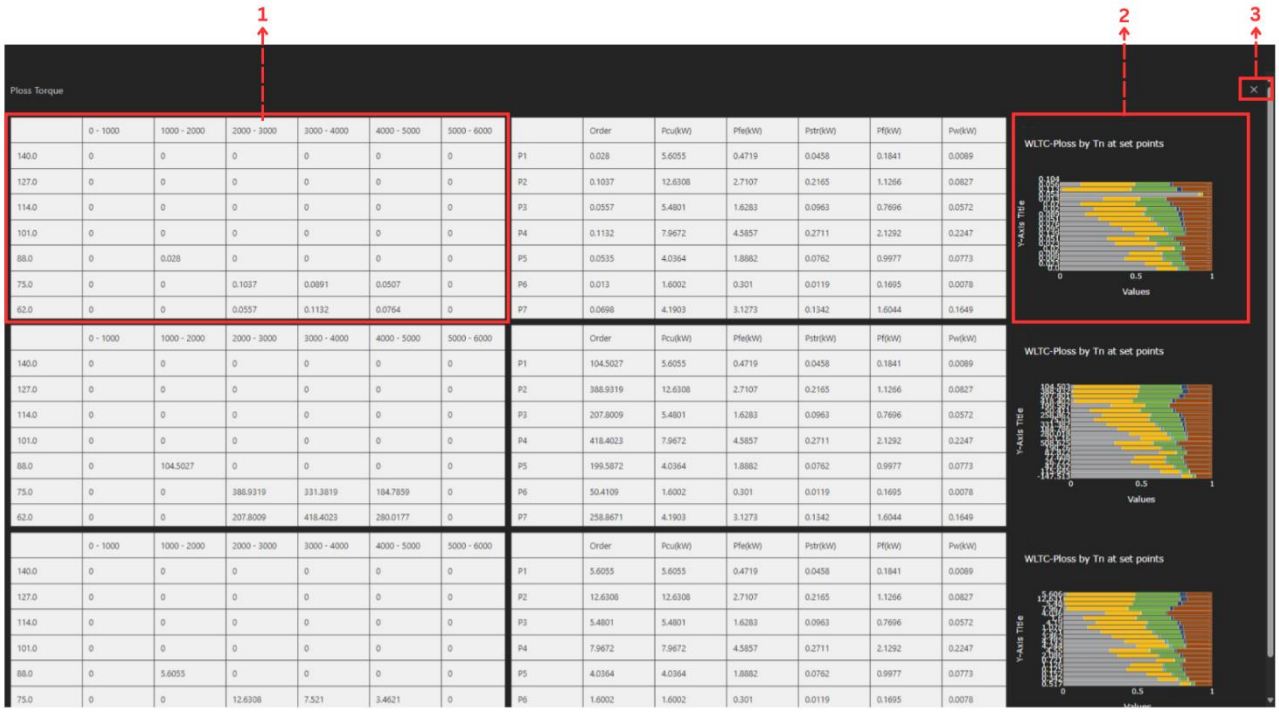

Figure 11 Torque Output

In figure 11:

1 - Output table

2 - Output graphs

3 - close button

View the resultant output values on 1. View the resulting output graphs on 2. Click on 3 to close the frame.

