User Manual

xEV Simulator

Version 6.1

NIDEC ADVANCE TECHNOLOGY CORPORATION

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

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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:

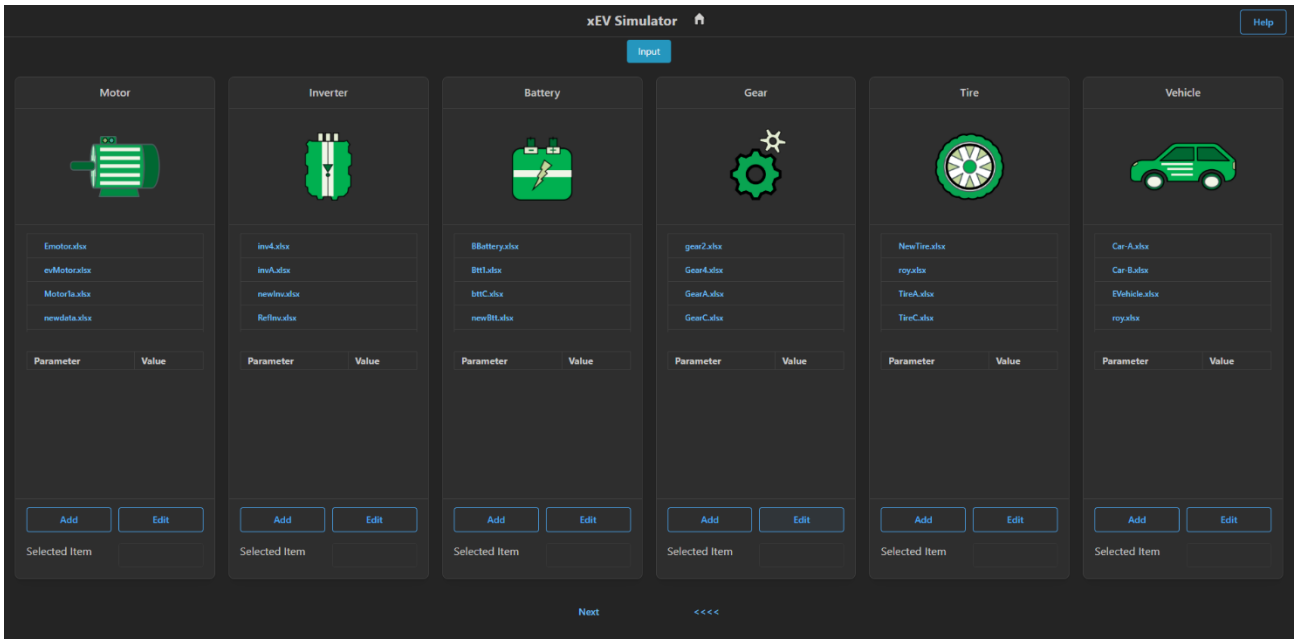
On this page, selecting the xEV simulator button starts the motor simulator application.

3.2 Input Tab:

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

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

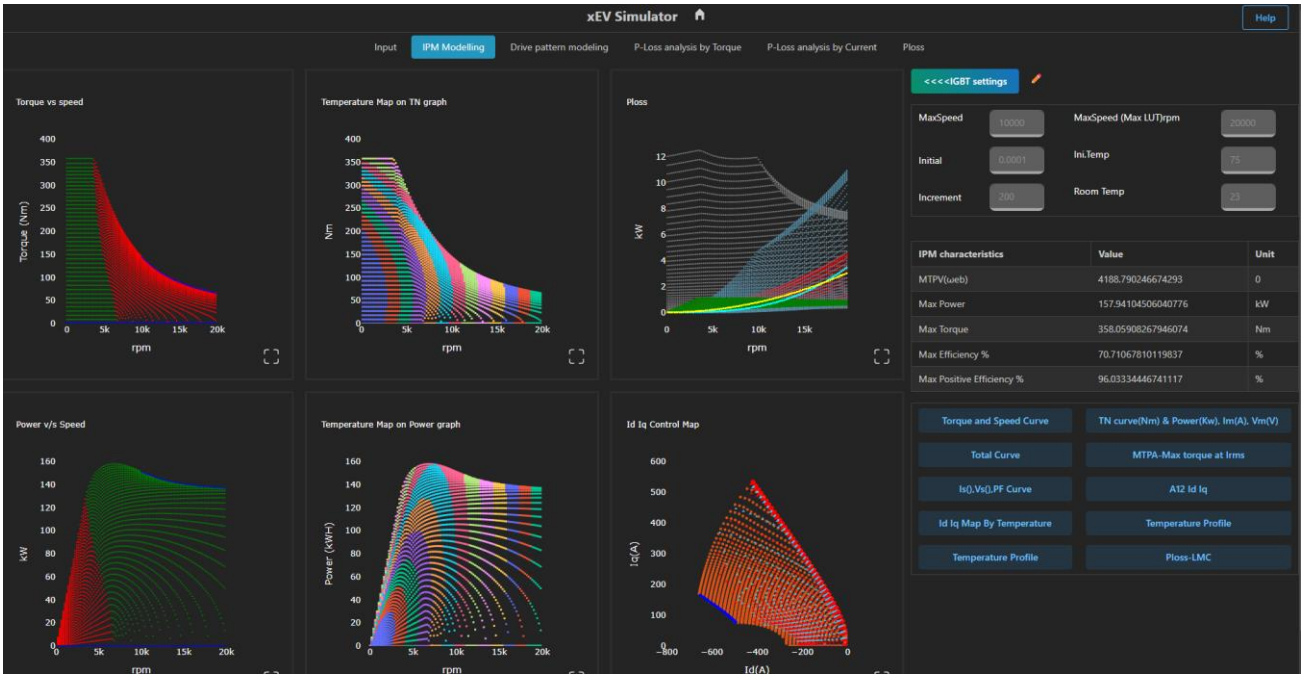
1. IPM Modeling
2. Drive Pattern
3. P-Loss Analysis by Torque
4. P-Loss Analysis by Current
5. Data



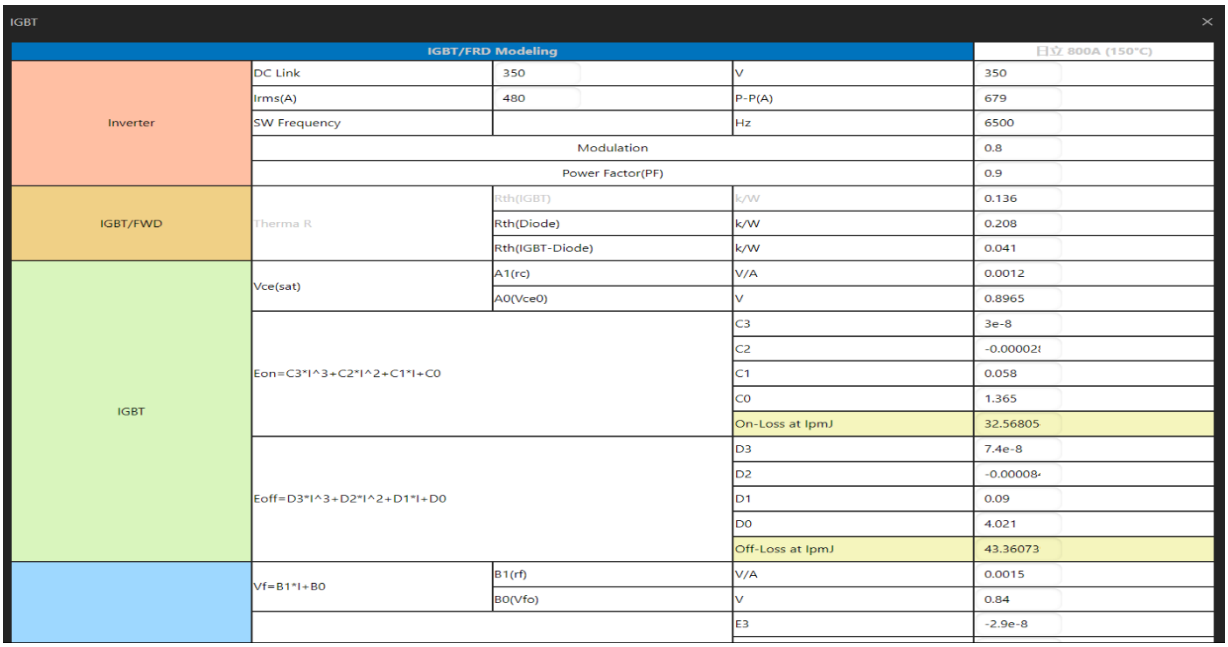
3.2.1 Digital Twin:

3.3 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.



