FMDB *Transactions on Sustainable Energy Sequence*

Simple Optimized Power Converter for a Wireless Charging System for a Sustainable Development of Electric Vehicle Propulsion System

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Abstract: People are buying more electric vehicles (EVs) because the world wants to use less fossil fuels and deal with the environmental problems caused by air pollution and greenhouse gas emissions. However, building a strong and effective charging infrastructure is a major obstacle to the widespread use of electric vehicles (EVs). While traditional plug-in charging methods work, they often have problems with user convenience, maintenance, and safety. Wireless charging systems (WCS) have emerged as a promising alternative to these issues. WCS uses inductively coupled power transfer (ICPT) technology to let users transfer energy without touching it. This makes it easier for users and reduces wear and tear on mechanical connectors. This paper discusses the design and construction of a wireless charging system for electric vehicles (EVs) using ICPT. Using MATLAB/Simulink, a detailed simulation model is made to test how well the proposed system works in different situations. We look at important performance metrics like how well energy is transferred and how stable the system is. The simulation results show that the ICPT-based WCS is a reliable and effective way to charge EVs. This means it has significant potential for use in urban transport networks in the future.

Keywords: Electric Vehicle; Wireless Charging Systems; Inductively Coupled Power Transfer; MATLAB Simulation; Sustainable Mobility; Green Energy; System Efficiency; Transportation Systems.

Received on: 26/05/2024, **Revised on:** 03/08/2024, **Accepted on:** 10/10/2024, **Published on:** 09/06/2025

Journal Homepage: https://www.fmdbpub.com/user/journals/details/FTSES

DOI: https://doi.org/10.69888/FTSES.2025.000416

Cite as: S. Manivannan, P. Karuppusamy, K. Rajalashmi, R. Subbulakshmy, and N. Santhosh, "Simple Optimized Power Converter for a Wireless Charging System for a Sustainable Development of Electric Vehicle Propulsion System," *FMDB Transactions on Sustainable Energy Sequence*., vol. 3, no. 1, pp. 39-50, 2025.

1. Introduction

The rise in interest in electric vehicles around the world is no longer just a technological trend; it is now an important part of plans to protect the environment and encourage long-term transportation systems. Electric vehicles are a good alternative to

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fossil fuels because they lower greenhouse gas emissions, noise pollution, and promote energy diversification. These concerns are becoming more serious as fossil fuels run out and climate change worsens. However, switching from traditional internal combustion engine vehicles to electric vehicles presents new challenges, particularly regarding the infrastructure needed to support them. The availability and efficiency of charging systems are one of the biggest problems that keep electric vehicles from being widely used. Currently, the most common way to charge is with standard plug-in charging stations. However, they have several problems, including mechanical wear over time, safety concerns with exposed conductors, and the inconvenient need for physical connections [1]. When people and businesses charge their devices in public places, the issues of overcharging become even worse. Plugging and unplugging them often can damage both the cables and the connectors, making them less reliable and costing more to maintain. Wireless charging systems have received a lot of attention as a new way to charge devices, offering many advantages over traditional wired methods. These systems use inductively coupled power transfer technology to allow electric vehicles to receive power without having to touch the charging station directly. This not only makes things easier for the user by eliminating the need to plug in the charger by hand, but it also enhances safety by reducing the risk of electric shock or fire caused by poor connections. Also, wireless charging systems work better with self-driving cars and smart transportation infrastructure, where people don't want to have to do much.

The basic idea behind inductively coupled power transfer is to use a transmitting coil built into the charging pad to create a magnetic field. This magnetic field causes a current to flow in a receiving coil mounted on the vehicle. Several factors affect this method of transferring energy without contact. These include the alignment of the coils, the distance between them, the frequency of operation, and the design of the power electronics parts. The design of the power converter is one of the most important factors affecting the performance and reliability of the entire charging system. The power converter is the most crucial component for converting electrical energy from the grid into a form that can be sent wirelessly and stored in the vehicle's battery. A well-made converter keeps the voltage stable, protects against electrical problems, and makes sure that as little power as possible is lost. It also adjusts to different load conditions and ensures that the system operates at its optimal performance points. Even the best wireless charging setup would have problems with energy transfer rates, overheating, and unstable charging behaviour without a good converter[2]. So, it is important to make a strong and efficient power converter if wireless charging systems are going to be able to compete in the market and in technology.

This study is about using MATLAB and Simulink to model and simulate a power converter system designed specifically for wirelessly charging electric cars. MATLAB/Simulink is a good choice because many engineers use it, and it can accurately model complicated electrical and control systems. The suggested converter design has four main parts: a DC-AC inverter, a resonant compensation network, a rectifier, and a DC-DC converter. Each of these parts was made with a certain job in mind, and when they work together, they make a smooth energy conversion chain. A DC power source is the first step in the process. It is the energy that comes from the power grid or a storage unit[3]. The inverter then changes this DC energy into high-frequency alternating current. High-frequency operation is important because it makes magnetic parts smaller, increases power density, and enhances inductive coupling between the sending and receiving coils. The resonant compensation network takes the inverter's output and tries to make the power transfer as efficient as possible by keeping the resonance conditions and minimizing reactive power losses. When designing this network, it is important to choose the right values for inductors and capacitors so that the system works at its resonant frequency. This will make sure that the most energy is transferred with the least amount of loss. A rectifier circuit then changes the high-frequency AC voltage that was induced in the receiving coil back into DC. This rectified voltage might have ripples and may not be suitable for charging batteries immediately, so a DC-DC converter processes it further. The final DC output is adjusted to meet the battery's needs for voltage and current while it is charging. This completes the wireless charging cycle.

