Simulation of Electric Vehicle with DC Fast Charging for V2G and G2V Operation

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Abstract:- This Paper Describes Detailed Overview Of The Model Definition, Components, and capabilities of The Electric Vehicle Model in the Microgrid Library Using Real-time HIL Topology Which Provides flexibility of DC Fast Charging When Connected to Grid. Electric Vehicle Work Efficiency in V2G and G2V operation. And the Minimum Power Quality impact in the connection to grid.

Keywords:- *Electric Vehicle Model, DC Fast Charging,HILTopology,V2G Operation,G2V Operation.*

I. INTRODUCTION

Electric Vehicles (EVs) have gained popularity in recent years as a cleaner and more sustainable mode of transportation. The reduction of carbon dioxide emissions is one of the main reasons why governments around the world are encouraging the adoption of EVs. The Kyoto treaty, signed in 1997, set the target of reducing greenhouse gas emissions, including CO2, and has played an important role in promoting the development of EV technology[1],[2].There are different types of EVs available in the market, including Hybrid Electric Vehicles (HEVs), Plug-in Electric Vehicles (PEVs), Fuel Cell Electric Vehicles (FCEVs), and more. HEVs use both electric motors and combustion engines, while PEVs can be further divided into Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs)[3]. FCEVs, on the other hand, use fuel cells to generate electricity.

EV chargers are an essential component of EV infrastructure. They allow drivers to recharge their vehicles' batteries when they are low on charge. Depending on their power flow characteristics, EV chargers can be unidirectional or bidirectional. Unidirectional chargers only allow Grid to Vehicle (G2V) operation, meaning that they only supply power from the grid to the vehicle. Bidirectional chargers, on the other hand, allow both G2V and Vehicle to grid (V2G) operation, meaning that they can also supply power from the vehicle back to the grid. Now-a-days Vehicle to Vehicle (V2V) energy sharing is emerging as an alternate source for charging infrastructure[4].so this project discusses about the modelling and simulation of Electric Vehicle with DC Fast Charging (less than 30min) forV2G, G2V and V2V operation and minimum power quality impact in the connection to the grid[5],[6].

This model consists of an EV with a 270kW induction motor and a 250 Ah Li-ion battery. The battery charger is implemented using the battery inverter component from the microgrid library, which supports different modes of operation including grid-forming and grid-following modes for vehicle-to-grid, grid-to-vehicle, and uninterruptible power supply (UPS) operation this model represents a comprehensive simulation of an EV with a battery charger and power train control module that support various modes of operation, including vehicle-to-grid, grid-to-vehicle, and uninterruptible power supply.

II. METHODOLOGY AND COMPONENTS DESCRIPTION

Adopting a research methodology that combines the theory model with empirical evaluation and refinement of the proposed system on HIL simulation tool.HIL simulation is a high-level development environment that allows for the integration of mathematical models, numerical computations, data analysis, optimization methods, and testing in a real-time environment. This is because Typhoon HIL consists of various tool boxes. This makes it a powerful tool for developing and testing complex systems, such as electric vehicles and their components, in a controlled and efficient manner. build custom models easier. Moreover, the visualization and debugging features of HIL are simple[7]. then prepare a new modified block diagram based on the requirement of an electric Vehicle with DC Fast Charging and start modelling and simulation that block diagram by including power electronics devices and achieve the requirement of an Electric Vehicle with DC Fast charging for V2G, G2V and V2V operation. And that would use Typhoon HIL simulation software to model and simulate the model.

After modelling and simulating the EV model, then test that EV model with real time virtual environment in HIL software and then know how this model works in real time environment.

Fig. 1: Electric Vehicle with charging station

Grid and Residential load consists of The three-Phase grid con 240V/60 Hz voltage source and an RL-section impedance.the grid is connected to the Rest of the circuit by the Contactor S1 as we can see in Fig2.Next to the contractor is a 20KVA load,which represents a household load that can draw power either from the grid or from the vehicle battery.

