VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ELECTRICAL ENGINEERING

Wireless Charging Station For Electric Vehicles

Done by

19BEE0046- Akshat Sharma

19BEE0091- B V S K Teja Reddy

20BEI0330 - Sohan Das

For the course

Course Code: EEE4016

Course Name: ELECTRIC VEHICLES

Semester: Win 2021

Abstract

Typically, electric vehicle systems are made up of a number of modules that work together to provide the vehicle's high power and track stability. The charging mechanism is connected to the bulk of these components. In this context, dynamic wireless power transfer is a viable solution for addressing electric car range anxiety while also lowering onboard battery costs. Wireless recharging has long been a feature of pure electric vehicles, and it allows for charging even while the vehicle is moving. However, analysing this method is challenging due to its complicated working philosophy, which includes a number of variables and parameters. In addition, the status of the vehicle, whether it is moving or not, determines various characteristics such as vehicle speed and coil receiver sizes and diameters. This research proposes an innovative way for improving the dynamic wireless recharge system's performance. Receiver coils have been added to the proposed system to maximise charging power by providing a dynamic mathematical model that can characterise and measure source-to-vehicle power transmission while in motion. All physical parameters of the model were presented and addressed in the proposed mathematical model. The results demonstrated that the proposed paradigm is effective.

1. Introduction

With the rapid increase in population the use of IC (Internal Combustion) Engines is also increasing rapidly. As a result, the use of fossil fuels is also increasing day by day causing more environmental pollution and global warming. To prevent environmental hazards, Electric Vehicles (EV) are an effective solution and charging these vehicles can be made convenient by using a wireless charging system. Wireless Charging is basically based on Wireless Power Transfer and is classified into two types, that is Static Wireless Charging (SWC) and Dynamic Wireless Charging (DWC). In the case of the SWC system, when the vehicle is charging, it is expected to be parked in alignment with the transmitter to receive the power from it. But for the DWC system, the vehicle can be charged while in motion and thus the vehicles can travel longer with a small battery. So DWC system development can provide development to the EVs in future.

2. Literature Review

TITLE	JOURNAL NAME AND YEAR	HIGHLIGHTS
REVIEW AND COMPARATIVE ANALYSIS OF TOPOLOGIES AND CONTROL METHODS IN DYNAMIC AND WIRELESS CHARGING OF ELECTRIC VEHICLES	IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS, 2021	● It introduces practical metrics for a system designer to consider developing magnetics and power electronics for a Dynamic Wireless Power Transfer System to ensure good controllability. ● Described how the delay in communication can affect the control performance and impact recommendations for high-speed vehicle charging.
A NEW WIRELESS CHARGING SYSTEM FOR ELECTRIC VEHICLES USING TWO RECEIVER COILS	AIN SHAMS ENGINEERING JOURNAL,2022	● Improved version of Dynamic Wireless Charging System. ● A receiver coil was added to maximize charging power by offering a dynamic mathematical model and measuring the source to vehicle power transmission even if it is in motion.

DESIGN METHODOLOGY, MODELING AND COMPARATIVE STUDY OF WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLES	ARTICLE, ENERGIES 2018,11,1716	● New design methodology and control system for bidirectional 3.7kW and 7.7kW Wireless Power Transfer (WPT) in light-duty Electric Vehicles operating at both 40 kHz and 80 kHz resonance frequencies. ● The series-series (SS) WPT compensation topology is optimally designed and controlled for grid-to-vehicle(G2V) mode using Matlab/Simulink. The magnetic design of the coils and their parameters are verified by using COMSOL.

WIRELESS POWER TRANSFER SYSTEM DESIGN FOR ELECTRIC VEHICLE DYNAMIC CHARGING APPLICATION	INTERNATIONAL JOURNAL FOR POWER ELECTRONICS AND DRIVE SYSTEM,2020	● A wireless power transfer system was designed for electric vehicle dynamic charging applications. ● The dynamic wireless charging lane is designed for modularly. ● The magnetic coupler design is analyzed and optimized by fine element analysis (FEA) to reduce output power variation during dynamic charging.

INTERNET OF THINGS BASED REAL TIME ELECTRIC VEHICLE LOAD FORECASTING AND CHARGING STATION RECOMMENDATION	ISA TRANSACTIONS, VOLUME 97,2020	● Better EV charging system by utilizing the advantages of Internet of Things (IoT) technology. ● A real-time server-based forecasting application, that is to provide scheduling management to avoid wasting time and to provide a real-time CS recommendation for EVs with an economic cost and reduced charging time. ● The synergetic application is built up through the PHP programming language in the Linux UBUNTU 16.04 LTS OS.
Intelligent Wireless Charging Station for Electric Vehicles	2017 International Siberian Conference on Control and Communications (SIBCON)	● A solution to create a perfect alignment between the coils for maximum efficiency. ● Attachment the coil pad to a moving platform which can be adjusted by moving it in vertical and horizontal directions. ● A fingerprint system was also added to ensure the security of the operating console for the movement of charging pads.

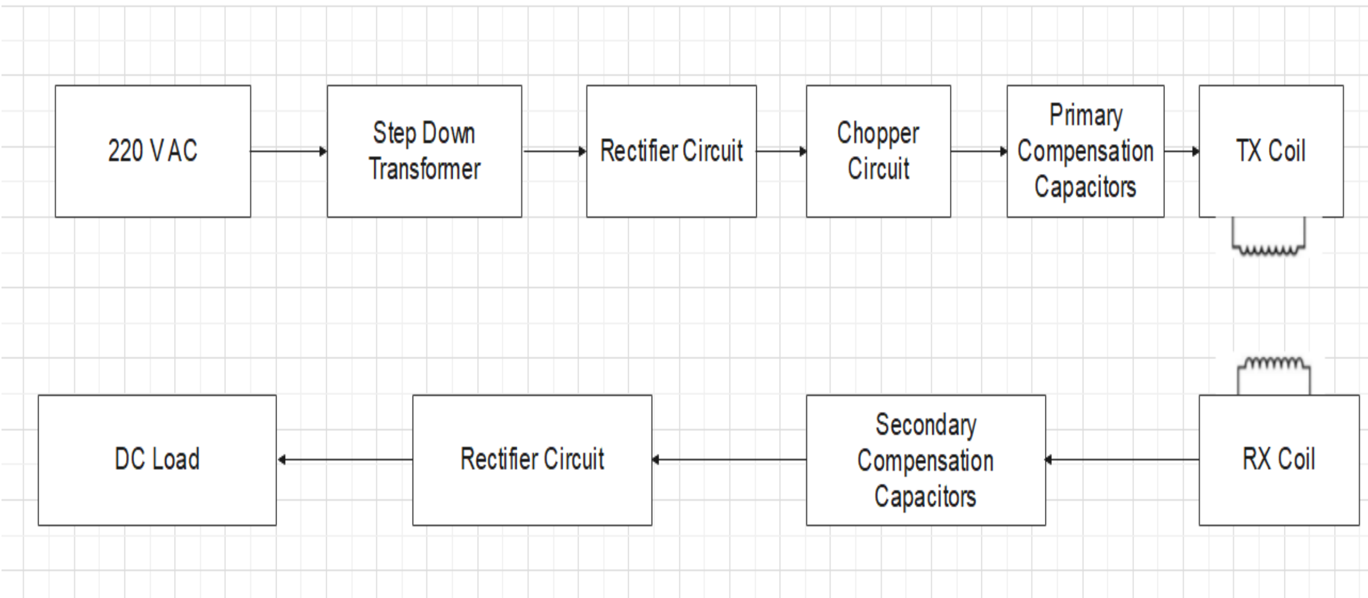
Advances in High-Power Wireless Charging Systems: Overview and Design Considerations	IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS 2020	● Commercial systems and laboratory prototypes are reviewed, focusing mostly on the advances in high-power wireless charging systems. ● The recent endeavours in magnetic pad designs, power electronics converters, and control strategies are illustrated. ● Both stationary and dynamic wireless charging systems are discussed, and critical differences in their designs and applications are emphasized.