3.3.1 IGBT:

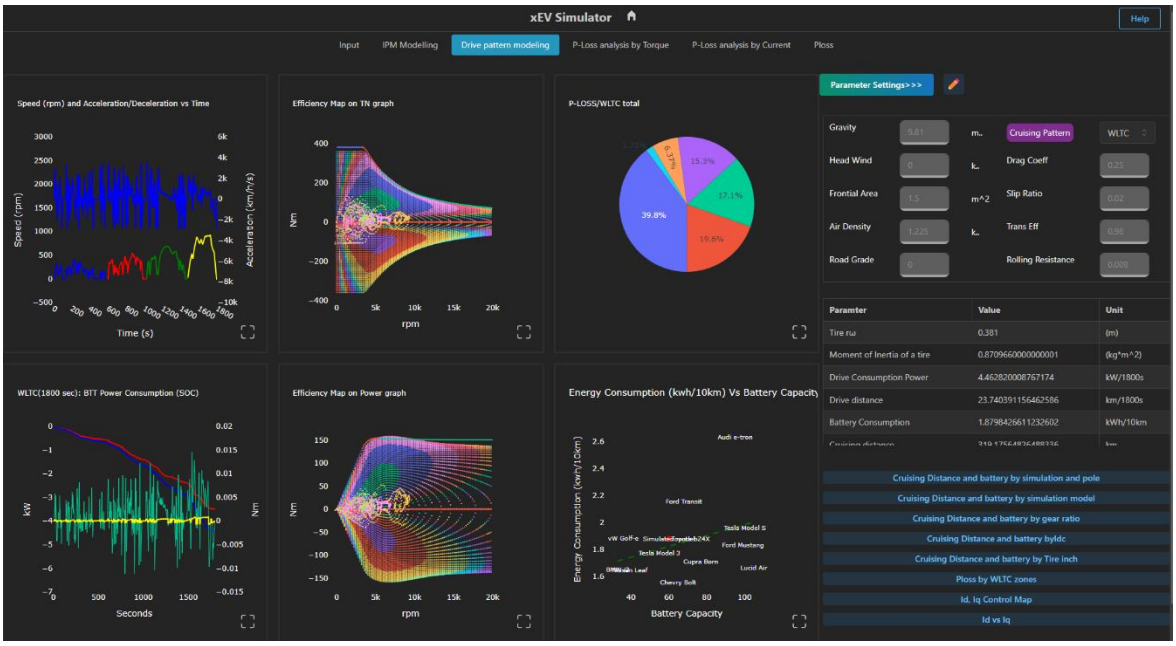


IGBT

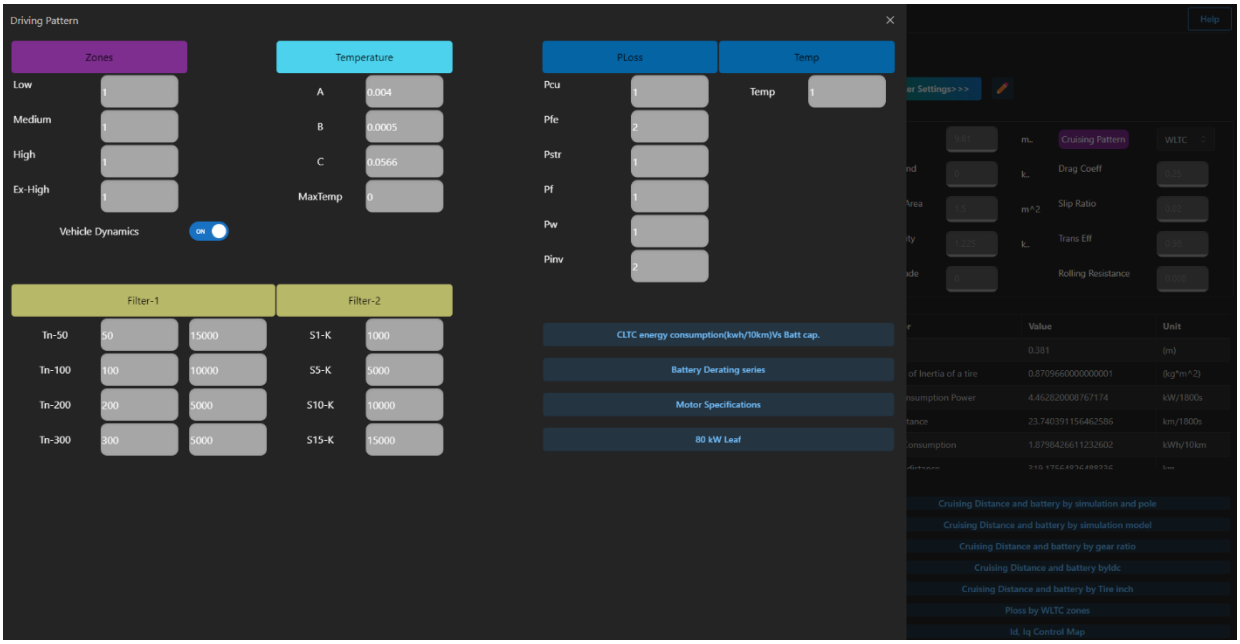
IGBT/FRD Modeling				800A (150°C)
Inverter	DC Link	350	V	350
	Irms(A)	480	P-P(A)	679
	SW Frequency		Hz	6500
	Modulation			0.8
	Power Factor(PF)			0.9
IGBT/FWD	Therma R	Rth(IGBT)	k/W	0.136
		Rth(Diode)	k/W	0.208
		Rth(IGBT-Diode)	k/W	0.041
IGBT	Vce(sat)	A1(rc)	V/A	0.0012
		A0(Vce0)	V	0.8965
	Eon=C3*I^3+C2*I^2+C1*I+C0		C3	3e-8
			C2	-0.00002
			C1	0.058
			C0	1.365
			On-Loss at IpmJ	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
			Off-Loss at IpmJ	43.36073
	Vf=B1*I+B0	B1(rf)	V/A	0.0015
		B0(Vfo)	V	0.84
			E3	-2.9e-8

3.4 Drive Pattern Modelling Tab:

The drive pattern tab simulates the vehicle dynamics by using the standard drive cycles namely WLTC (Worldwide 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.



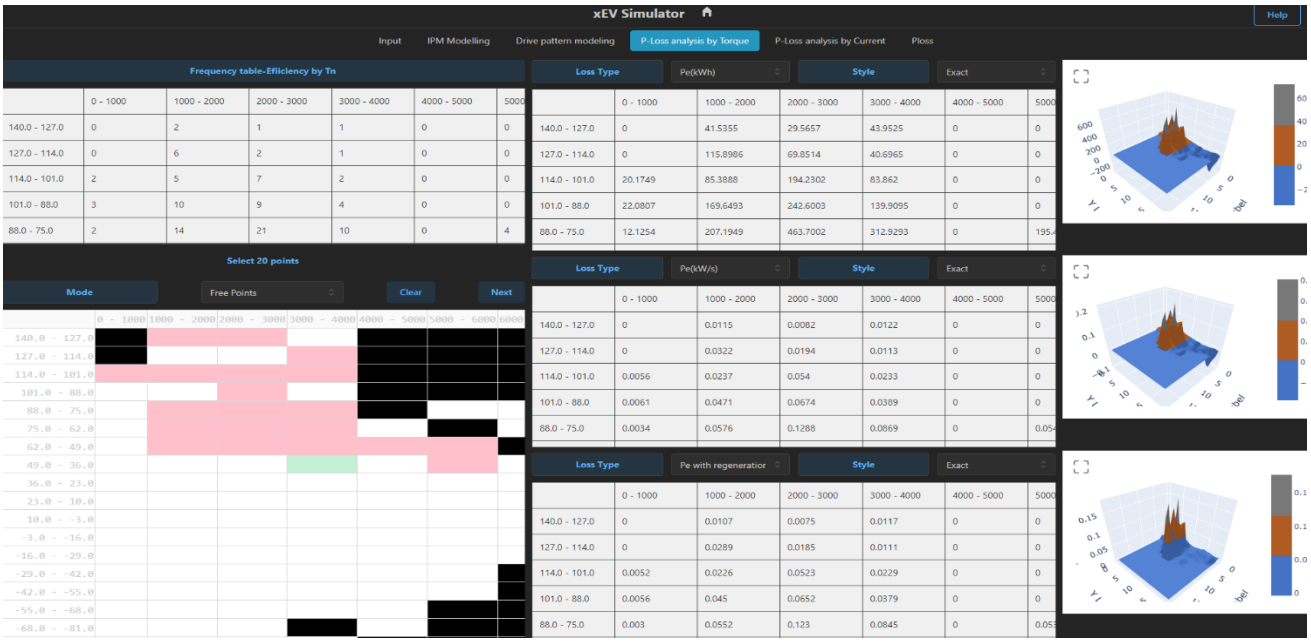
3.4.1 Parameter Settings:



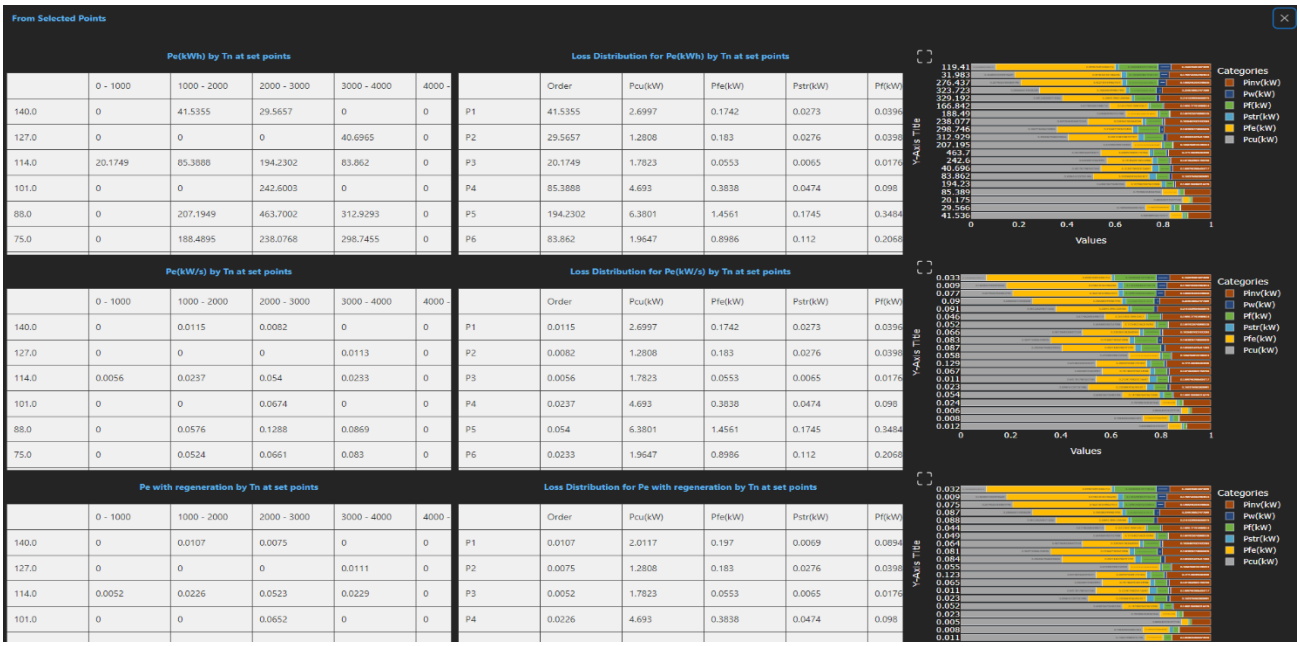
3.5 Ploss Analysis by Torque:

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.



3.5.1 Ploss Analysis by Torque Next:



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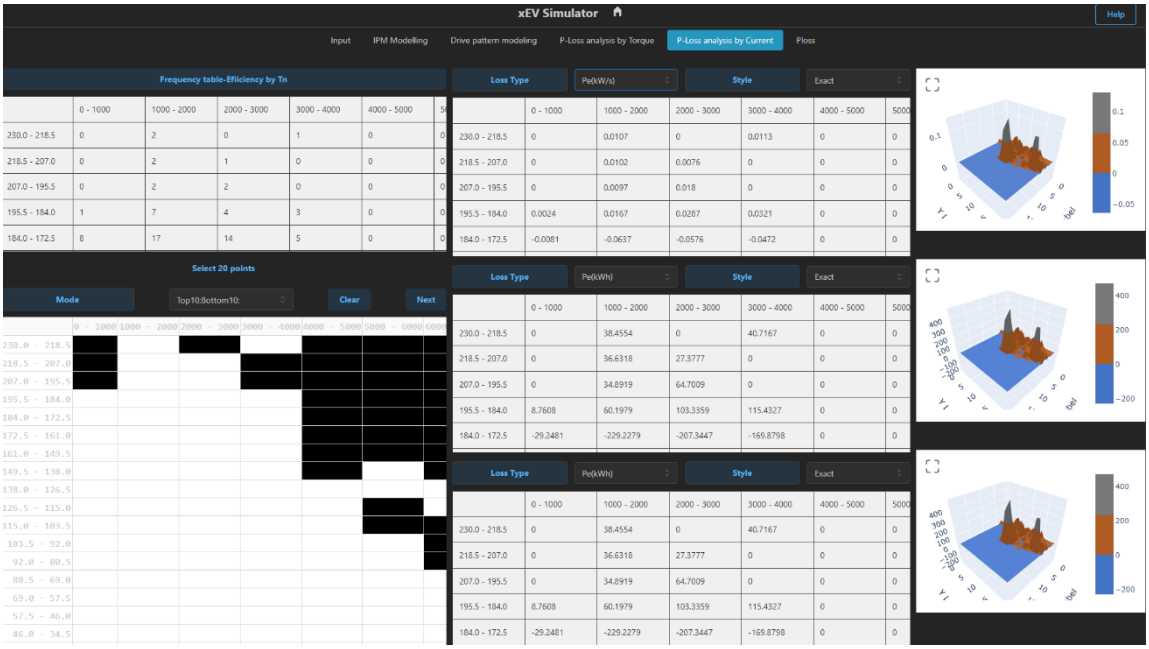
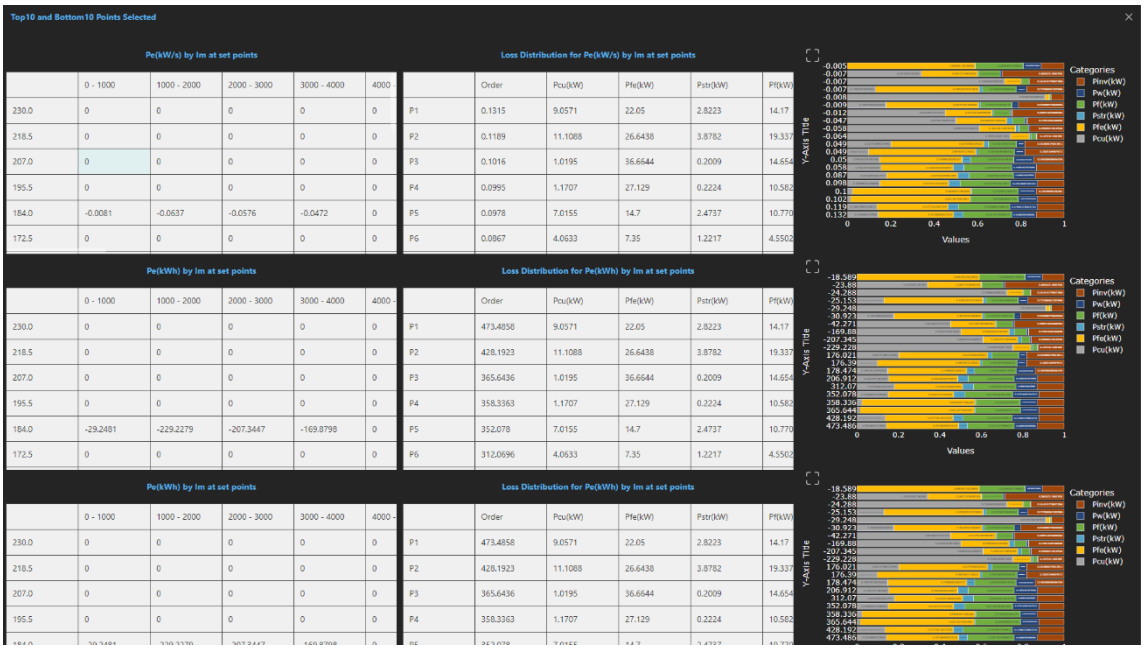
3.6 Ploss Analysis by Current:

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.