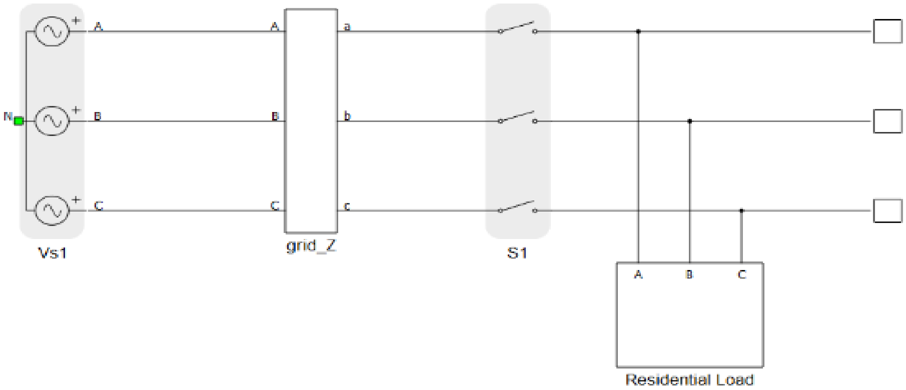

Fig. 2: Grid And residential Load

The 175KVA DC fast charging Station (Fig3) is implemented using "Battery Inverter" component from the microgrid library. In case of a Blackout the inverter can switch to grid -forming mode and supply the residence.

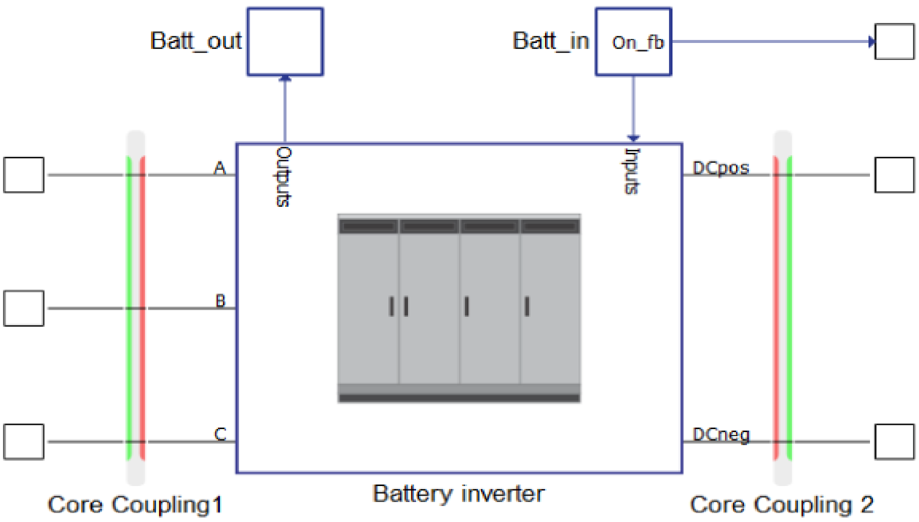

Fig. 3: Charging Station

In the Fig. 1 we can observe that the Electric Vehicle is connected to Grid with thehelp of Charging station and the vehicle if getting charged from the charging station connected to (Grid to Vehicle) and in peak load hours the Electric Vehicle supplies powerto Grid (Vehicle to Grid).

The model Consists of mainly Three subsystem:1.Grid and Residential Load 2.Charging station3.electric vehicle.

Table 1: Battery Inverter Parameters

Parameter	New Values	Default Values
Nominal Voltage	240V	480V
Nominal Power	175kVA	1.6 MVA
Nominal DC Link Voltage	400 V	10kV

The Electric Vehicle Shown in Fig4 Consists of a Converter Which Can Convert AC-DC as well as DC-AC. It a.it consists of a Battery Bank to supply Power to The Motor. The motor is used To drive the transmission mechanism. The Motor is capable of Regenerative braking. The EV subsystem consists of EV model consists induction motor, three phase inverter which is in internal modulated mode, Connection logic this will tell about how to connect charger and when to connect and how to run the motor and when to run the motor, Control Elements Here Field Oriented Control scheme is implemented PWM signals generated by PCM(Powertrain Control module). PCM Is Based on FOC scheme.

Table 2: Electric Motor Parameters

Type	Values
Nominal Voltage	400 V
Maximum power	270 kW
Maximum Frequency	565 Hz
Maximum RPM	16950