Simulink gives us standard electrical parts and control blocks that we can use to model each part of the converter system in the simulation environment. The system settings, like the input voltage, switching frequency, coil shape, and load resistance, are carefully chosen to match real-world situations. We examine the simulation results using several performance metrics, such as voltage regulation, power conversion efficiency, levels of electromagnetic interference, and thermal performance. The results show that the proposed converter design keeps a stable voltage output across a range of load conditions, transfers energy efficiently, and works safely within thermal limits [4]. These results show that the proposed converter design can be used in real-world wireless charging situations. One of the most important benefits seen in the simulation is that the system can work in a variety of situations. For example, the converter maintains stable output by adjusting its switching patterns and control strategies when the coils aren't aligned correctly or when the load changes due to variations in the battery's state of charge. In real-world situations, this dynamic response is crucial because static system behaviour could slow charging or even cause the system to fail. Soft-switching techniques in the inverter and feedback control loops in the DC-DC converter enhance system performance by reducing switching losses and maintaining accurate voltage.

These design choices make a big difference in how energy-efficient the wireless charging system is. Also, the modular design of the converter makes it easy to add to existing electric vehicle architectures. The parts can be changed or scaled to fit the needs of each vehicle, allowing the system to work with a wide range of EV models. The simulation also includes safety features like overvoltage protection, short circuit protection, and fault detection mechanisms. These show that the system can work reliably even when conditions are bad. These features are crucial for public use, where safety standards are very high, and the ability to keep working is paramount. Another interesting aspect of this work is that the proposed system could allow energy to flow in both directions, enabling vehicle-to-grid applications. This study primarily focuses on charging in one direction. Still, the converter topology can be modified to allow energy to flow from the car's battery back to the grid. This ability is at the heart of new smart grid ideas and the use of renewable energy, where electric cars can work as distributed energy storage units. The system can help keep the grid stable and the energy supply going by adding the right control strategies and power flow management algorithms to the current design.

The results of this study have significant implications for future research and development in the area of charging electric vehicles. The simulation results look good, but more work is needed to validate the system by integrating it into hardware and testing it in the real world. Experimental studies can reveal more issues with electromagnetic interference, thermal management, and material limitations that aren't fully apparent in simulation environments. Additionally, integrating wireless charging systems into public infrastructure like roads, parking lots, and charging stations requires extensive planning, standardisation, and cooperation among stakeholders such as car makers, utility companies, and government agencies. To sum up, creating a power converter for wireless charging of electric cars using inductively coupled power transfer technology is a significant step forward in the pursuit of environmentally friendly transportation. The MATLAB/Simulink simulation shows that the proposed design is technically possible and has performance benefits. This study sets the stage for future improvements in wireless charging infrastructure by looking at important problems like voltage stability, energy transfer efficiency, and operational reliability. The results support the use of wireless charging systems as a practical, safe, and effective alternative to wired methods. This is part of a larger goal to reduce the impact on the environment and encourage the use of clean energy technologies in modern transportation systems.

2. Classification of the Wireless Charging System

Wireless charging systems for electric vehicles (EVs) are classified based on the method of power transfer [5]. The three primary types include Inductive Wireless Charging (IWC), Resonant Wireless Charging (RWC), and Capacitive Wireless Charging (CWC). Each of these technologies offers unique advantages and challenges, influencing their adoption in EV applications [6].

2.1. Inductive Wireless Charging (IWC)

Inductive charging is the most commonly used wireless power transfer (WPT) technology for EVs. It operates based on electromagnetic induction, where power is transferred between two magnetically coupled coils—one embedded in the charging station (transmitter) and the other installed in the EV (receiver) [7]. A high-frequency alternating current (AC) in the transmitter coil generates a time-varying magnetic field, inducing voltage in the receiver coil. When coils are properly aligned, they deliver high efficiency and offer a limited charging range. No direct electrical contact ensures safety and reliability [8]. Heat dissipation occurs due to the eddy current losses. IWC is widely adopted in static EV charging stations, where vehicles remain stationary while charging. However, misalignment between coils significantly reduces power transfer efficiency, making it less suitable for dynamic charging applications [9].

2.2. Resonant Wireless Charging (RWC)

Resonant charging builds upon inductive charging by utilising resonance tuning to enhance power transfer efficiency. Both the transmitter and receiver coils are designed with resonant circuits, ensuring they operate at the same resonant frequency [10]. This technique allows energy transfer over longer distances and reduces sensitivity to coil misalignment. This system offers an extended power transfer range. This complex circuit design is susceptible to electromagnetic interference. RWC is considered a promising solution for dynamic wireless charging, where EVs receive power while moving along designated charging lanes. This technology could potentially eliminate the need for large onboard batteries, reducing vehicle weight and cost [11].

2.3. Capacitive Wireless Charging (CWC)

Capacitive charging operates using electric fields instead of magnetic fields for power transfer. In this method, two conductive plates are placed in the transmitter and receiver, forming a capacitor through which energy is transferred at high frequency [12]. Unlike inductive and resonant methods, which rely on magnetic coupling, CWC utilises displacement currents to enable wireless power transfer. The absence of heavy coil windings makes it lightweight and cost-effective [13]. Its low power efficiency makes it less suitable for high-power applications. CWC is still in the research and development stage for EV applications. It is primarily explored for low-power, short-range wireless charging, where space and weight constraints are critical factors [14].

2.4. Hybrid Wireless Charging (HWC)

To overcome the limitations of individual WPT methods, researchers are exploring hybrid wireless charging systems that combine inductive, resonant, and capacitive technologies [15]. Hybrid systems can improve charging efficiency, power transfer range, and alignment flexibility, making them a viable option for future EV charging networks. This system implements galvanic isolation and high-frequency operation [16]-[18].

3. Proposed System and its Specifications

Figure 1 represents a wireless power transfer (WPT) architecture that efficiently delivers power from a conventional 230V/50Hz AC grid to a DC load. Initially, the AC voltage from the grid is converted into DC using an AC-DC rectifier, ensuring a stable and regulated DC output. This rectification process helps eliminate AC fluctuations, providing a smooth DC supply for further processing. Next, the DC-AC inverter converts the rectified DC into high-frequency AC to facilitate efficient wireless power transmission. The inverter plays a crucial role in improving the transmission efficiency and reducing losses during wireless power transfer. The generated high-frequency AC is then fed into a wireless transformer system, which consists of two magnetically coupled coils designed to transfer power across an air gap without direct electrical connections. After transmission, the received AC voltage is again converted back to DC using an AC-DC rectifier on the secondary side.