Emerging Wireless Charging Systems for Electric Vehicles - Achieving High Power Transfer Efficiency: A Review	2018 IEEE Industry Applications Society Annual Meeting (IAS)	Electric vehicles (EVs) are increasingly purchased worldwide, however, several issues, such as the limited driving range, battery deterioration, unavailability of charging stations etc, present barriers for the advancement of EVs. ● To overcome these barriers, it's crucial to develop its advanced charging infrastructure. In this paper, a literature review is conducted on EV wireless charging systems with the focus on achieving high power transfer efficiency. ● A general classification of wireless charging techniques is firstly presented and various wireless charging techniques are summarized and compared.

Research on an EV Dynamic Wireless Charging Control Method Adapting to Speed Change	MDPI Energies 11 June 2019	● An EV dynamic wireless charging control method adapting to speed change. ● Firstly, a dynamic wireless charging model based on along-track transmitting coil is established. ● Secondly, the influence of the EV charging number and maximum driving speed on the range of system parameters is studied. ● Afterwards, a charging power control method adapting to the speed variation by load adjustment is proposed.
Wireless Charging of Electric Vehicles: A Review and Experiments	ASME 2011 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 3: 2011	● The technologies for EV wireless charging are reviewed including the inductive coupling, magnetic resonance coupling and microwave. ● A basic experimental setup and a prototype electric vehicle wireless charging system are developed for experimental purposes. ● The system well demonstrates the idea of fast and frequent wireless charging of supercapacitor electric vehicles using magnetic resonance coupling.

A Wireless Power Transfer Charger with Hybrid Compensation Topology for Constant Current/Voltage Onboard Charging	MDPI Applied sciences 2021	• Proposal of a constant current/voltage (CC/CV) charging compensation topology with near-communication based on receiving-side hybrid topology switching, which is unaffected by the dynamic loads. • Both the CC and CV modes are operated under the conditions of zero voltage switching (ZVS) for reducing the loss of the WPT systems. • The maximum efficiency of the proposed WPT charger was found to be approximately 91%. • The experimental results were consistent with those of the theoretical analysis
WIRELESS CHARGING OF ELECTRIC VEHICLE	IRJET Volume 7 Issue 3 Mar 2020	• A wireless dynamic charging system with transfer end and receiver end coil which are connected to magnetic pads that can be implanted beneath or on the ground for power transfer. • Inspired by wireless charging implemented in new generation smartphones.

3. Block Diagram



4. Design And Approach

4.1. Software Requirements:

The latest version of Matlab with Simscape Electricals Library

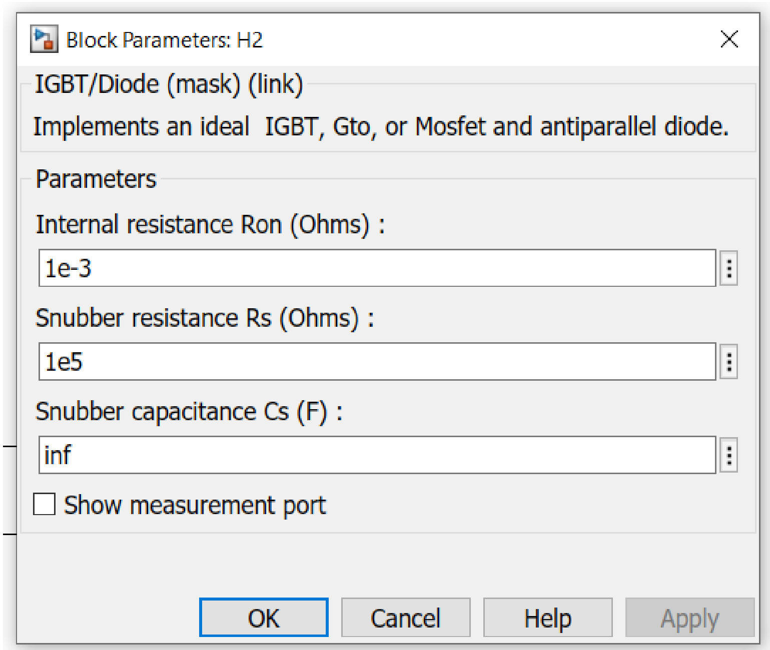
4.2. List of Blocks used in Simulink Model:

AC Voltage Source	325V
Current Measurement	
Voltage Measurement	
Goto	
From	
Inductance 1	10mH
Capacitance 1	300uF
Capacitance 2	105nF
Capacitance 3	109nF
Multimeter	
Scope	
Product	
Mean	
Battery	
Bus Selector	
Mutual Inductance	
Power	
Gain	
powergui	
Source Rectifier	
IGBT	
NOT Gate	
PWM Generator DC-DC	30KHz

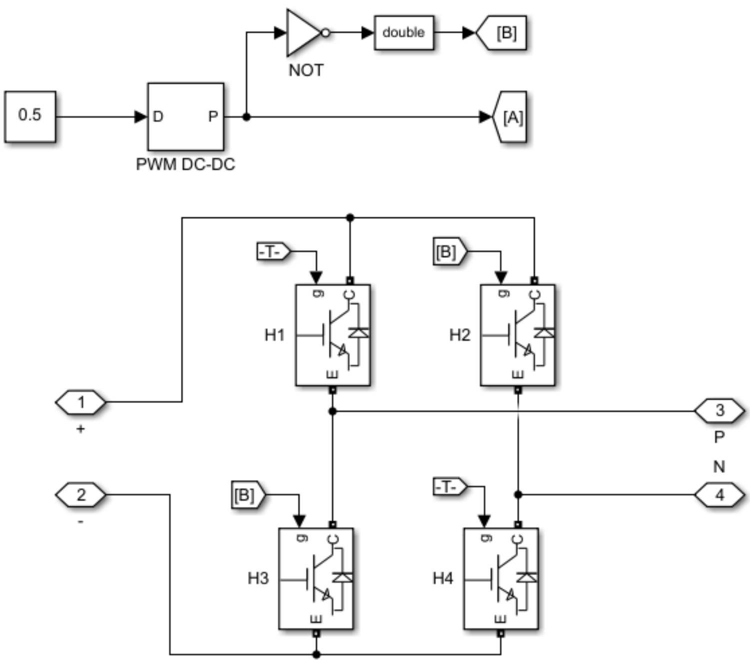
Constant Block	0.5
Data Type Converter	
Diode	