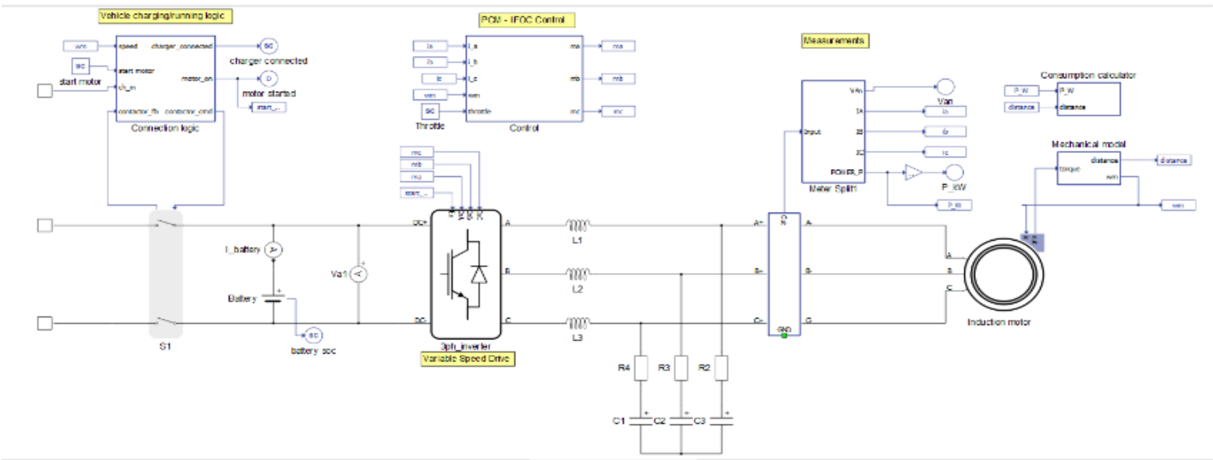

Fig. 4: Electric Vehicle Subsystem

III. RESULTS AND DISCUSSION

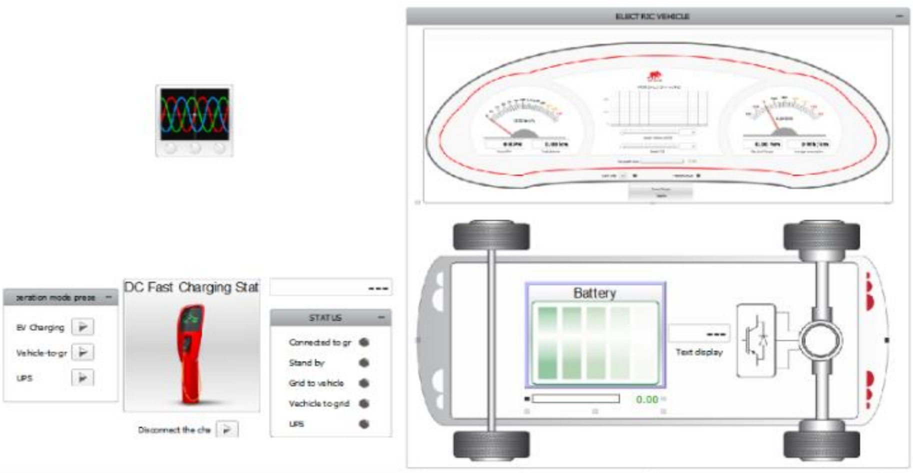

Fig. 5: Simulation of Electric Vehicle

In this Simulation we will be observing the performance of battery, the vehicle and all other blocks in detail.

The simulation results are almost equal to Real time Scenario. In this Simulation we will observe the results of Grid to Vehicle operation, Vehicle to Grid operation and also wewill observe the results when the vehicle is moving.

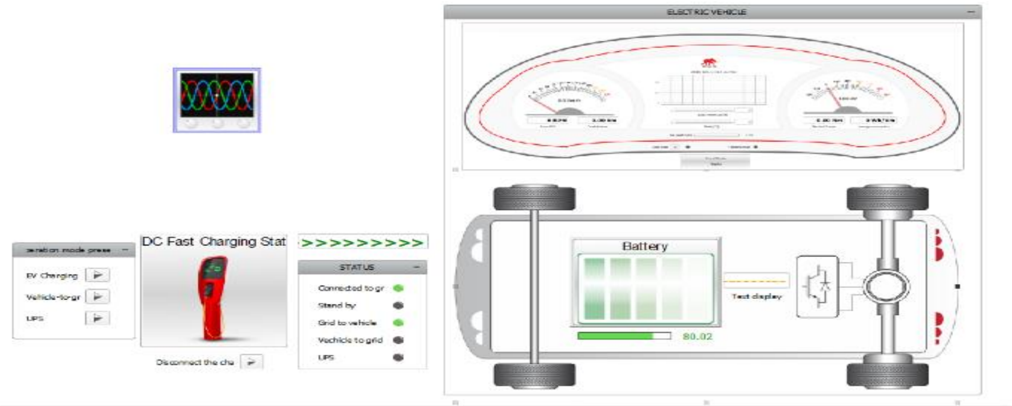

Fig. 6: Grid To Vehicle

From Fig6we can observe the grid to vehicle operation. The Electric Vehicle is getting charged from the Grid and the percentage of Battery charge is being increased.