3.6.1 Ploss Analysis by Current Next:



3.7 Ploss Tab

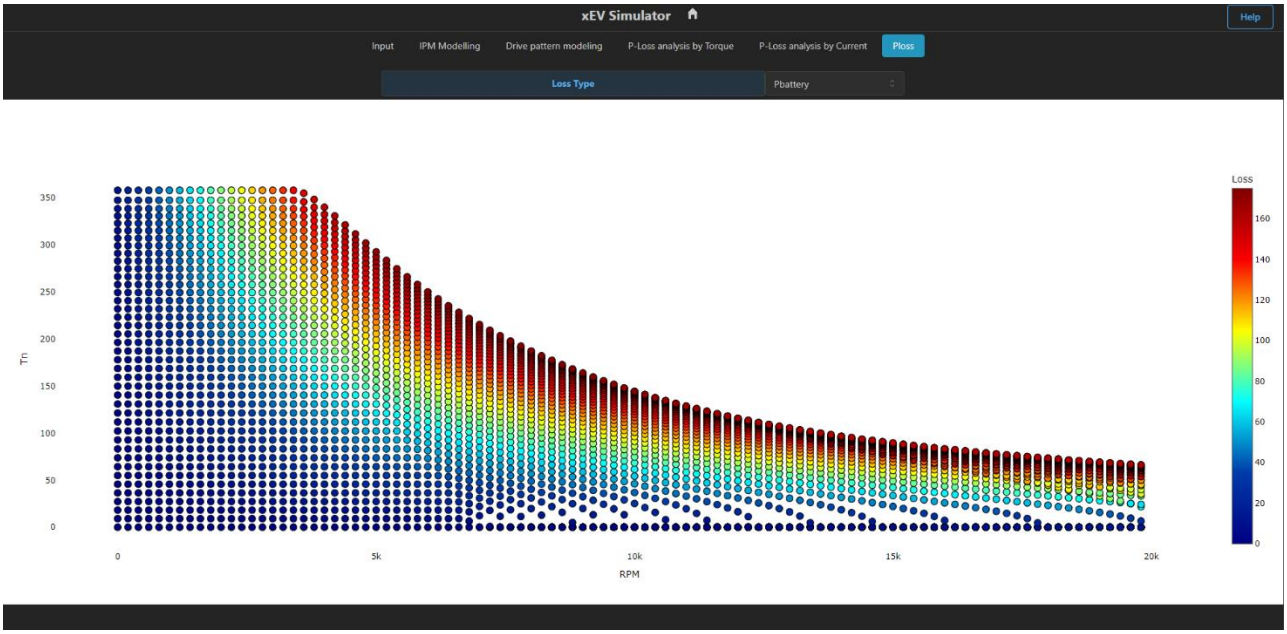
This tab consists of several graphs which could be used for comparative analysis.

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.



4. Detailed Functionality

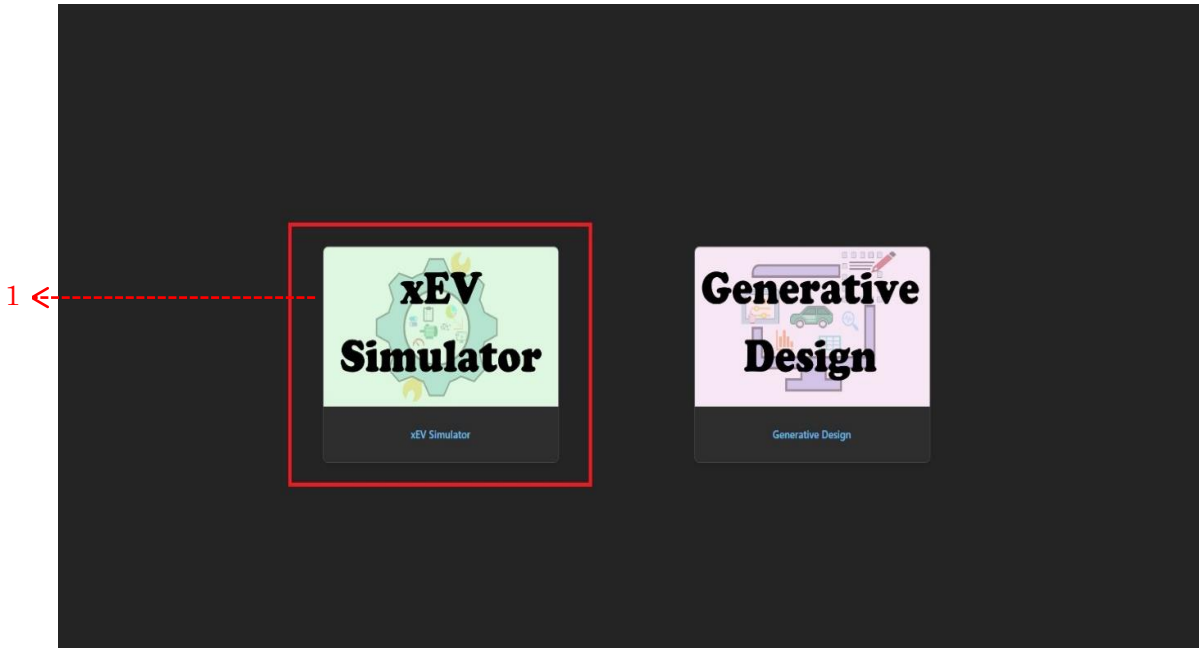


Figure 1 : Home Page

In Figure 1:

1 - xEV Simulator Button

Click button 1 to proceed with xEV simulator Application

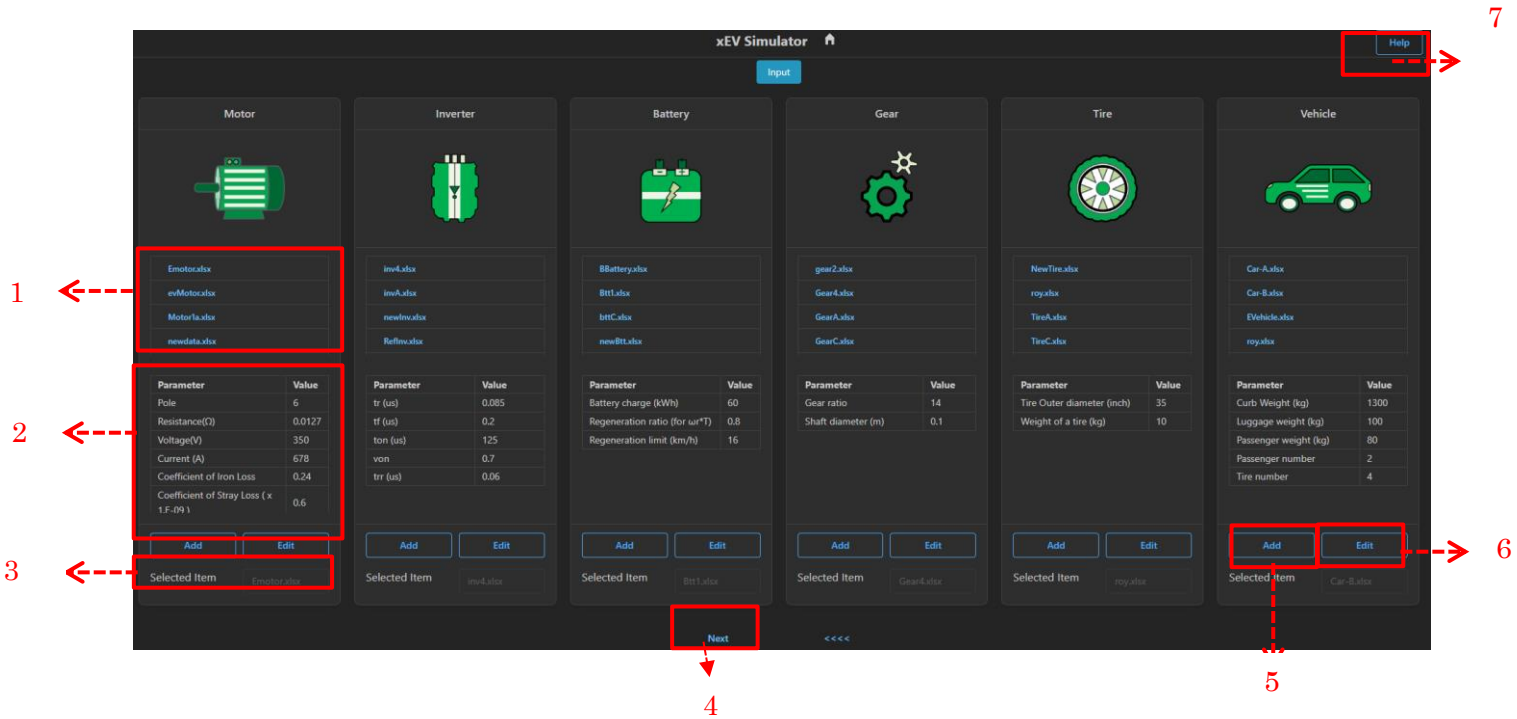


Figure 2 : Input Tab

In Figure 2 :

1- File list

2- Selected File content

3- Selected file name

4- Edit button

5- Next Button

6- Add button

7- Help button

Click on button 1 to select the input file for all parameters. Button 2 allows viewing the selected file contents, and button 3 displays the selected file name. Click on button 6 to edit the file contents. Button 5 adds a new file. After selecting files for each parameter, click on button 6 to display all the tabs for the selected parameters. Click on button 7 to view User Manual.