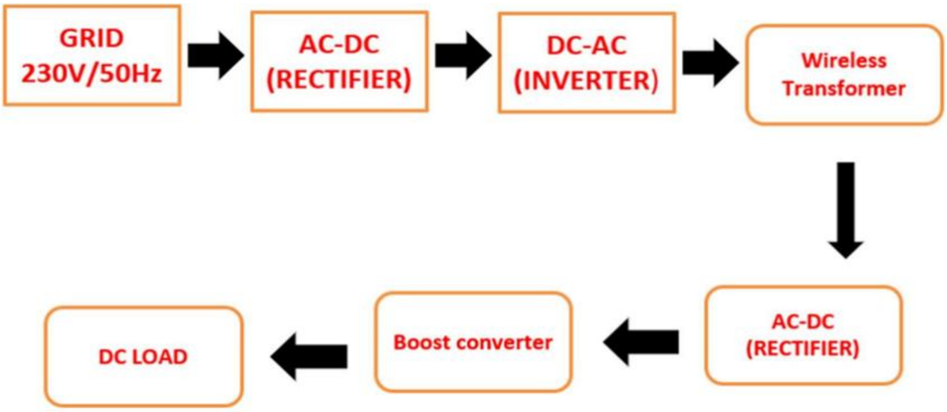

Figure 1: Block diagram representation of the proposed system

This step ensures that the power is suitable for DC applications, making it compatible with various electronic devices and loads. However, the rectified DC voltage may not always meet the required level for the intended DC load, which necessitates further voltage regulation and control. To achieve the required output, a boost converter is implemented to regulate and step up the DC voltage as per the load demand. This final stage ensures that the DC load receives a stable and efficient power supply, making the system suitable for applications such as EV charging, renewable energy integration, and industrial automation. The combination of wireless power transfer and efficient conversion stages makes this system highly adaptable for modern power distribution needs.

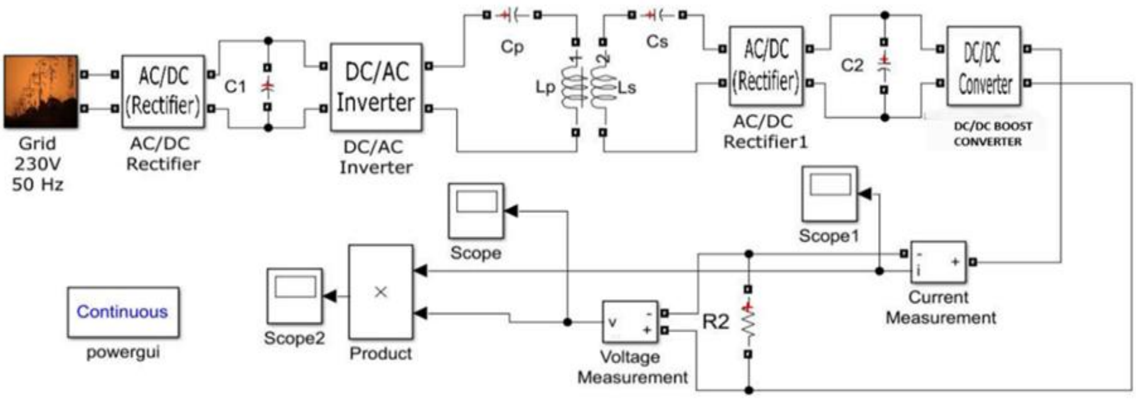

Figure 2: Proposed MATLAB circuit diagram

Figure 2 represents a high-frequency resonant inductive wireless power transfer (WPT) system for efficient energy transmission without physical connections. It begins with an AC power source (230V, 50Hz), which is rectified into DC voltage by an AC/DC rectifier. A DC-link capacitor (C_1) filters the ripples before a high-frequency inverter converts it back into AC. This high-frequency AC drives a primary resonant circuit (Cp, Lp), generating an alternating magnetic field that inductively couples with the secondary coil (Ls). The secondary LC circuit (Cs, Ls) is tuned for resonance to maximise efficiency. The secondary AC/DC rectifier receives high-frequency AC, which is smoothed using a filter capacitor (C2) and regulated through a DC-DC buck converter to provide a stable output for the load. Voltage and current measurement blocks monitor system performance, while a product block calculates power transfer efficiency. Scopes are integrated for real-time visualisation of key electrical parameters. This ensures reliable power delivery and system optimisation. This resonant WPT system offers high-efficiency power transfer, galvanic isolation for safety, and stable voltage regulation through the buck converter. Its high-frequency operation reduces component size and enhances performance, making it ideal for applications such as EV charging, industrial automation, and biomedical devices. The system is designed for low energy losses, high reliability, and real-time monitoring, ensuring optimal operation in wireless power applications.