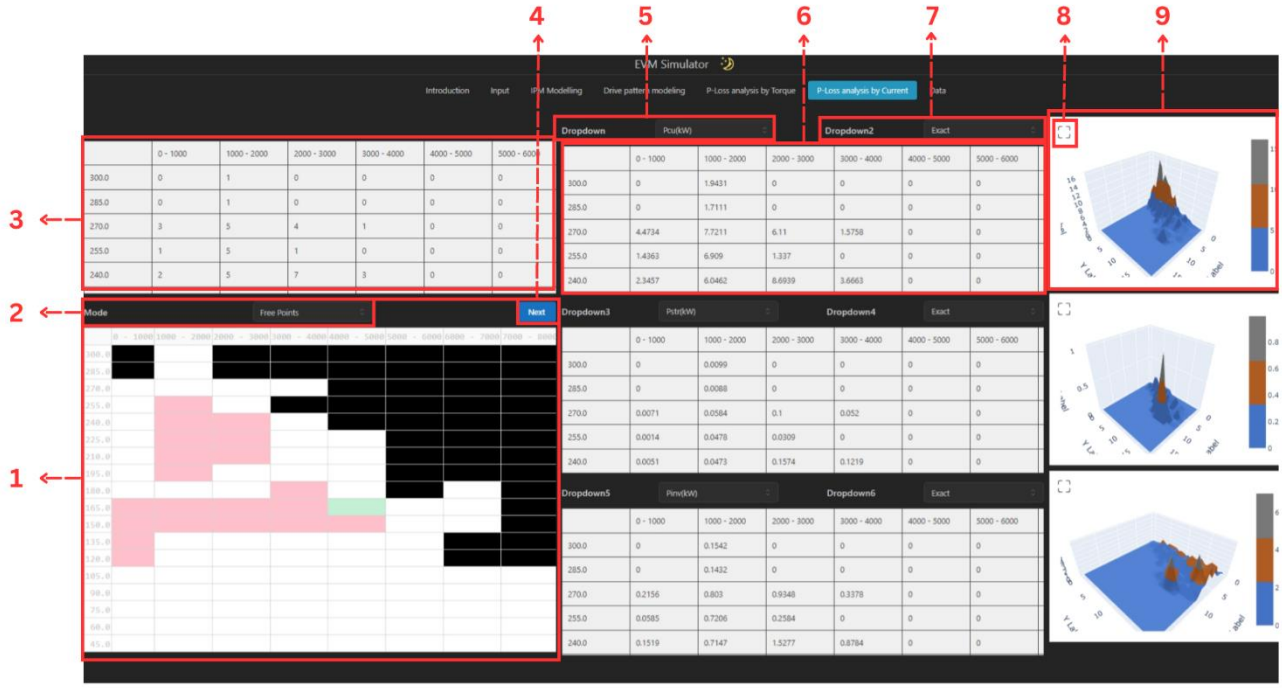

Figure 12 Ploss Analysis by Current Tab

In Figure 12:

1 - Im Frequency table

2 - Im Free points table

3 - Mode dropdown

4 - Next button

6 - Loss Dropdown

7 - Loss table

8 - Exact/Average drop down

9 - Loss graphs

Im frequency table is displayed on 1. Select 20 points on table 2 when dropdown 3 is set at free points or set dropdown 3 to Top10: Bottom10. Click on dropdown 6 to view all loss options, after selecting three different loss options. Click on button 4 to view the resultant output tab. Click on button 5 to clear all free points selected. Select dropdown 8 to alter the loss tables between exact and average setting. View the resulting graphs in frame 9.

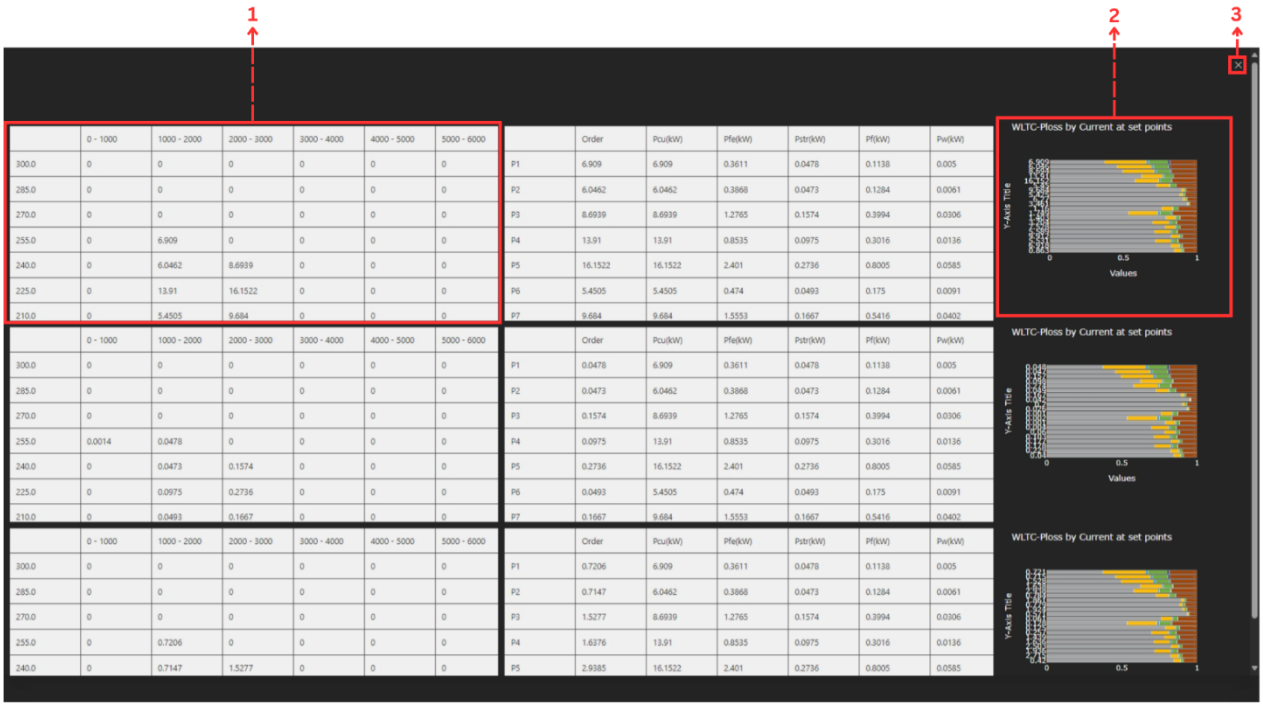

Figure 13 : Current Output

In Figure 13

1 - Output table

2 - Output graphs

3 - close button

View the resultant output values on 1. View the resulting output graphs on 2. Click on 3 to close the frame.

Figure 14 : Data Tab

In Figure 14

1 - Data graphs

View Data graphs in frame 1

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