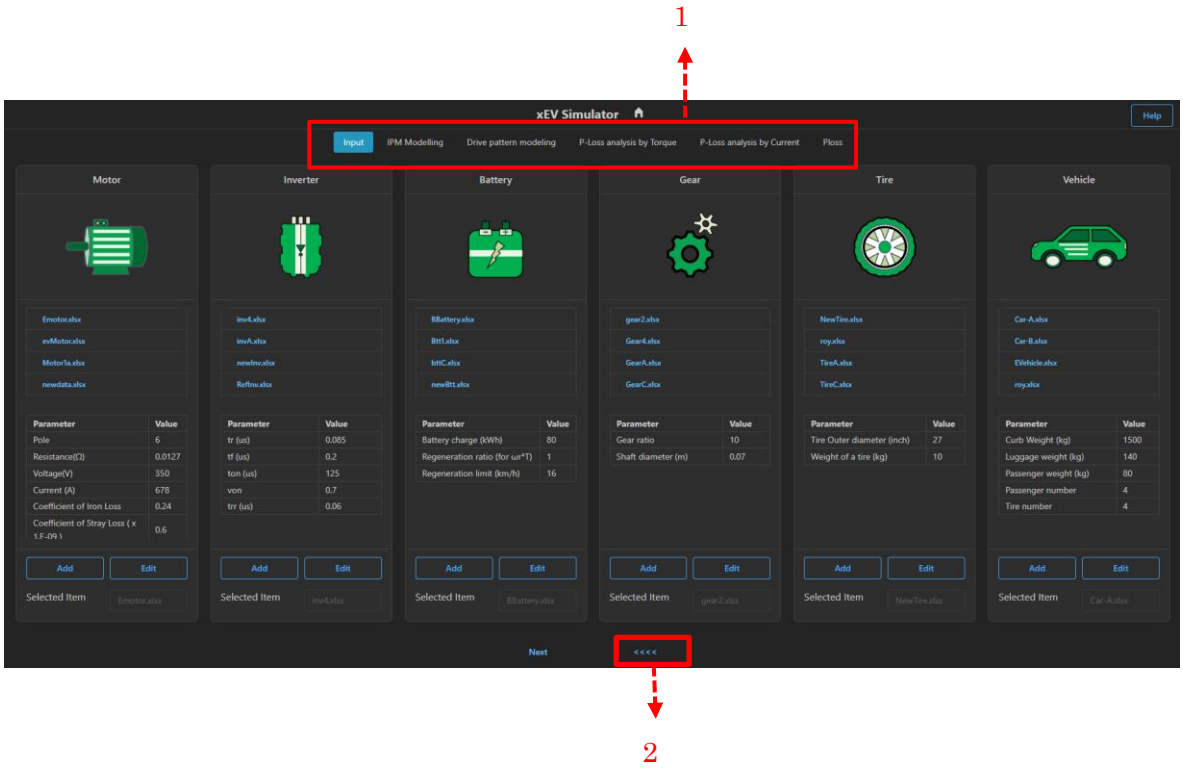


Figure 3 : Input Tab

In Figure 3

1 - Tab navigation

2 - Digital Twin button

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

Figure 4 : Digital Twin

In Figure 4

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.

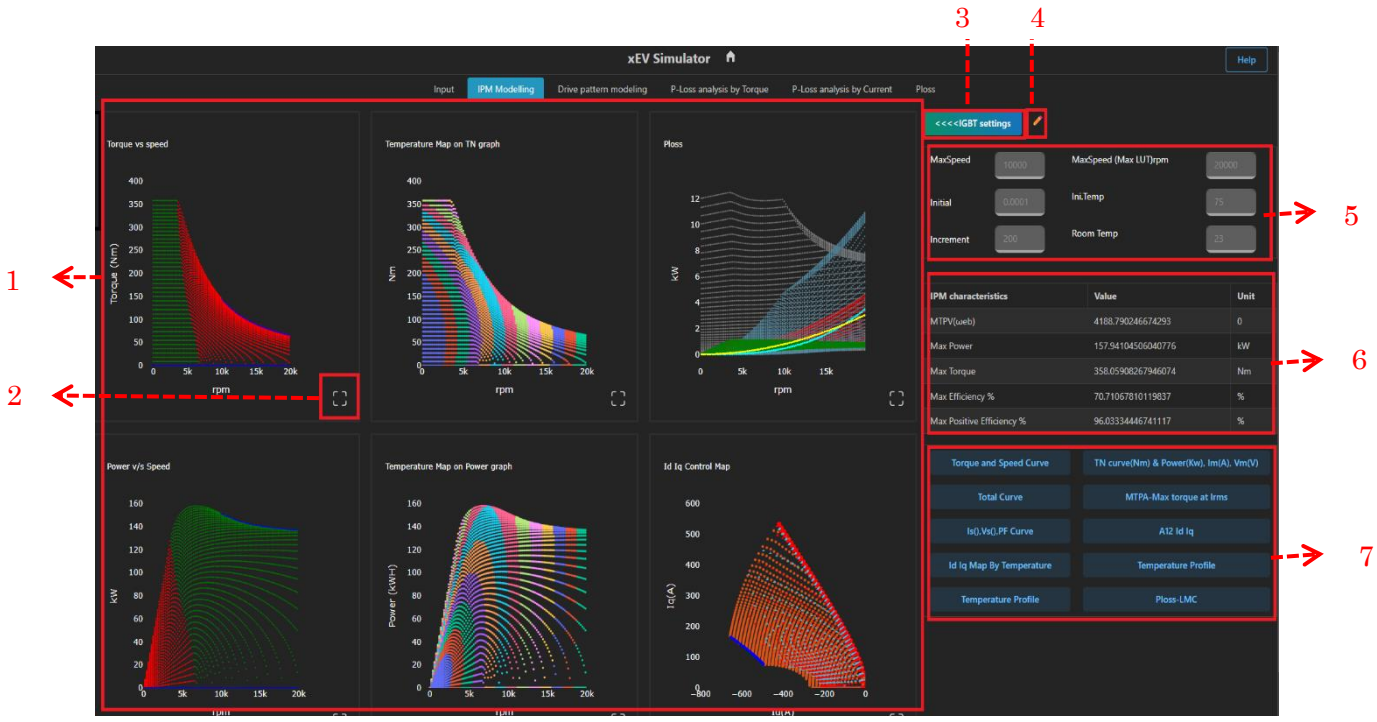


Figure 5: IPM Modelling Tab

In Figure 5 :

1 – IPM Modelling graphs

2 - Enlarge button

3 - IGBT settings button

4 - Edit/Confirm button

5 - Input Parameters

6 - Output Parameters

7 - Secondary graphs

Section 1 displays all the primary IPM modeling graphs. Clicking button 2 enlarges individual graphs. Button 3 opens the IGBT settings, and button 4 allows editing of input parameters shown in section 5. The resulting output parameters are displayed in section 6. Buttons in section 7 can be selected to display various secondary graphs individually.