We can observe the green arrows showing the power flow from Grid to Vehicle along with DC Fast Charging.

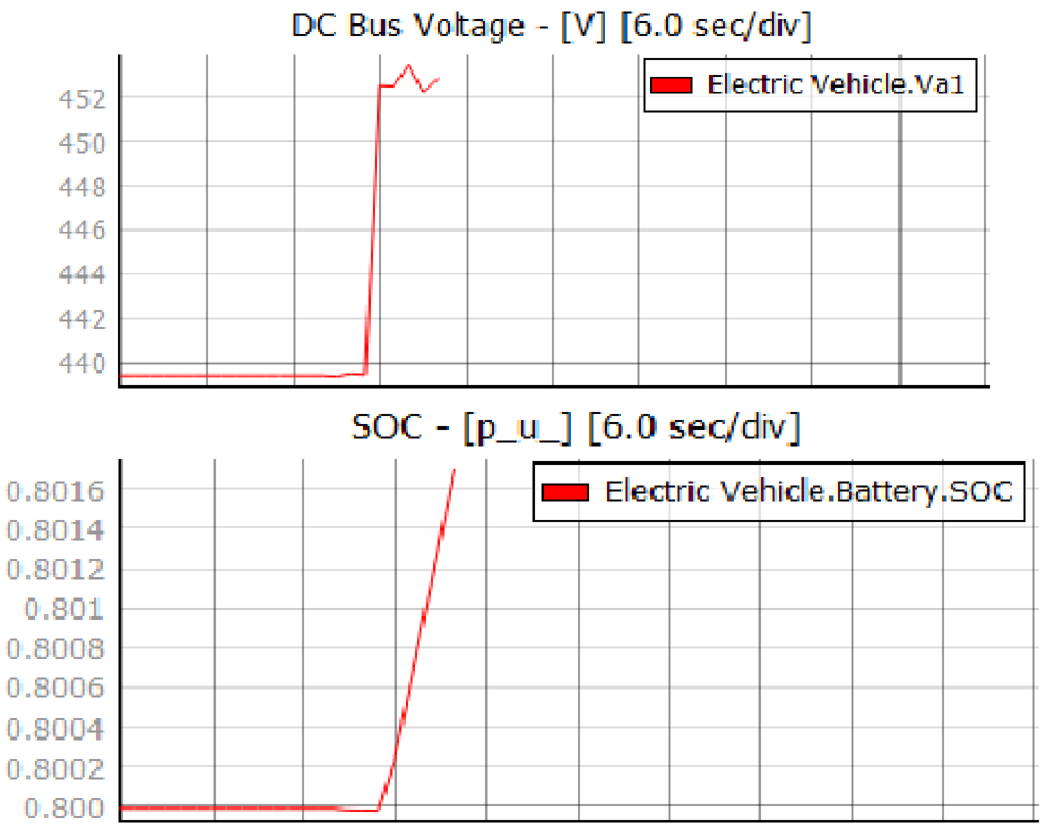

Fig. 7: DC Bus Voltage and SOC

Fig. 7 shows that the State of Charge of the battery is increasing rapidly which states that the charging was DC Fast Charging, and we can also see that the terminal voltage of the battery is also increasing.

From The Fig 8 we can see the values of active power, reactive power, DC line voltage, frequency, battery charge and LEDs showing what mode of operation is going on.

And the graphs showing the instantaneous recording of the values.