4.3. Block Parameters

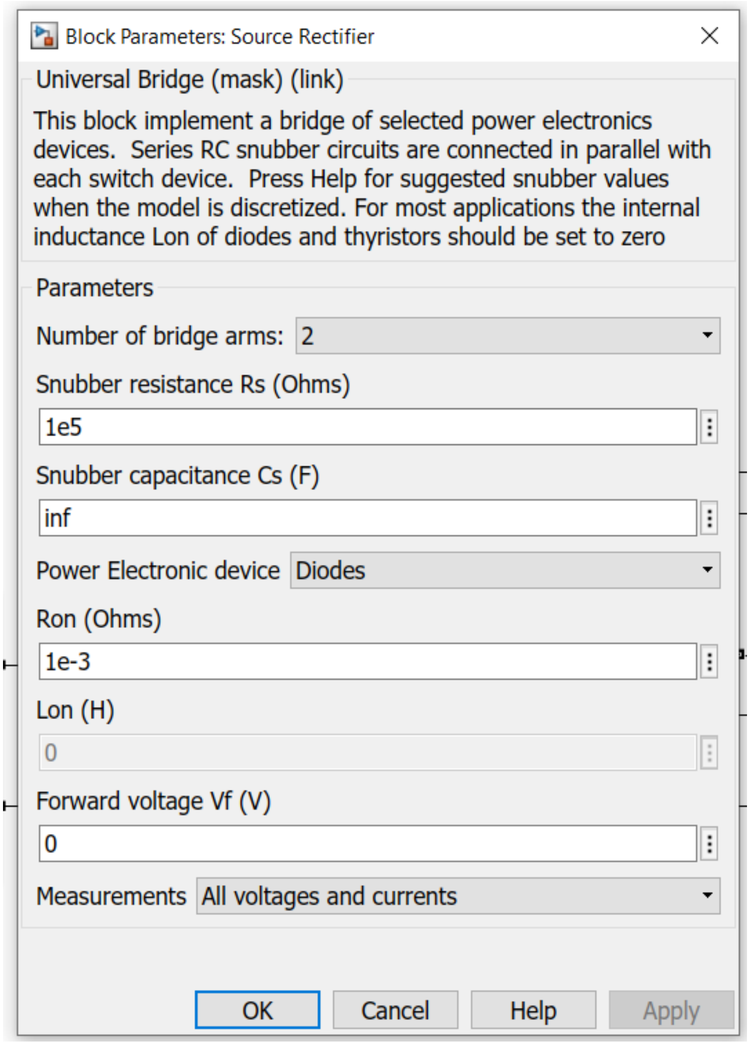
IGBT Diode in HF Inverter:



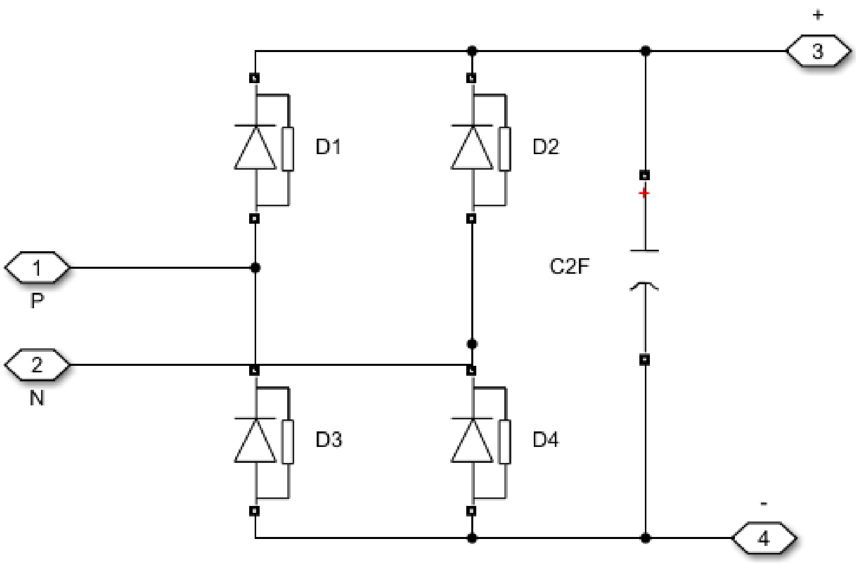
HF Inverter:



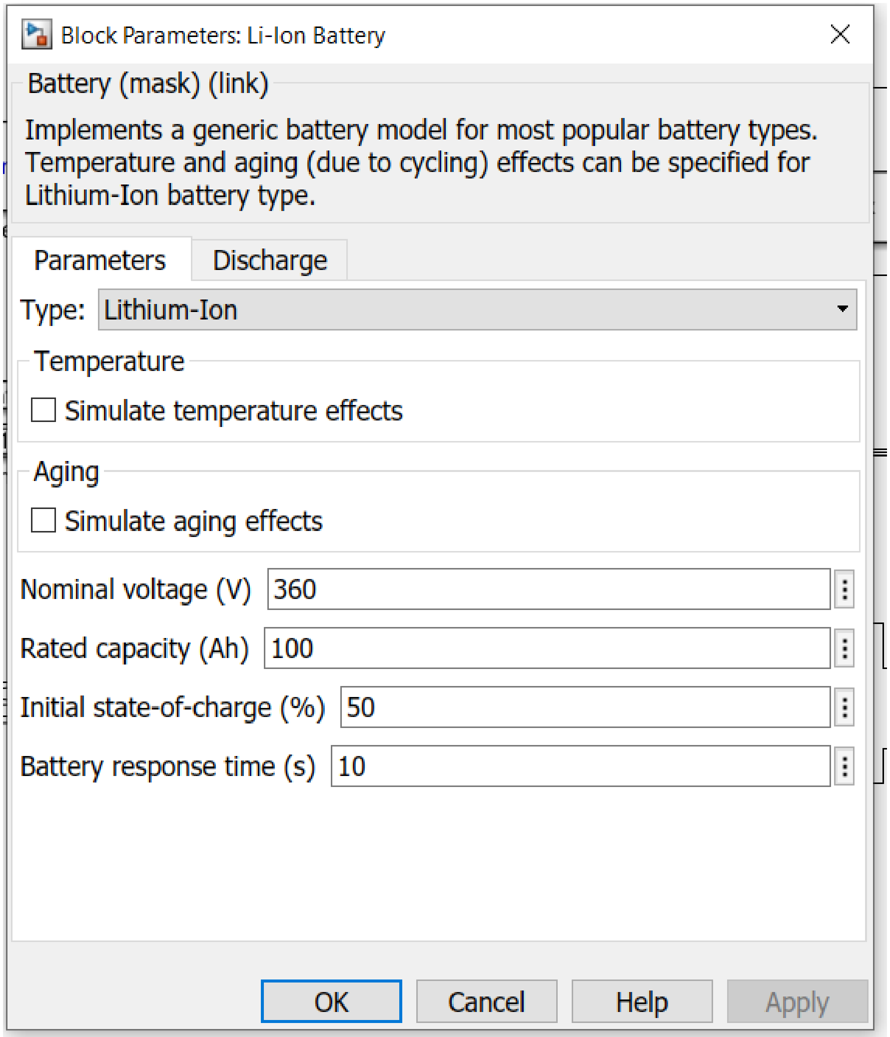
Source Rectifier:



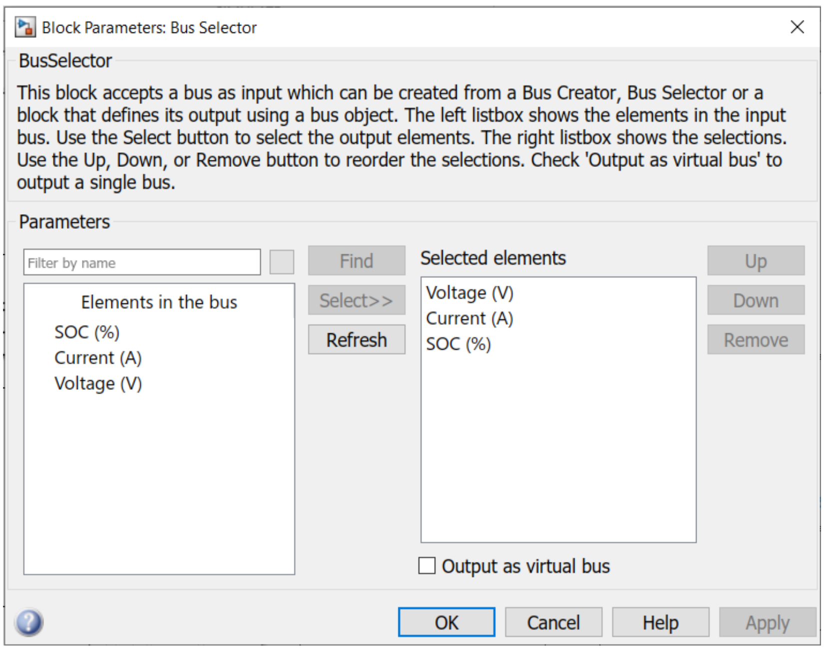
Vehicle Rectifier:



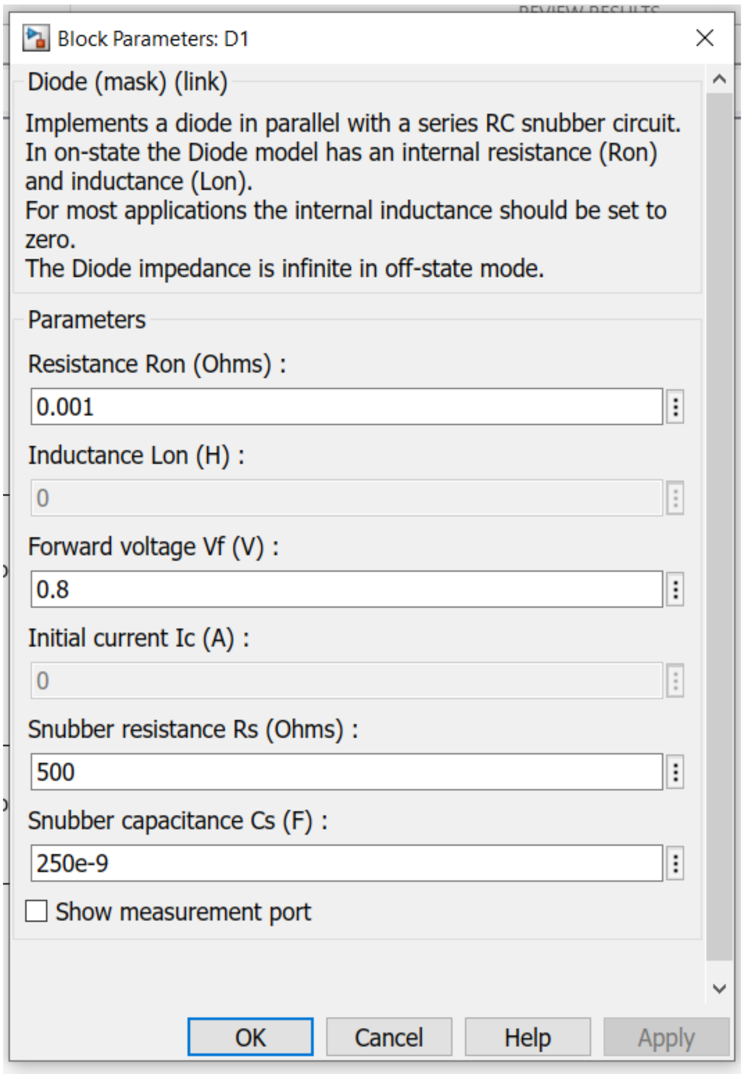
Battery:



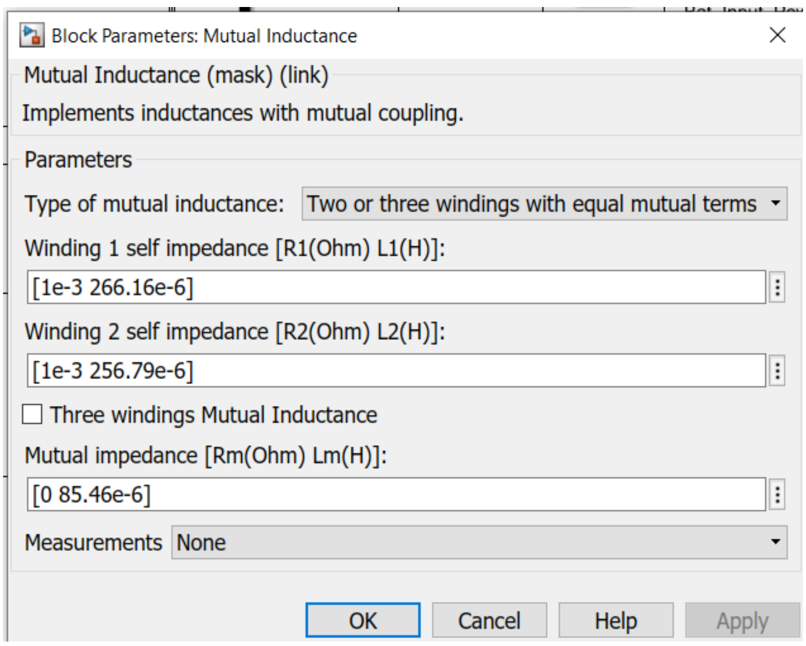
Bus Selector:



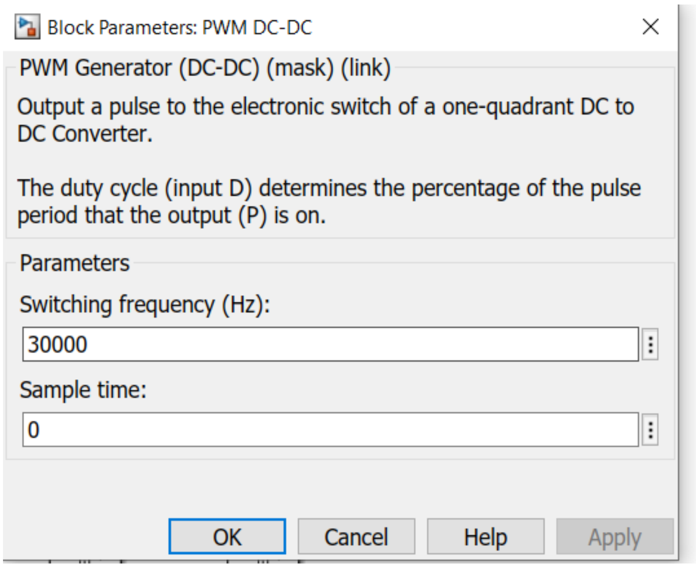
Diode in Vehicle Rectifier:



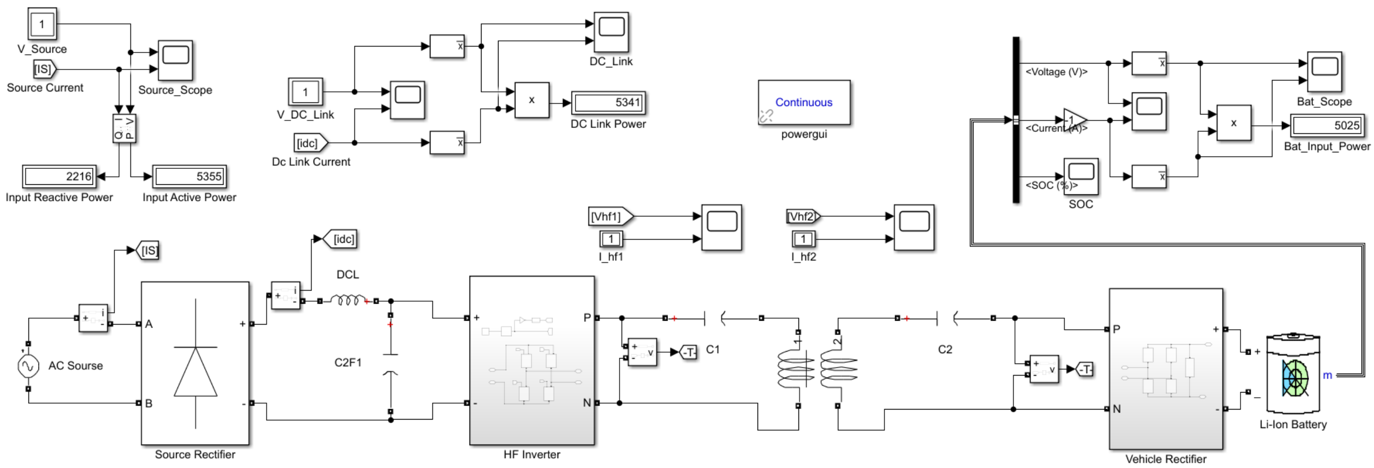
Mutual Inductance:



PWM Generator:

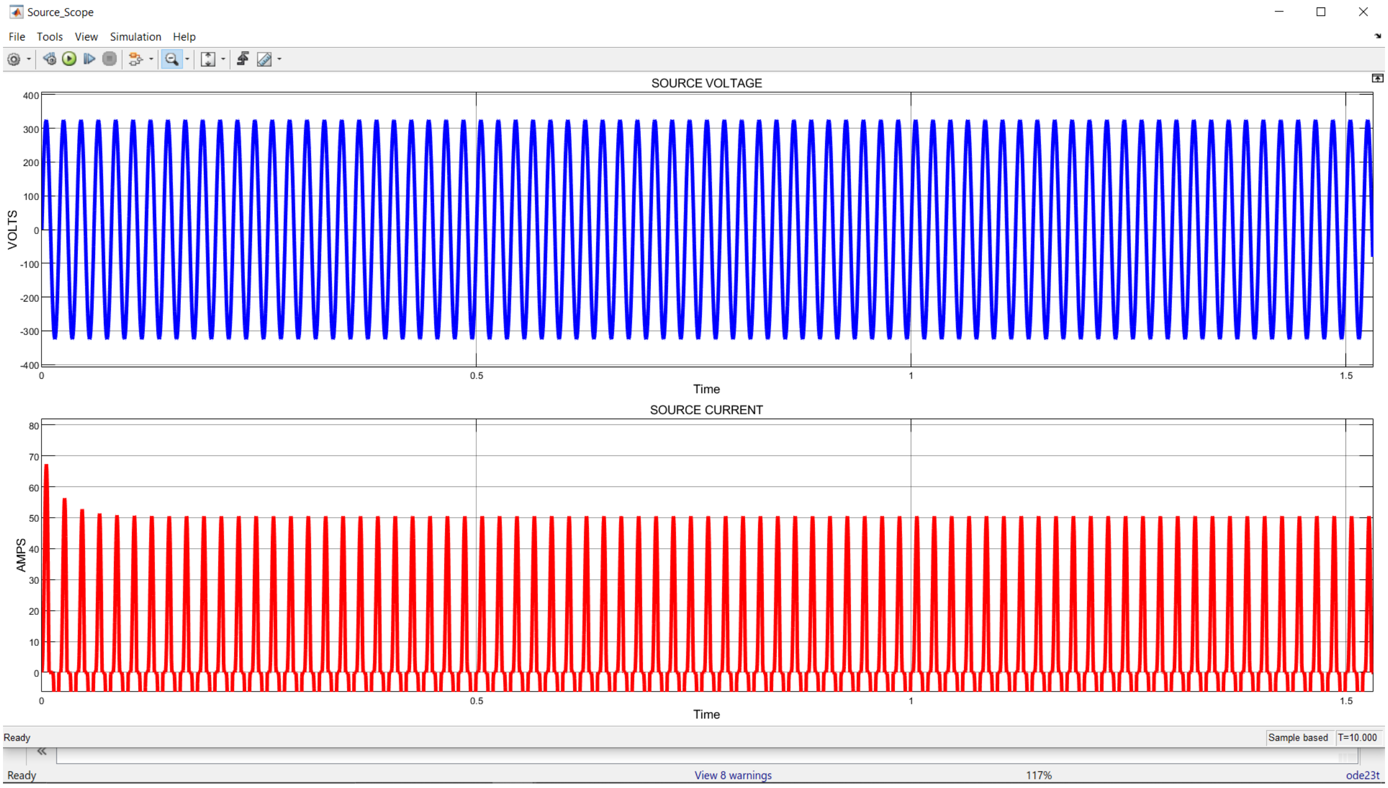


4.4. Simulation Model

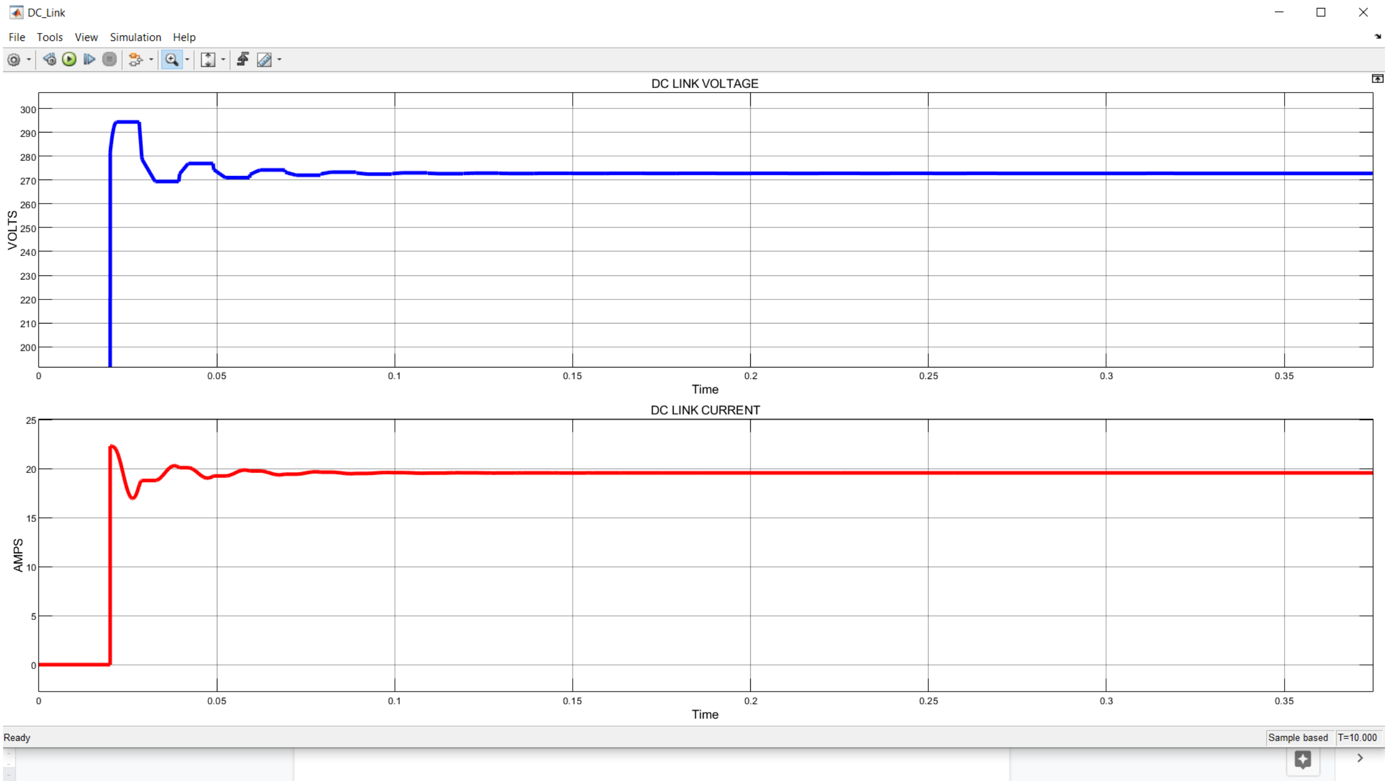


5. RESULT

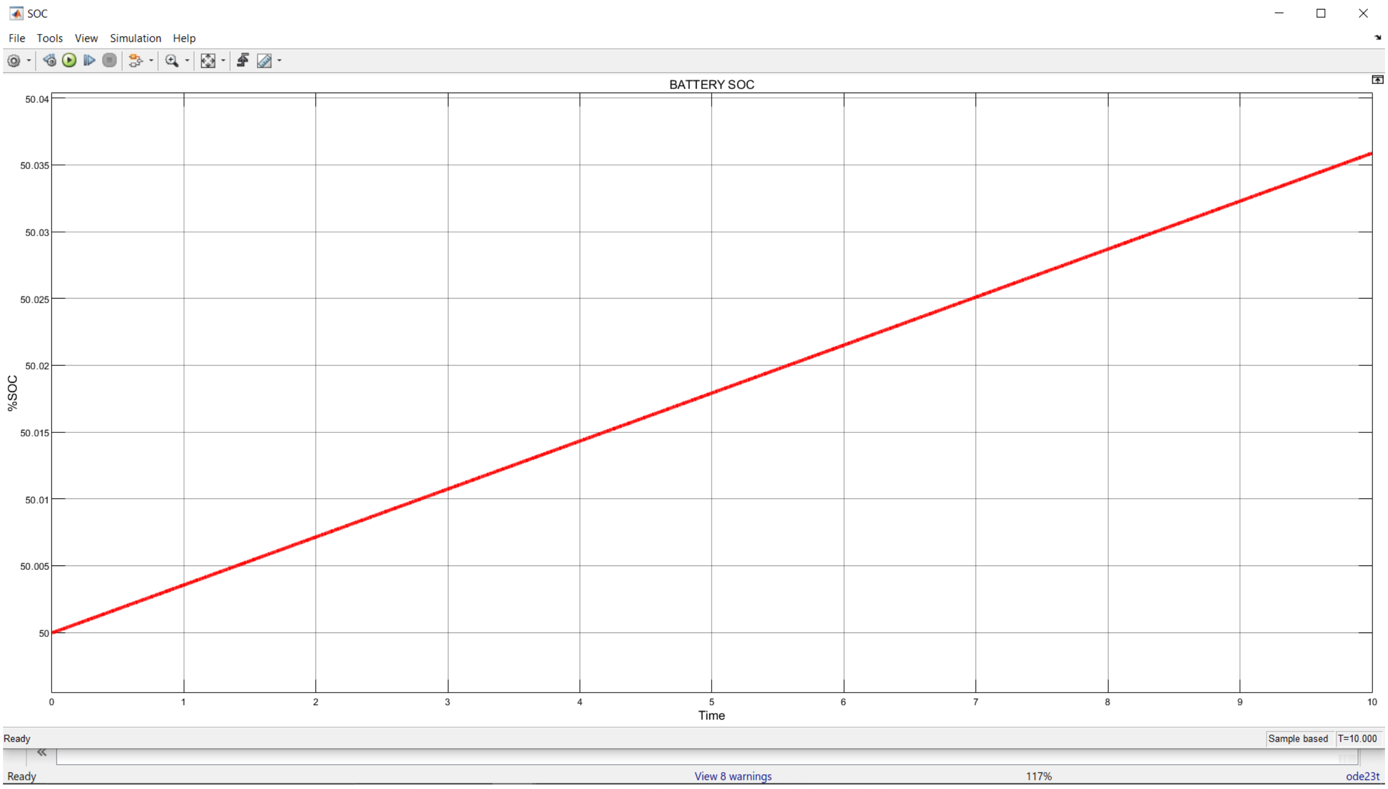
Source Scope



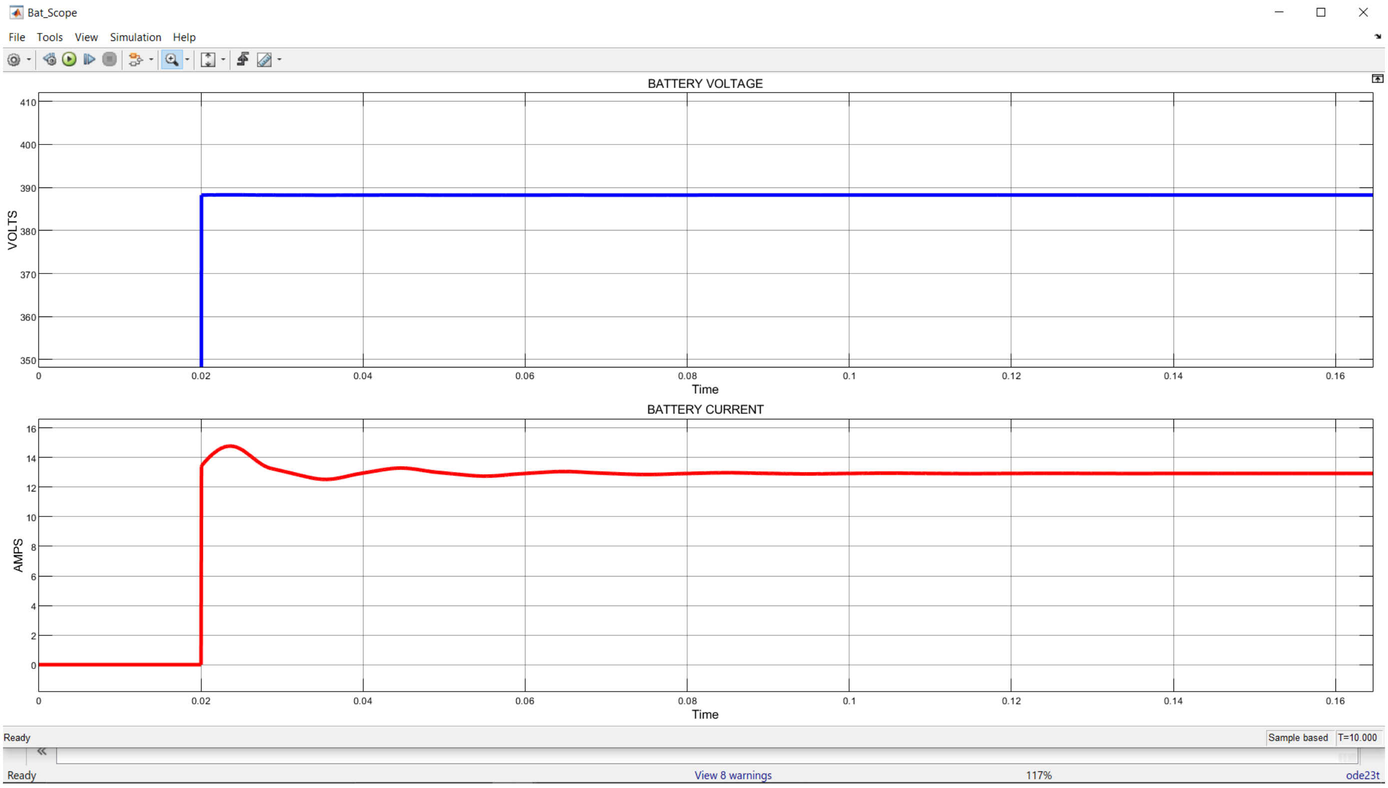
DC-Link Scope



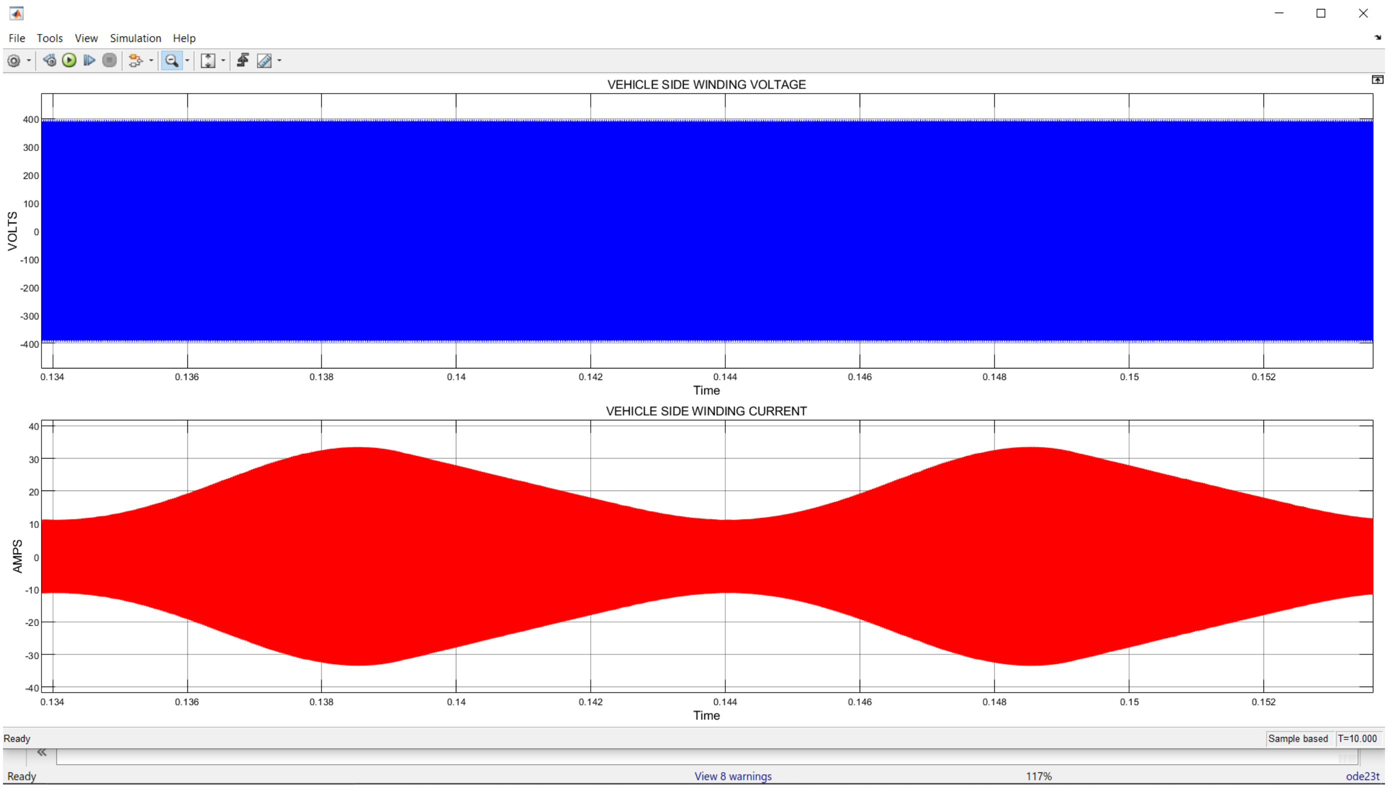
Battery SOC



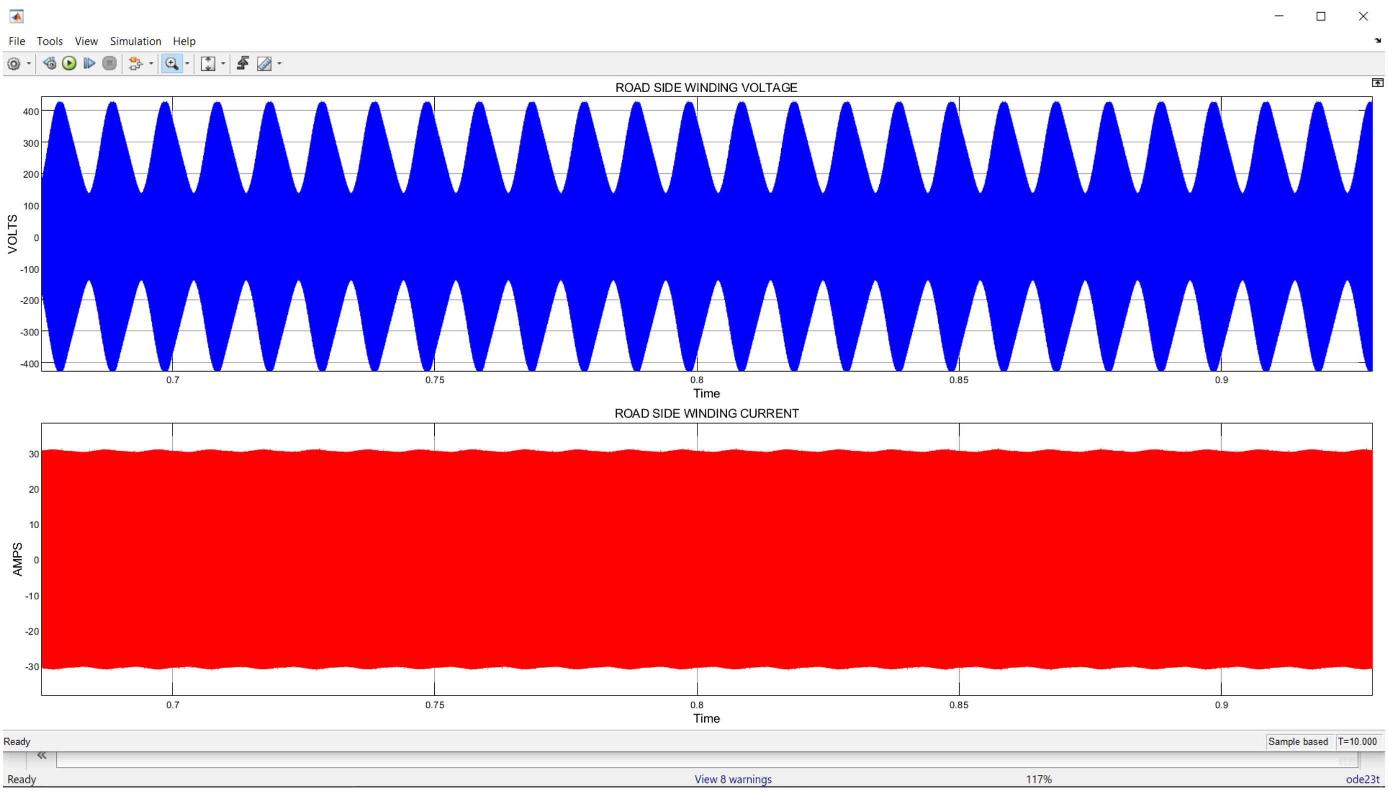
Battery Scope



Vehicle Side Scope



Road Side Scope



6. CONCLUSION

We proposed a simulation for a wireless charging station for electric vehicles by utilising the information gathered from various research papers in MatLab.We gave the statistics for the

7. FUTURE SCOPE

This simulation can aid in the making of new wireless charging technology for Electric vehicles in an efficient and cost-efficient way.

8. REFERENCES

[1]A. C. Bagchi, A. Kamineni, R. A. Zane, and R. Carlson, "Review and Comparative Analysis of Topologies and Control Methods in Dynamic Wireless Charging of Electric Vehicles," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 9, no. 4. Institute of Electrical and Electronics Engineers (IEEE), pp. 4947–4962, Aug. 2021. doi: 10.1109/jestpe.2021.3058968.

[2]N. Mohamed et al., "A new wireless charging system for electric vehicles using two receiver coils," Ain Shams Engineering Journal, vol. 13, no. 2. Elsevier BV, p. 101569, Mar. 2022. doi: 10.1016/j.asej.2021.08.012.