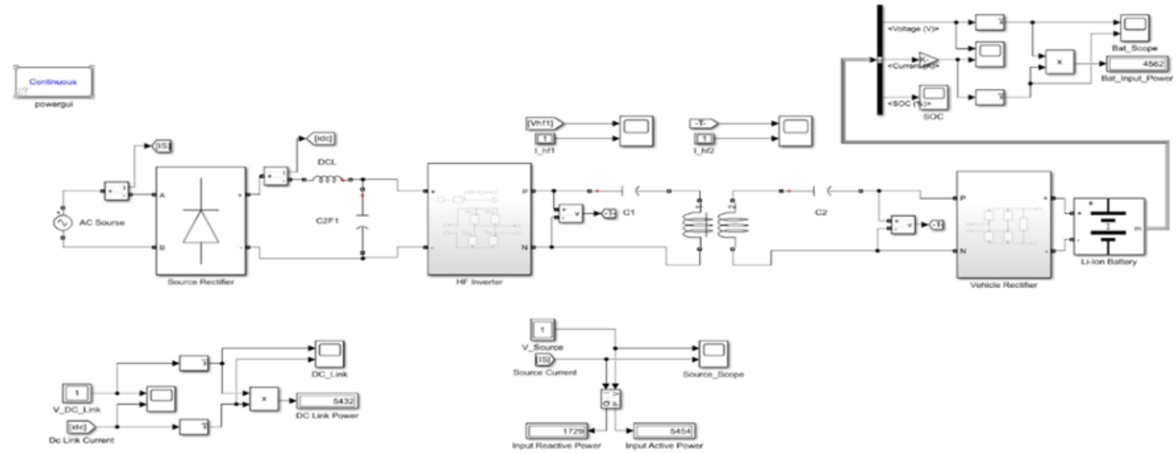

Figure 3: Simulation of a power converter wireless charging system

Figure 3 presents a simulation of a 5kW Wireless Power Transfer (WPT) system designed for electric vehicle (EV) charging. The system operates in multiple stages to ensure efficient and contactless power transfer. It starts with an AC power source, which is converted into DC power using a rectifier. This DC power is then processed through a high-frequency (HF) inverter, which converts it into high-frequency AC. This conversion is necessary to enable efficient wireless energy transfer through inductive coupling. The wireless power transfer stage consists of a primary and secondary coil, along with compensation capacitors. The primary coil generates a high-frequency magnetic field, which induces voltage in the secondary coil placed in the vehicle. This allows power to be transferred across an air gap without any physical contact. This method ensures safe and efficient energy transfer, making it ideal for EV charging applications. On the vehicle side, the received AC power is converted back into DC using a rectifier. This DC power is then used to charge a Li-ion battery, ensuring a controlled and stable charging process. Throughout the system, various monitoring components track key parameters like battery voltage, current, and state of charge (SOC) to optimise performance. The simulation results confirm that the proposed WPT system delivers power efficiently and maintains stable charging conditions. By eliminating physical connectors, this system enhances safety, convenience, and durability for EV charging. This research demonstrates the potential of wireless charging technology for the future of sustainable transportation.

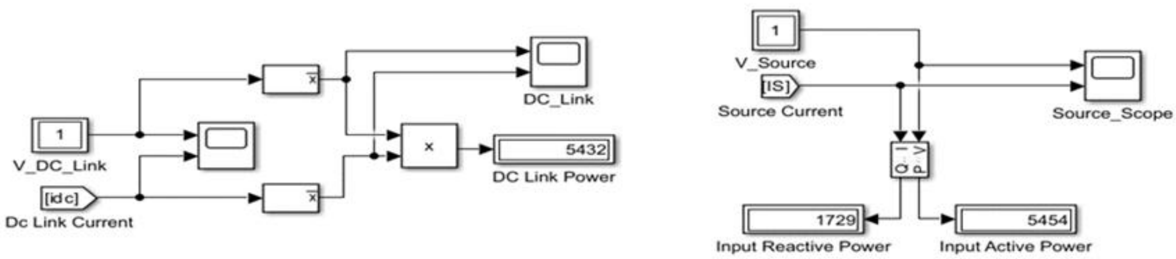

Figure 4: Power flow & efficiency

The WPT system consists of several interconnected stages, including an AC source, rectifier, DC-link, high-frequency inverter, resonant coupling circuit, vehicle rectifier, and battery storage. At the input stage, the system receives 5454W of active power from the AC source. After rectification and DC-link stabilisation, 5432W is transferred to the high-frequency inverter, resulting in negligible losses in this conversion stage. The power is then wirelessly transferred via inductive coupling to the vehicle-side rectifier, where the battery receives 4562W. This means that a total of 870W is lost in the transmission and conversion process, mainly due to coupling inefficiencies, switching losses, and misalignment factors. Figure 4 is used to calculate the power flow and converter efficiency. The overall system efficiency is calculated as 83.7%, which is within the acceptable range for inductive power transfer applications. The DC-link efficiency remains exceptionally high at 99.6%, indicating minimal rectification losses. However, the primary losses occur during the wireless transmission and vehicle-side conversion, highlighting the need for better coil alignment, resonant tuning, and advanced control techniques to improve performance.

4. Simulation Result

A software program called MATLAB is used for calculations in applied mathematics, science, and engineering. It provides great graphics, a robust programming language, and a wealth of specialised expertise. The MathWorks, Inc. is the publisher and trademark owner of MATLAB. It emphasises computing over mathematics: Except for the optional Symbolic Toolbox, a sophisticated interface to Maple, symbolic expressions and manipulations are not possible. Because of the inherent rounding mistakes in computer arithmetic, all findings are not just numerical but also imprecise. Although the restriction to numerical computing may be viewed as a disadvantage, it is also a strength: when it comes to numbers, MATLAB is far more popular than Maple, Mathematica, and similar programs. Numerical computation on workstations for non-computation experts is MATLAB's specialty. The quantity of MATLAB-related books on mathworks.com is one indicator of how specialised this market is. Before more time-consuming writing in a different language, MATLAB can be a useful setting for exploring and optimising methods, even for users of supercomputers. The majority of successful computing environments and languages develop a unique personality or culture.