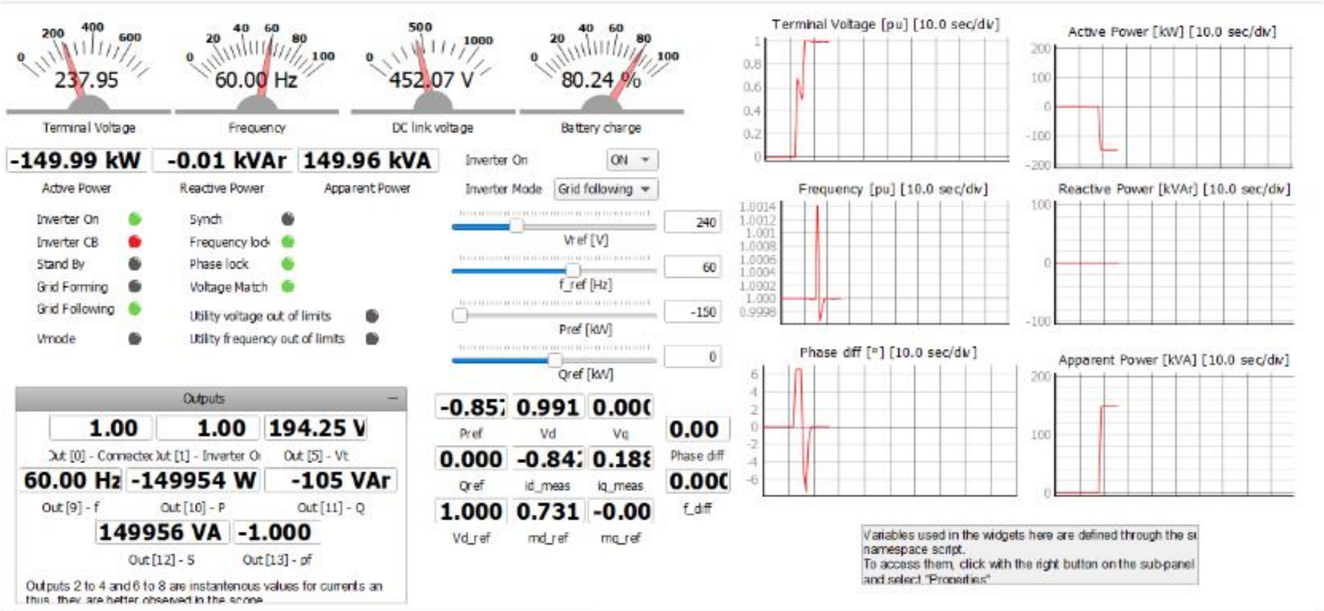

Fig. 8: Grid To vehicle

In the Fig. 9 we can observe the RED arrows showing the flow of power from Vehicle to Grid and Battery SOC has decreased.