[3]Y. Yang, M. El Baghdadi, Y. Lan, Y. Benomar, J. Van Mierlo, and O. Hegazy, "Design Methodology, Modeling, and Comparative Study of Wireless Power Transfer Systems for Electric Vehicles," Energies, vol. 11, no. 7. MDPI AG, p. 1716, Jul. 01, 2018. doi: 10.3390/en11071716.

[4]N. T. Diep, N. K. Trung, and T. T. Minh, "Wireless power transfer system design for electric vehicle dynamic charging application," International Journal of Power Electronics and Drive Systems (IJPEDS), vol. 11, no. 3. Institute of Advanced Engineering and Science, p. 1468, Sep. 01, 2020. doi: 10.11591/ijpeds.v11.i3.pp1468-1480.

[5]G. F. Savari, V. Krishnasamy, J. Sathik, Z. M. Ali, and S. H. E. Abdel Aleem, "Internet of Things based real-time electric vehicle load forecasting and charging station recommendation," ISA Transactions, vol. 97. Elsevier BV, pp. 431–447, Feb. 2020. doi: 10.1016/j.isatra.2019.08.011.

[6]A. Sultanbek, A. Khassenov, Y. Kanapyanov, M. Kenzhegaliyeva, and M. Bagheri, "Intelligent wireless charging station for electric vehicles," 2017 International Siberian Conference on Control and Communications (SIBCON). IEEE, Jun. 2017. doi: 10.1109/sibcon.2017.7998497.

[7]H. Feng, R. Tavakoli, O. C. Onar, and Z. Pantic, "Advances in High-Power Wireless Charging Systems: Overview and Design Considerations," IEEE Transactions on Transportation Electrification, vol. 6, no. 3. Institute of Electrical and Electronics Engineers (IEEE), pp. 886–919, Sep. 2020. doi: 10.1109/tte.2020.3012543.