Math Works Inc.'s Simulink (Simulation and Link) is an addition to MATLAB. It provides dynamical system modelling, simulation, and analysis in a graphical user interface (GUI) environment by integrating with MATLAB. Using click-and-drag mouse operations makes building a model easier. A vast block library of toolboxes for both linear and nonlinear studies is included with Simulink. Because the models are hierarchical, both top-down and bottom-up methods can be used. Since Simulink is a fundamental component of MATLAB, switching between the two environments is simple, allowing the user to fully utilise the features available in both. This system shows a wireless power transfer (WPT) setup that effectively sends power from a standard 230V/50Hz AC grid to a DC load. First, the AC voltage from the grid is converted into DC using an AC-DC rectifier, ensuring a stable and regulated DC output. This rectification process eliminates AC fluctuations, providing a steady DC supply for the next steps in processing. After that, the DC-AC inverter converts the rectified DC into high-frequency AC, which helps make wireless power transmission more efficient. The inverter is crucial for making wireless power transfer more efficient and reducing losses. The high-frequency AC is sent into a wireless transformer system. This system has two coils that are magnetically coupled, designed to transfer power through an air gap without any direct electrical connections. Once the transmission is complete, the AC voltage received is converted back to DC using an AC-DC rectifier located on the secondary side.

This step ensures that the power is suitable for DC applications, helping it work well with various electronic devices and loads. However, the corrected DC voltage might not always reach the necessary level for the intended DC load, indicating a need for additional voltage regulation and control. A boost converter is used to adjust and increase the DC voltage to meet the load requirements. This last stage ensures that the DC load receives a stable and efficient power supply, which is beneficial for applications like EV charging, renewable energy integration, and industrial automation. This system is really adaptable for today's power distribution needs because it combines wireless power transfer with efficient conversion stages. This circuit demonstrates a high-frequency resonant inductive wireless power transfer (WPT) system designed for efficient energy transmission without any physical connections. The process starts with an AC power source of 230V and 50Hz, which is then converted into DC voltage using an AC/DC rectifier. A DC-link capacitor (C1) helps to smooth out the ripples before a high-frequency inverter changes the DC voltage back into AC. The high-frequency AC powers a primary resonant circuit (Cp, Lp), which creates an alternating magnetic field that interacts inductively with the secondary coil (Ls). The secondary LC circuit (Cs, Ls) is adjusted for resonance to enhance efficiency. The high-frequency AC that we get is converted to DC by the secondary AC/DC rectifier. Then, it gets smoothed out with a filter capacitor (C2) and regulated using a DC-DC buck converter to ensure a stable output for the load.

Voltage and current measurement blocks monitor how the system is performing, and there's a product block that determines the efficiency of power transfer. Scopes are used to visualise important electrical parameters in real-time. This makes sure that power is delivered reliably and the system is optimised. This resonant WPT system provides efficient power transfer, ensures safety with galvanic isolation, and maintains stable voltage regulation using the buck converter. The high-frequency operation makes components smaller and improves performance, which is great for uses like EV charging, industrial automation, and biomedical devices. The system is built to minimise energy losses, provide high reliability, and enable real-time monitoring, which helps ensure optimal operation in wireless power applications.

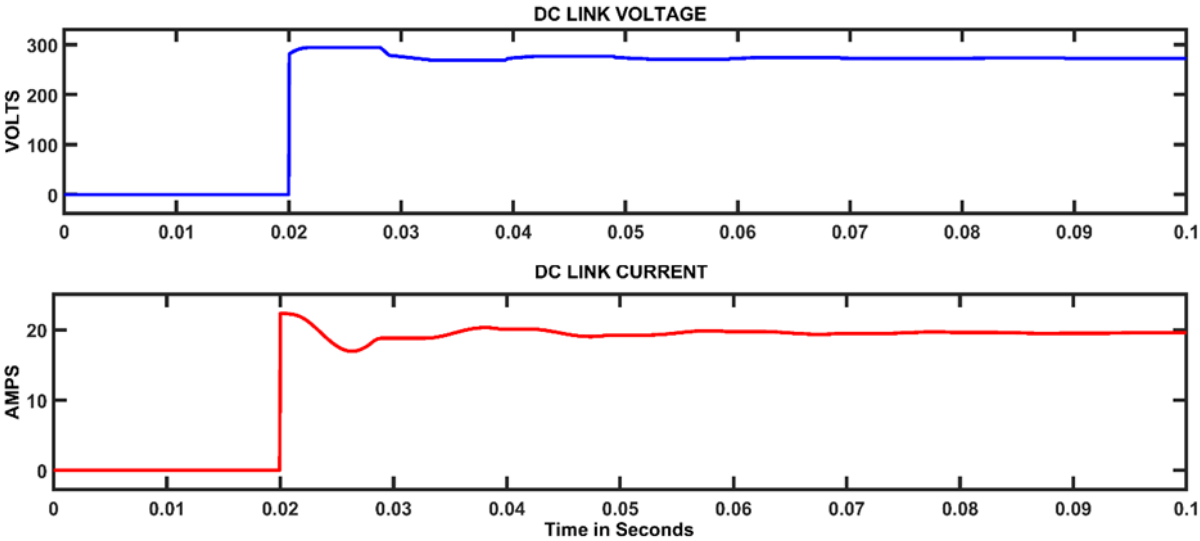

Figure 5: Analysis of DC link voltage & current characteristics

At the initial state (0 – 0.02s) in Figure 5, the voltage and current remain at 0V and 0A, indicating no power flow. The DC link voltage rapidly rises to 300V. Minor voltage dip occurs but quickly stabilises. The DC link current increases to 20A, indicating capacitor charging and power transfer initiation. Slight variations are observed due to switching and load adjustments. At the steady-state operation, the current stabilises, ensuring smooth and reliable power flow.