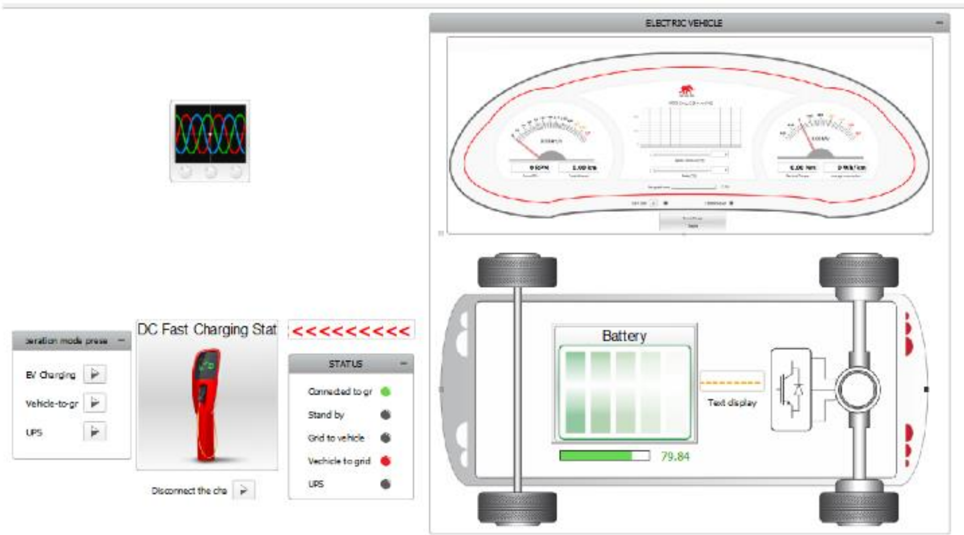

Fig. 9: Vehicle to Grid

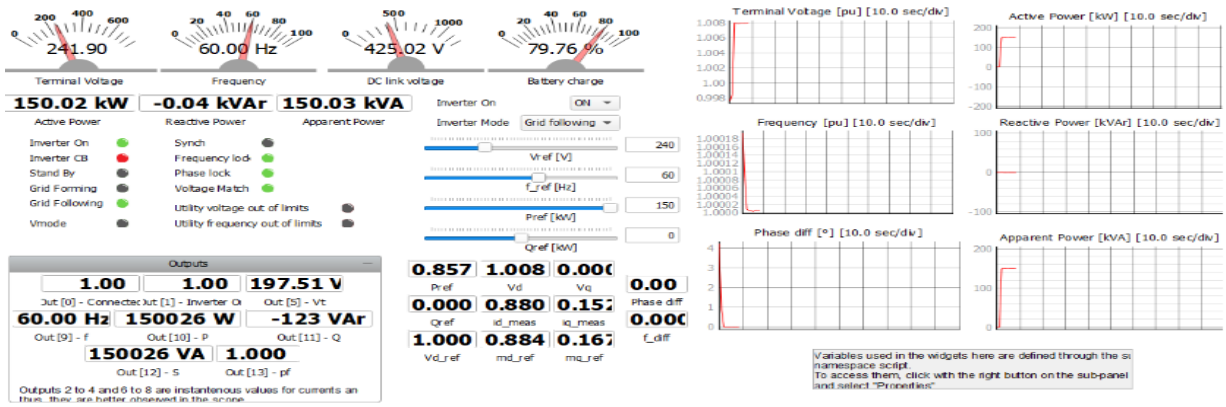

Fig 10: Vehicle To Grid

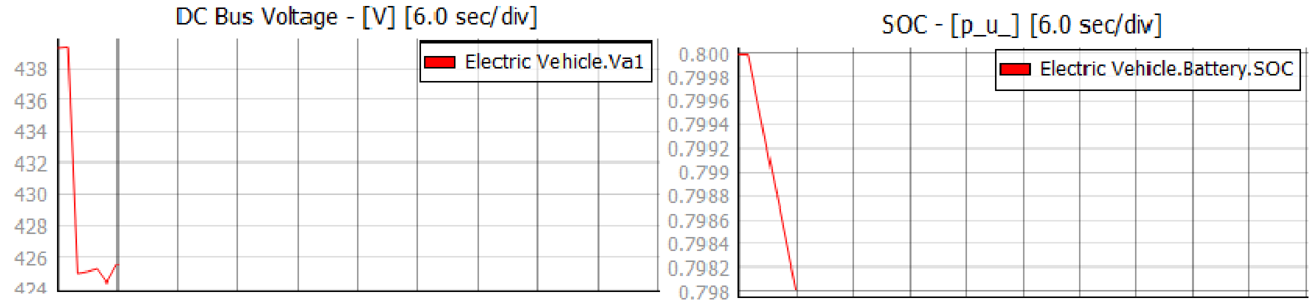

Fig. 11 : DC Bus Voltage and SOC

From Fig 10 As the EV is connected to Grid and is working under V2G operation so the battery gets discharged to supply power back to Grid. The same is observed in the above figure that terminal voltage and SOC of the Battery is decreasing. Basically the V2G operation is very much essential in order to meet the peak load hours of the grid. And by supplying power to grid we are awarded with money for the power that we supply to grid.

From Fig11 we see the different values and how are they affected when power flow if from Vehicle to Grid.

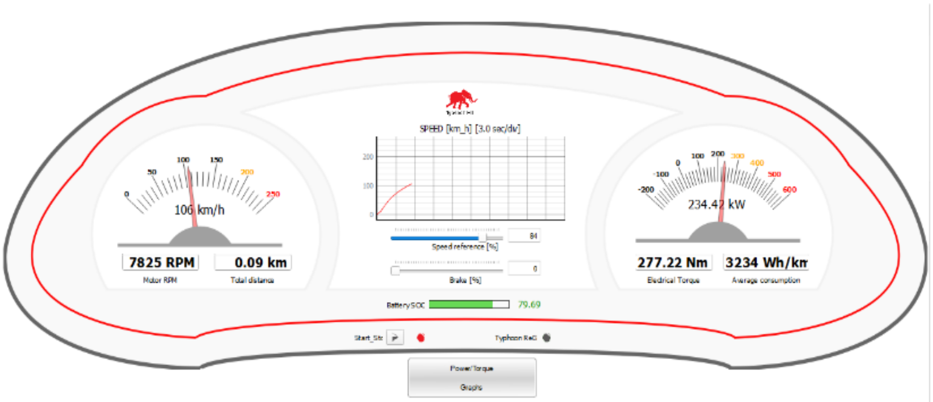

Fig 12: Vehicle In running Condition

From Fig 13 We can observe the Speed and Torque of our Electric Vehicle under running condition.From the Fig 14 Speed graph we can notice that time taken to reach the desired for ourElectric Vehicle is very less and battery charge is being decreased as vehicle moves on andnot only that we can even observe the distance travelled by the vehicle.