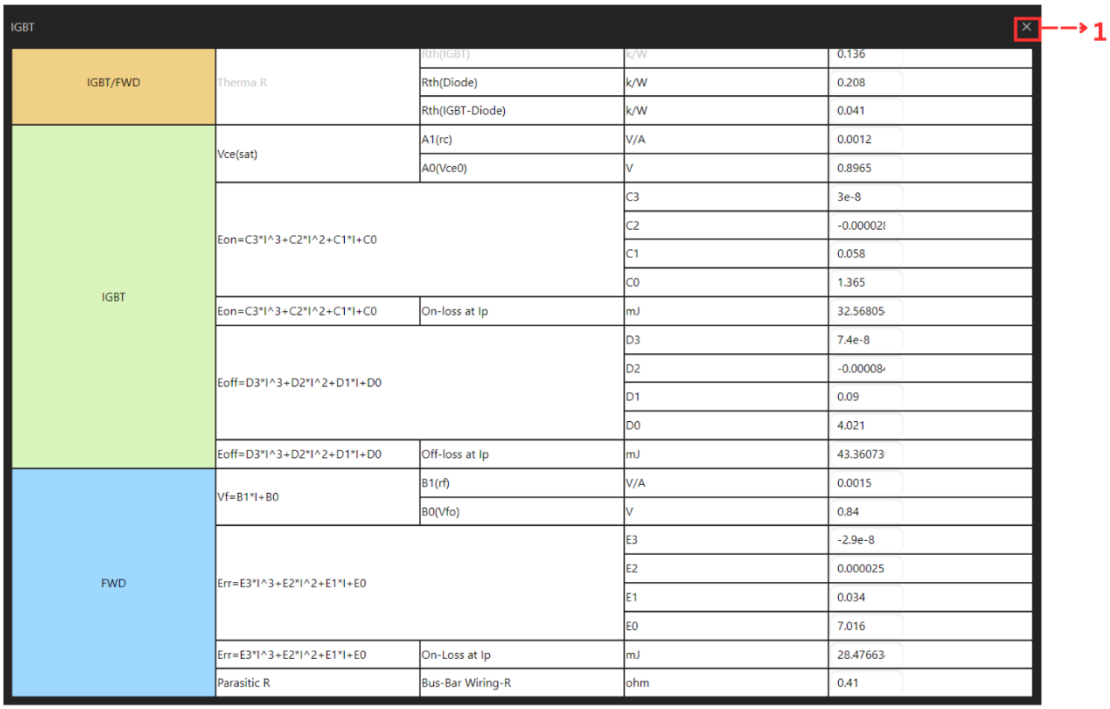


Figure 6 : IGBT Parameters

In Figure 6:

1 - Close button

Select 1 to close IGFBT settings frame.

Figure 7 : Drive Pattern Modelling Tab

In Figure 7:

1 - Drive Pattern graphs

2 - Enlarge button

3 - Cruising Pattern dropdown

4 – Input Parameters

5 - Parameter Setting button

6 - Edit/Confirm button

7 - Output Parameters

8 – Secondary graphs

In section 1, the primary Drive Pattern graphs are displayed. By clicking on button 2, you can enlarge individual graphs. Dropdown menu 3 allows the selection of different drive patterns, changing the graphs accordingly. Button 5 opens the parameter settings, and button 6 enables the editing of input parameters shown in section 4. The resulting output parameters are displayed in section 7, and the graph buttons in section 8 provide options for displaying specific resulting graphs.

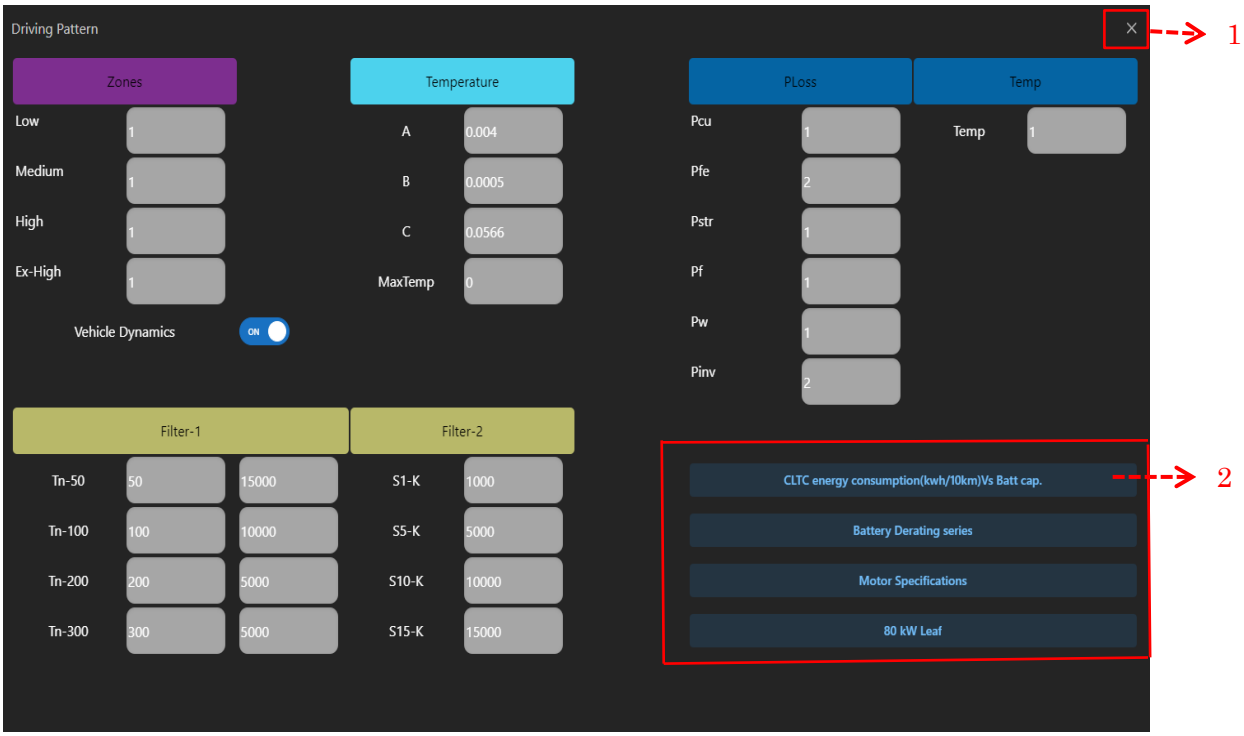


Figure 8 : Parameter Setting

In Figure 8:

1 - Close button

2 – Secondary graphs

Graph buttons in section 2 provide options for displaying specific resulting graphs. Select 1 to close Parameter Setting frame.

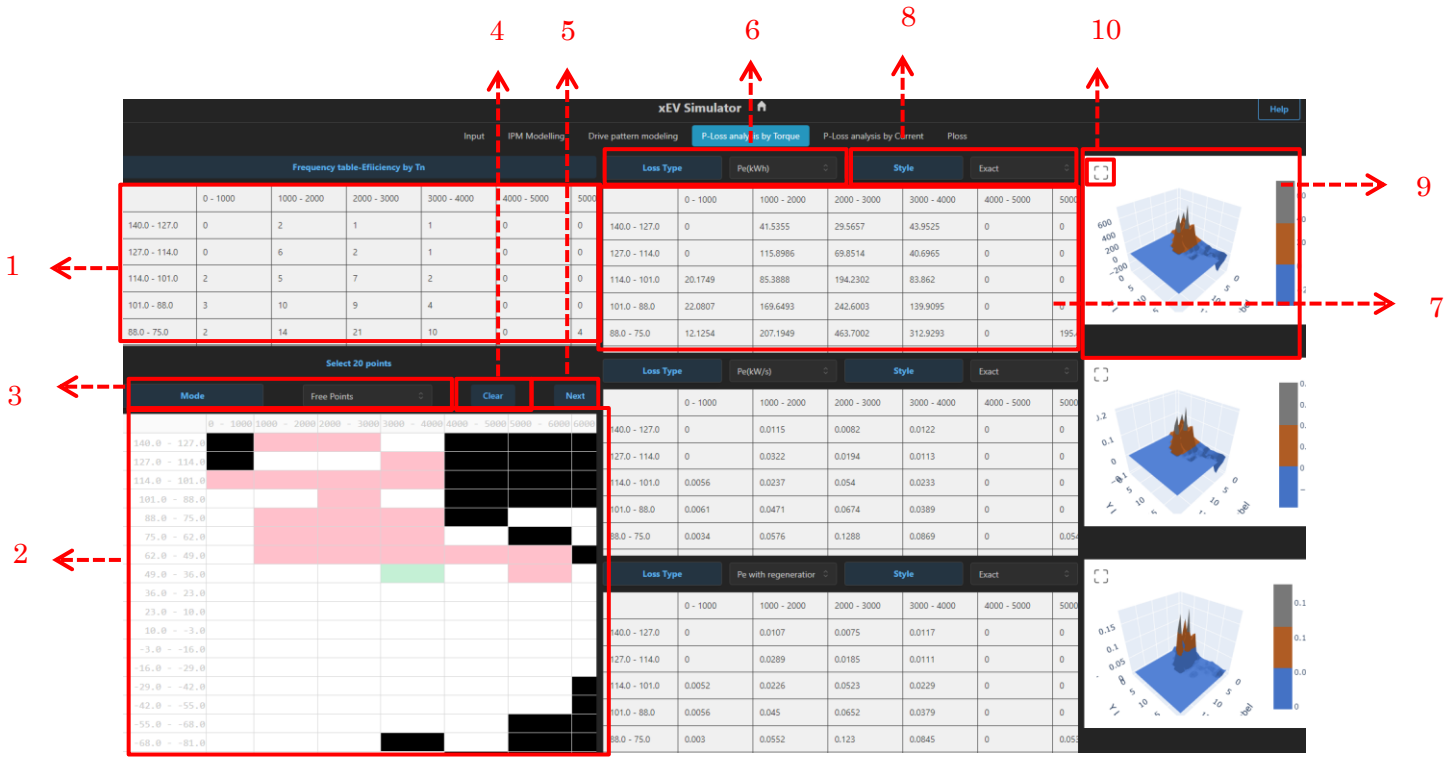


Figure 2 ： Ploss Analysis by Torque Tab

In Figure 12:

1 - Tn Frequency table

2 - Tn Free points table

3 - Mode dropdown

4 – Clear button

5 - Next button

6 - Loss Dropdown

7 - Loss table

8 - Exact/Average drop down

9 - Loss graphs

10 – Enlarge Button

The Tn frequency table is displayed in 1. Select 20 points from the table in 2 when the Mode dropdown (3) is set to "Free Points," or choose "Top10: Bottom10" from dropdown 2. Use the Loss Type dropdown (6) to view all available loss options after selecting three different loss types. The Clear button (4) removes selected points, while the Next button (5) moves to the next output tab. Use dropdown 8 to toggle the Loss Table (7) between "Exact" and "Average" values. The results are shown in the graphs (9), and the Enlarge button (10) expands individual graphs.