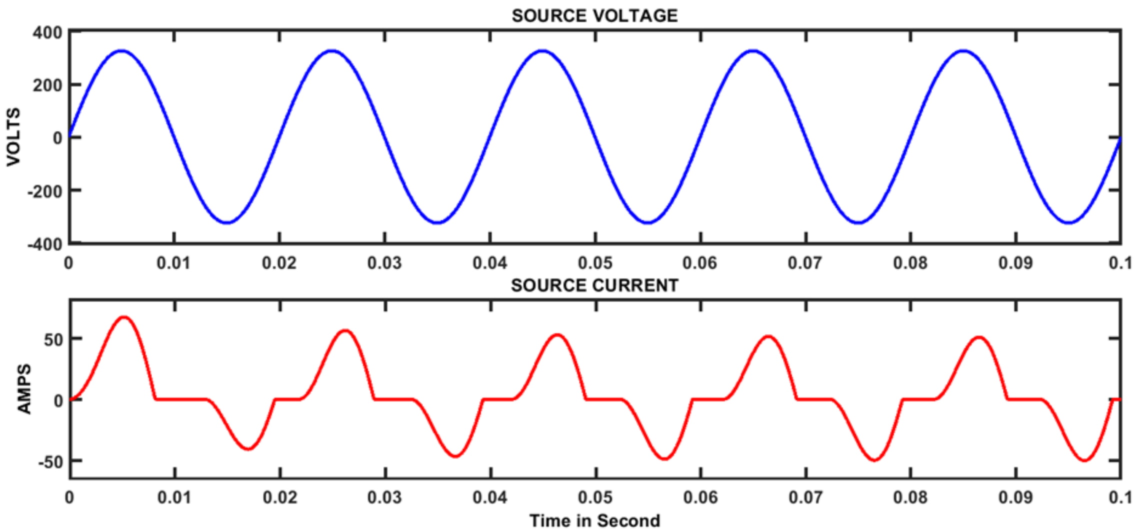

Figure 6: Source voltage & current waveforms

The above voltage waveform in Figure 6 follows a smooth sinusoidal pattern, peaking at approximately ±325V, which corresponds to a 230V RMS AC supply. The source current shows distortion and flat regions, indicating the presence of nonlinear loads or switching devices in the circuit. The current waveform has periods of zero value, suggesting intervals where no current is drawn due to power electronic switching. The current does not perfectly align with the voltage, indicating the influence of inductive or capacitive components, possibly from rectifiers or inverters. The source current reaches up to ±50A – 60A. The observed waveform distortion and phase shift indicate the need for power factor correction or filtering to improve efficiency.

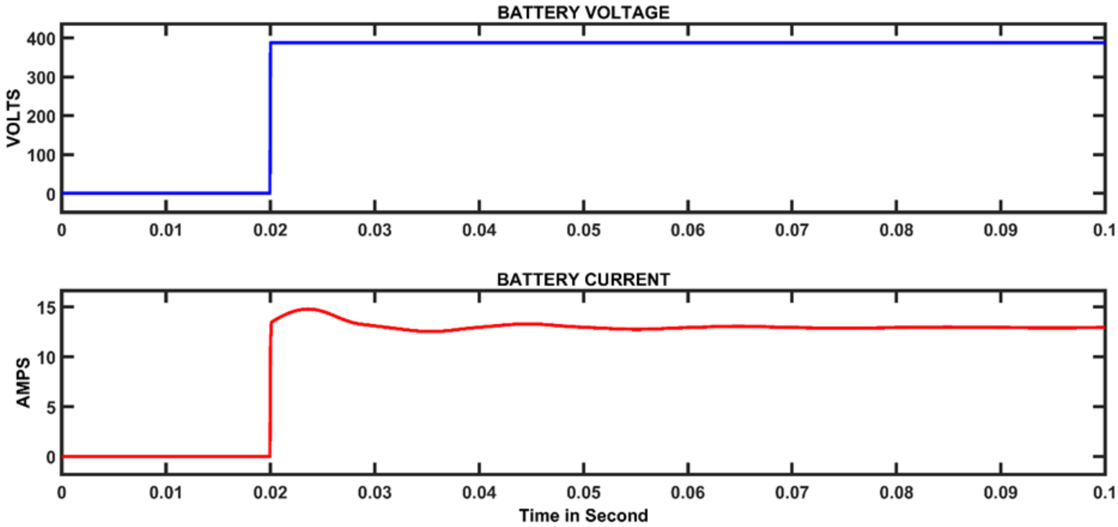

Figure 7: Battery output voltage & current

Initially, the voltage remains at zero and sharply increases at 0.02s in Figure 7, indicating the start of the charging process. The voltage continues to rise progressively, ensuring a smooth and controlled charging process. The final voltage stabilises at approximately 380V. The current is initially zero and increases sharply at 0.02s. The peak current reaches approximately 14A, ensuring safe charging without excessive surges. Minor fluctuations in the current indicate active regulation by the charging system.