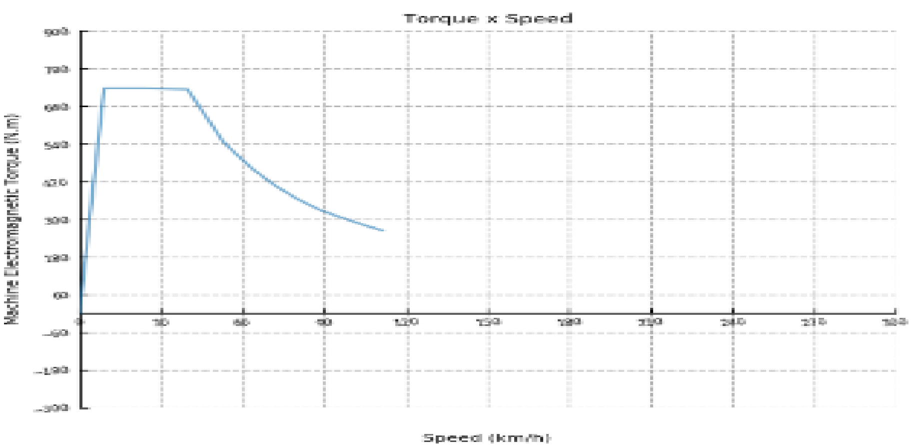

Fig. 13: Torque and Speed

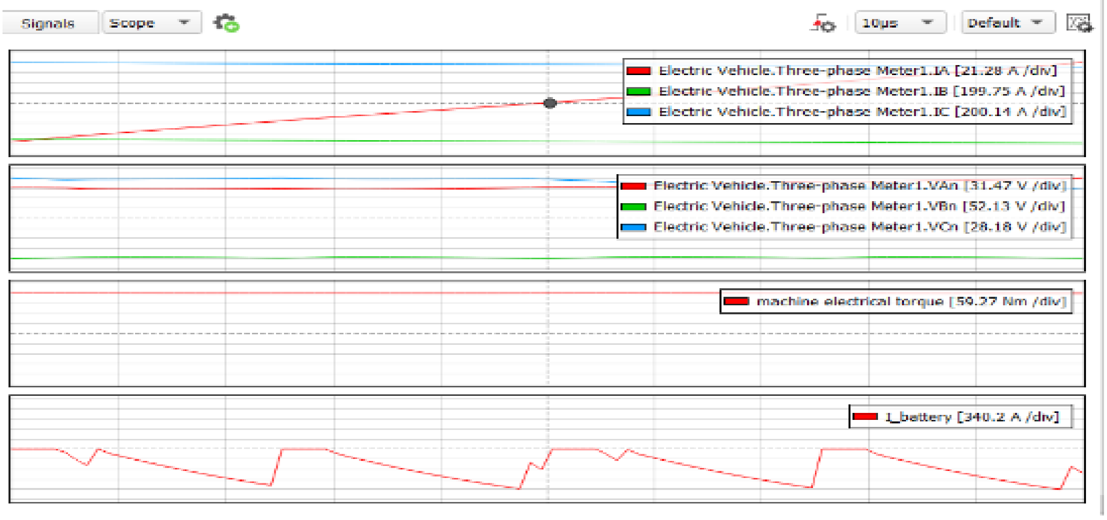

Fig. 14: Instantaneous Values

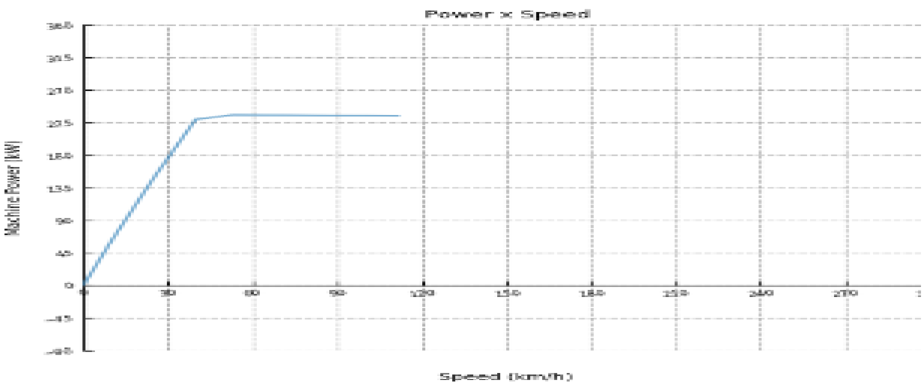

Fig. 15: Power and speed

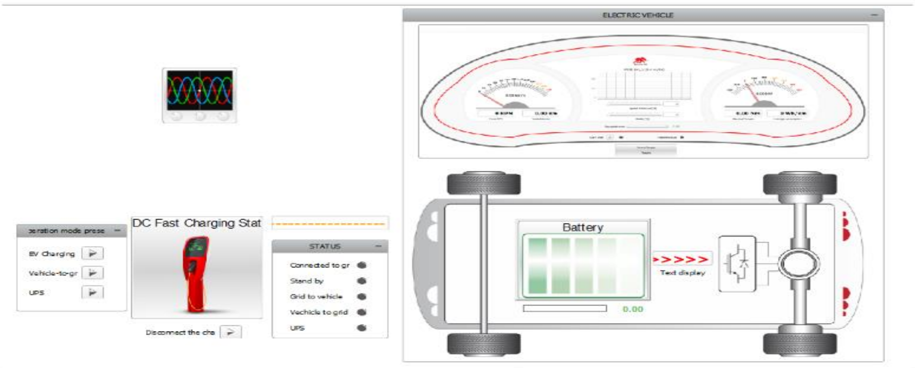

Fig. 16: Vehicle in running condition

In the Fig 14 we can observe that power is flowing from battery to controller to convertinto desired voltage values and then to motor which ensures that the Vehicle is working properly.

From The graph (Fig15) we can observe the instantaneous values of the followingparameters when the Vehicle is in motion.

- Battery current
- Mechanical Torque
- The Current of Three Phases
- The Voltage Of Three Phases

IV. CONCLUSION

We have designed the Electric Vehicle with DC Fast Charging for Vehicle to Grid(V2G) and Grid to Vehicl(G2V) operation. It is observed that the model is working efficiently in both V2G and G2V operation and is alsoworking properly under the running conditions. The EV that we designed is not only getting charged from the grid but it is successfully sending the power back to grid. Not only that the charging station that is designed in this model ensures 150kms+ distance by charging for justhalf an hour. And also the pickup speed of our designed model is high i.e; it is reaching its desired rated speed in very less time and consumes less power. So,finally we can say that our designed Electric Vehicle model works efficiently withDC Fast charging for V2G and G2V operation and also works efficiently under running conditions.

REFERENCES