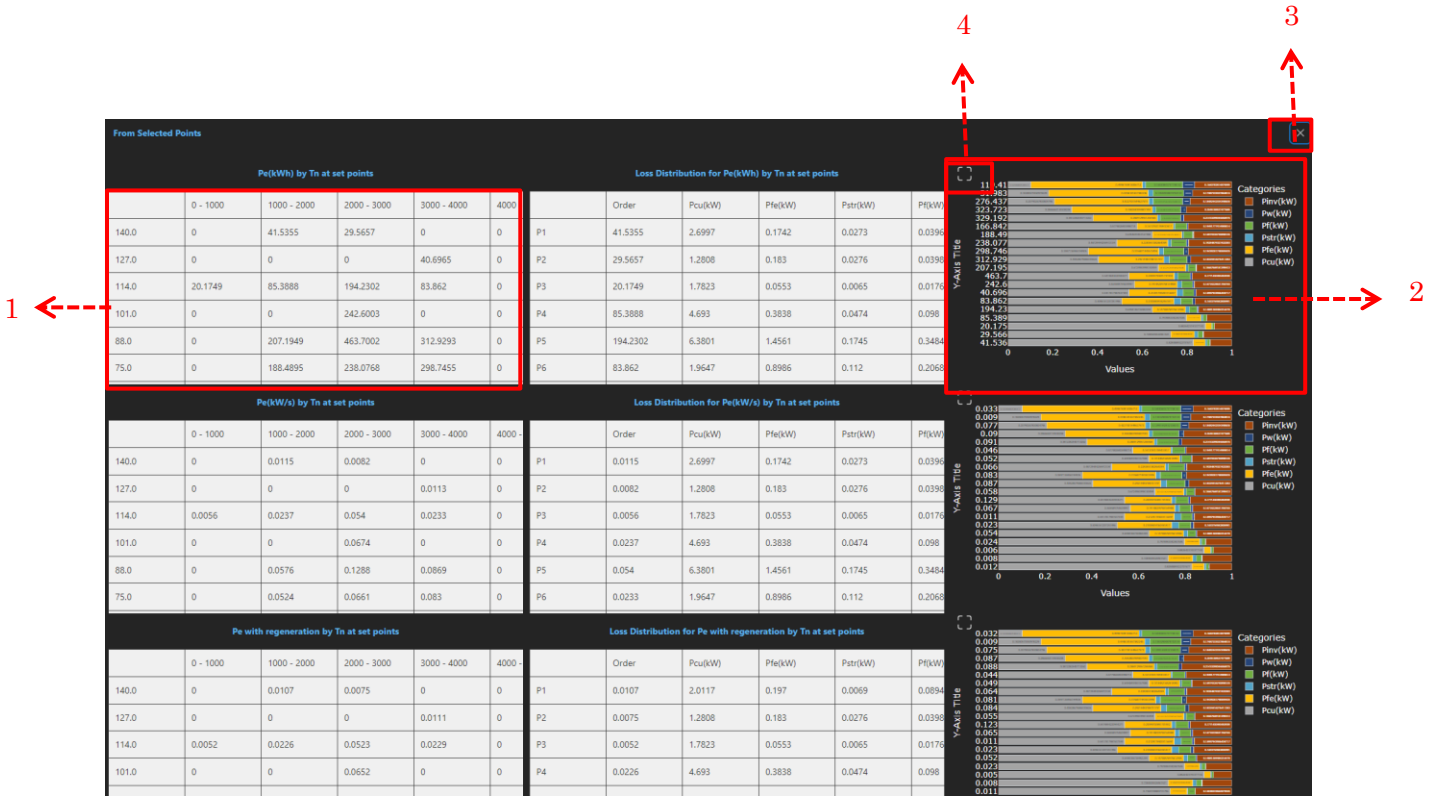


Figure 3 Torque Output

In figure 11:

1 - Output Table

2 - Output Graphs

3 - Close Button

4 - Enlarge Button

The resultant output values are displayed in the table (1). The corresponding output graphs are shown in section 2. Click on the Close button (3) to close the frame. Use the Enlarge button (4) to expand individual graphs.

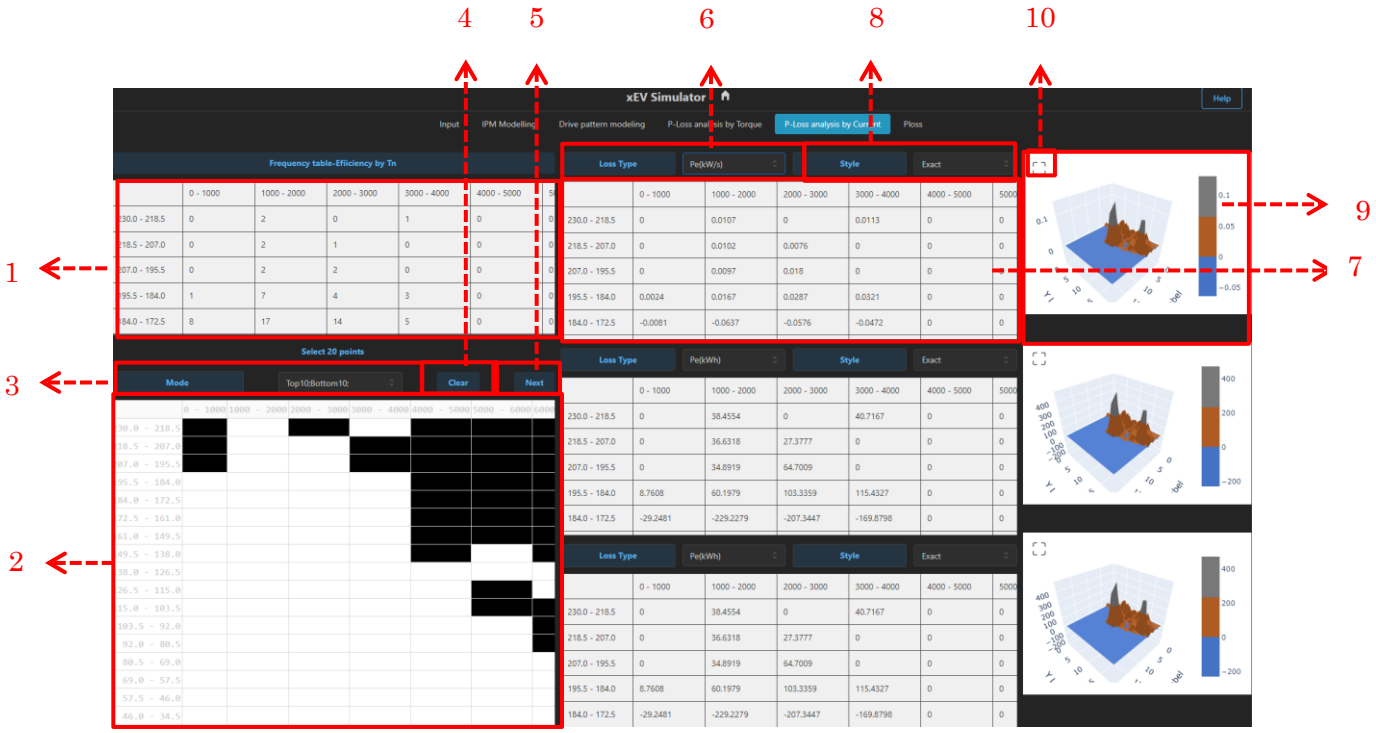


Figure 4 Ploss Analysis by Current Tab

In Figure 12:

1 - Im Frequency table

2 - Im Free points table

3 - Mode dropdown

4 – Clear button

5 - Next button

6 - Loss Dropdown

7 - Loss table

8 - Exact/Average drop down

9 - Loss graphs

10 – Enlarge Button

The Im frequency table is displayed in 1. Select 20 points from the table in 2 when the Mode dropdown (3) is set to "Free Points," or choose "Top10: Bottom10" from dropdown 2. Use the Loss Type dropdown (6) to view all available loss options after selecting three different loss types. The Clear button (4) removes selected points, while the Next button (5) moves to the next output tab. Use dropdown 8 to toggle the Loss Table (7) between "Exact" and "Average" values. The results are shown in the graphs (9), and the Enlarge button (10) expands individual graphs.