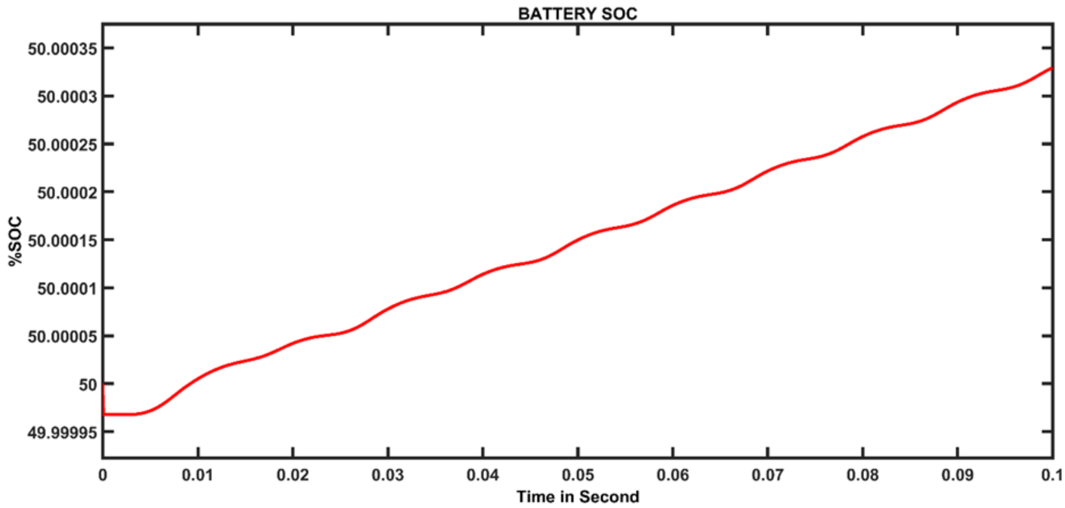

Figure 8: Battery state of charge

The initial SOC in Figure 8 is around 51.644%, and it steadily rises with the charging process. The smooth and controlled increase in SOC confirms efficient charging without abrupt fluctuations. After the initial transition phase, voltage, current, and SOC maintain stable trends, confirming efficient and reliable charging. The topmost graph shows the battery's State of Charge (SOC) in percentage. It begins slightly above 70.986% and gradually increases over the simulation time. This slow and steady rise suggests that the battery is being charged continuously. The smoothness of the curve implies a controlled charging process, likely regulated by a charging algorithm or controller, ensuring stable power flow into the battery. The middle graph illustrates the charging current. The waveform is distinctly pulsed or chopped, oscillating between approximately 0A and -110A. The negative current indicates that the current is flowing into the battery (charging mode). The pulsed nature suggests using a DC-DC converter or PWM control for charging, where current is supplied in controlled pulses to manage efficiency and thermal effects. The bottom graph shows the terminal voltage of the battery, fluctuating between about 50V and 65V. This also shows pulsed behaviour similar to the current, further supporting the idea that a switching converter is regulating the charging. The spikes in voltage correspond to the moments when current pulses are applied, showing the voltage response to those current injections.

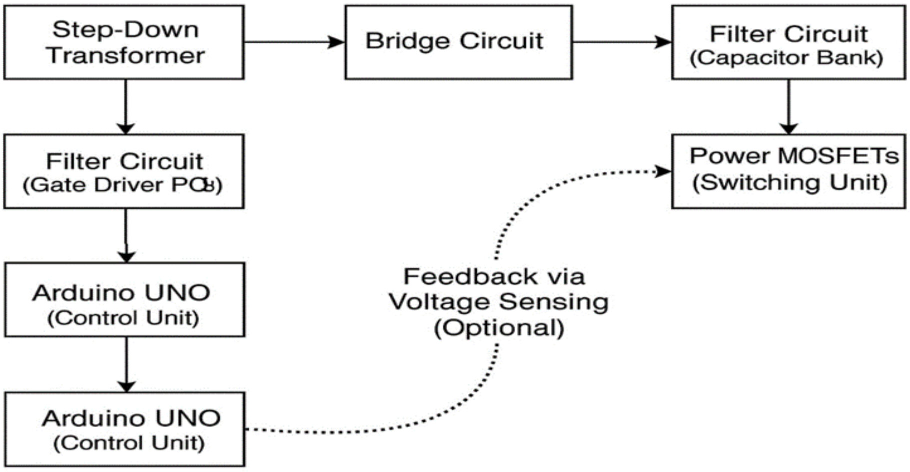

Figure 9: Block diagram representation of experimental validation

This simulation captures a realistic battery charging scenario using power electronics (likely a buck or boost converter). The pulsed current and voltage patterns indicate switching operations, while the steady rise in SOC confirms that energy is being effectively stored. Accurate control of energy flow, current injection, and SOC monitoring is essential for performance and battery life.

5. Experimental Validation

The block diagram in Figure 9 illustrates a power conversion and control system that utilises a combination of hardware components and microcontroller-based control. The process begins with a step-down transformer, which reduces the high input AC voltage to a safer and manageable level. This AC voltage is then passed through a bridge rectifier circuit to convert it into DC. To remove any ripples from the rectified voltage, a filter circuit using a capacitor bank is employed, ensuring a smooth DC output suitable for further processing. Following the filtering stage, Power MOSFETs are used in the switching unit to regulate the power flow. These MOSFETs operate based on signals received from the control unit and are essential for maintaining output stability, especially in dynamic load conditions. A separate filter circuit (Gate Driver PCB) is included to ensure that the MOSFETs receive clean, isolated gate signals, thereby preventing malfunctions and protecting sensitive components from voltage spikes.

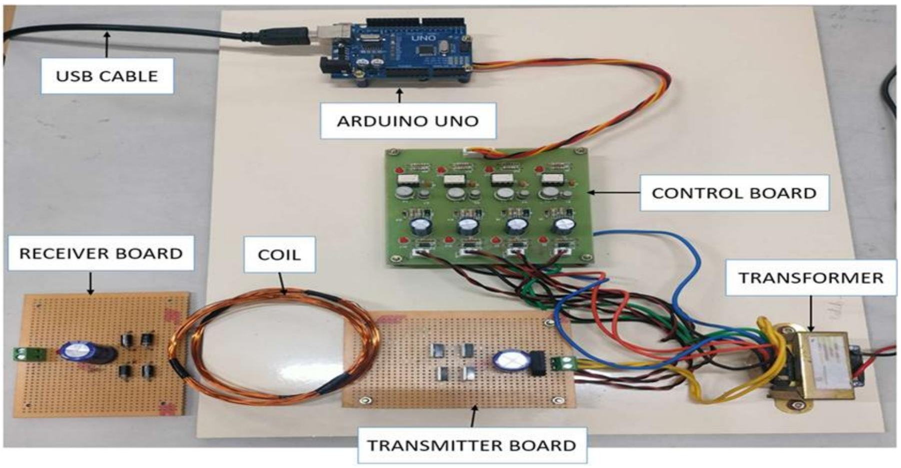

Figure 10: Real-time experimental validation

The system in Figure 10 is managed by two Arduino UNO boards functioning as the control units. These microcontrollers process input from sensors and the gate driver circuit, generating appropriate control signals for the power MOSFETs. The first Arduino handles initial signal conditioning and logic processing, while the second Arduino is responsible for executing control algorithms and coordinating switching actions for output regulation. An optional feedback loop via voltage sensing is integrated into the system. This allows the second Arduino to monitor the output voltage and make real-time adjustments to the switching pattern. Such a feedback mechanism enhances the system's reliability and responsiveness by automatically correcting voltage fluctuations, making the setup suitable for applications requiring stable and regulated DC output.