[1.] V. Nandurkar and V. Virulkar, "Modelling and Simulation of Electric and HybridElectric Vehicles," 2020 IEEE First International Conference on SmartTechnologies for Power, Energy and Control (STPEC), 2020, pp. 1-6, doi:10.1109/STPEC49749.2020.9297696.

[2.] R. G. Gago, S. F. Pinto and J. F. Silva, "G2V and V2G electric vehicle charger forsmart grids," 2016 IEEE International Smart Cities Conference (ISC2), 2016, pp. 1-6, doi: 10.1109/ISC2.2016.7580786.

[3.] S. Bhargavi, U. B. Jyothsna, K. Deepa, V. Sailaja and J. Ramprabhakar, "SmartV2G/G2V Charging for Grid connected-Electric Vehicles in Indian Scenario," 2022International Conference on Electronic Systems and Intelligent Computing(ICESIC), 2022.

[4.] M. Parchomiuk, A. Moradewicz and H. Gawiński, "An Overview of Electric Vehicles Fast Charging Infrastructure," 2019 Progress in Applied ElectricalEngineering (PAEE), 2019, pp. 1-5, doi: 10.1109/PAEE.2019.8788983.

[5.] C. Graf, J. Maas, T. Schulte and J. Weise-Emden, "Real-time HIL-simulation ofpower electronics," 2008 34th Annual Conference of IEEE Industrial Electronics,2008, pp. 2829-2834, doi: 10.1109/IECON.2008.4758407.

[6.] J.Channegowda,V. K. Pathipati and S. S. Williamson, "Comprehensive review and comparison of DC fast charging converter topologies: Improvingelectric vehicleplug-to-wheels efficiency," 2015 IEEE 24th International Symposium on Industrial Electronics(ISIE) 2015,pp. 263-268, doi: 10.1109/ISIE.2015.7281479

[7.] Abdullah T. J. C. Sousa, V. Monteiro, J. C. A. Fernandes, C. Couto, A. A. N. Meléndez and J.L. Afonso, "New Perspectives for Vehicle-to-Vehicle (V2V) Power Transfer, "IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society, 2018, pp. 5183-5188, doi: 10.1109/IECON.2018.8591209.