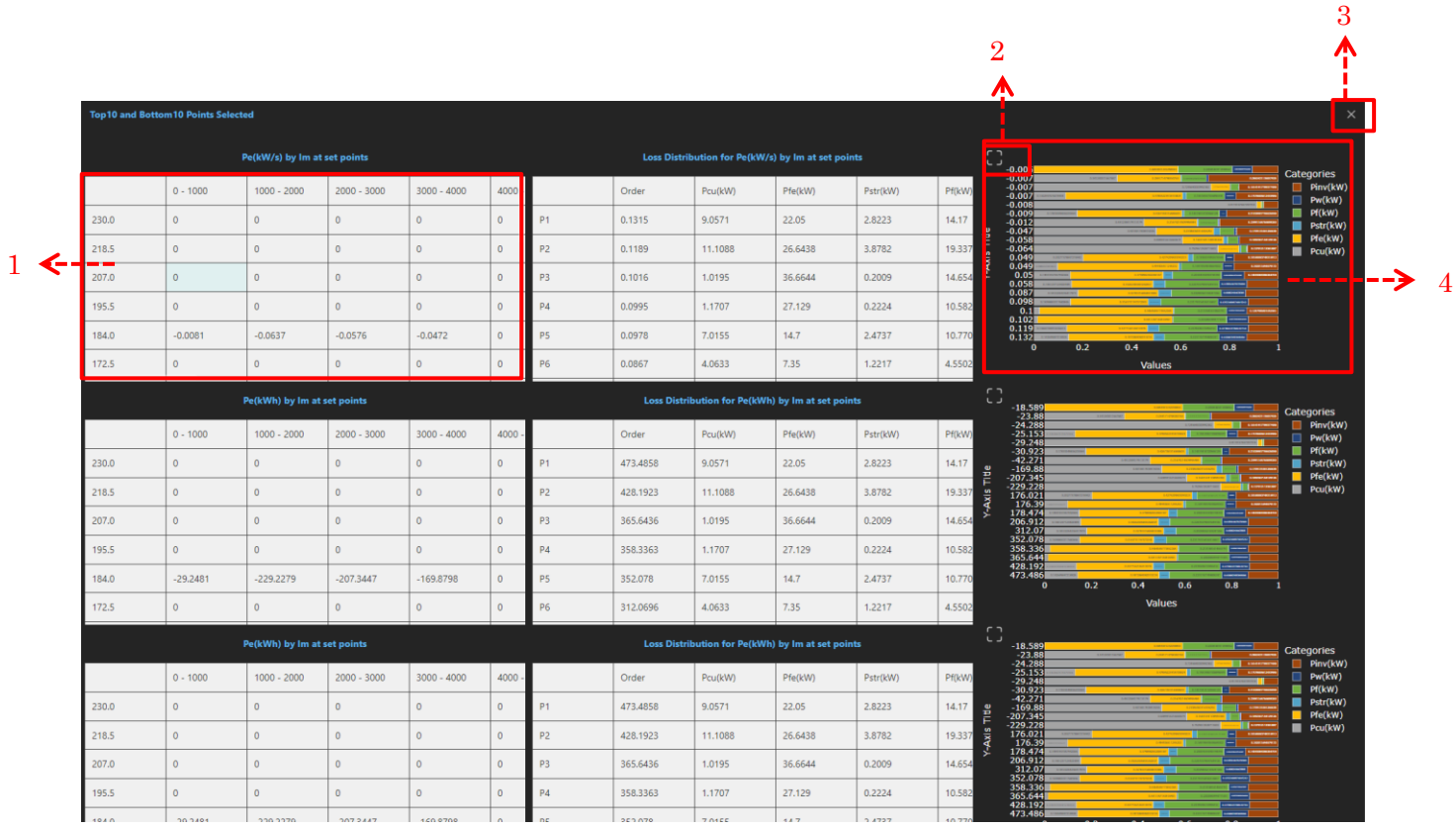


Figure 5 : Current Output

1 - Output Table
2 - Enlarge Button
3 - Close Button
4 - Output Graphs

The resultant output values are displayed in the table (1). The corresponding output graphs are shown in section 4. Click on the Close button (3) to close the frame. Use the Enlarge button (2) to expand individual graphs.

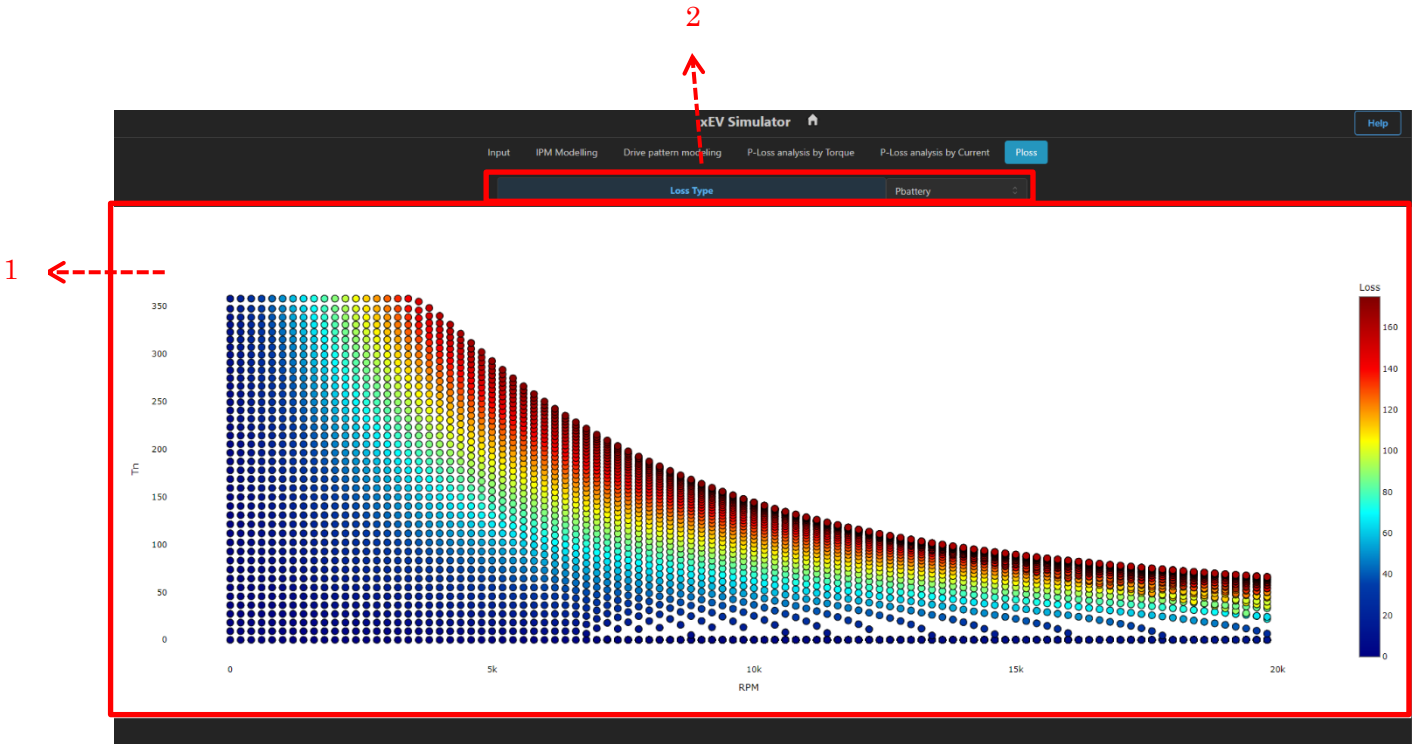


Figure 6 : Data Tab

In Figure 14

1 – Ploss graphs

2 – LossType Dropdown

Select an option from the Loss Type dropdown (2) to display the corresponding Ploss graph in area 1, based on the selected loss type.

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