[8]X. Liang and M. S. A. Chowdhury, "Emerging Wireless Charging Systems for Electric Vehicles - Achieving High Power Transfer Efficiency: A Review," 2018 IEEE Industry Applications Society Annual Meeting (IAS). IEEE, Sep. 2018. doi: 10.1109/ias.2018.8544484.

[9]Y. Wang, R. Yuan, Z. Jiang, S. Zhao, W. Zhao, and X. Huang, "Research on Dynamic Wireless EV Charging Power Control Method Based on Parameter Adjustment according to Driving Speed," 2019 IEEE 2nd International Conference on Electronics Technology (ICET). IEEE, May 2019. doi: 10.1109/eltech.2019.8839356.

[10]C. Ma, M. Fu, and X. Zhu, "Wireless Charging of Electric Vehicles: A Review and Experiments," Volume 3: 2011 ASME/IEEE International Conference on Mechatronic and Embedded Systems and Applications, Parts A and B. ASMEDC, Jan. 01, 2011. doi: 10.1115/detc2011-48942.

[11]G. Li and D.-H. Kim, "A Wireless Power Transfer Charger with Hybrid Compensation Topology for Constant Current/Voltage Onboard Charging," Applied Sciences, vol. 11, no. 16. MDPI AG, p. 7569, Aug. 18, 2021. doi: 10.3390/app11167569.

[12]Abinand D, Deepak M, Maaz Ahmed, Phanindar Ravi Parimi,"WIRELESS CHARGING OF ELECTRIC VEHICLE: A REVIEW",IRJET Volume 7,Issue 3,Mar 2020