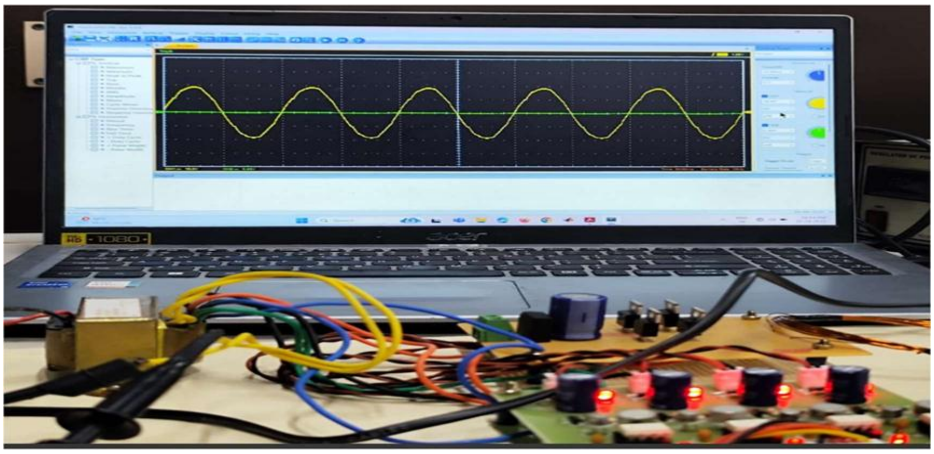

Figure 11: Input terminal voltage given to the power circuit

Figure 11 shows the input terminal voltage, displaying a typical sinusoidal waveform, indicating an AC voltage input. The smooth and repetitive wave pattern confirms a stable AC supply to the circuit.

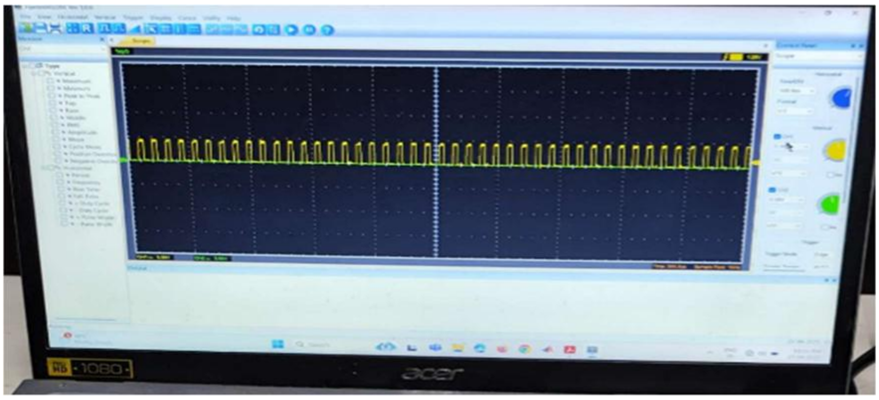

Figure 12: Control pulse generation using arduino

Figure 12 shows a pulse waveform generated by an Arduino, displaying a consistent square wave pattern. The waveform indicates regular switching between high and low voltage levels, typical of PWM (Pulse Width Modulation) signals. This waveform shows a PWM (Pulse Width Modulation) signal observed at the driver board, characterised by rapid, repetitive high and low voltage pulses. The consistent pulse pattern indicates stable switching control for driving a load, such as a motor or power device.

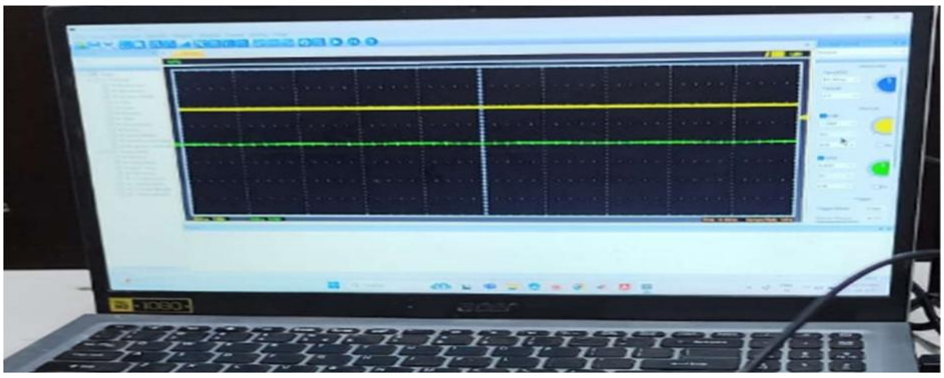

Figure 13: Output side receiver voltages

Figure 13 shows the output receiver voltage, where the waveform appears as a stable DC signal with very little ripple. The flat, constant voltage line indicates successful rectification and filtering at the receiver side.

6. Conclusion

This study successfully demonstrates a 5kW Wireless Power Transfer (WPT) system for electric vehicle (EV) charging using MATLAB Simulink simulations. The results validate the effectiveness of the proposed system in achieving efficient and controlled power transfer without physical connections. The battery voltage graph confirms a stable and regulated increase in voltage during the charging process, reaching 380V, ensuring safe operation within predefined limits. The battery current profile indicates a smooth transient response with a peak current of 14A, maintaining operational stability and preventing overcurrent risks. The variation in state of charge (SOC) further supports the efficiency of the WPT system, showing a gradual and controlled increase in SOC from an initial 51.644%. This steady rise indicates optimal energy absorption, minimising stress on the battery while ensuring effective charging. The transient response observed at 0.02s highlights the activation of power transfer, demonstrating the dynamic performance of the system in real-time conditions. The results validate that the wireless power transfer system effectively delivers energy without excessive fluctuations, ensuring a reliable charging solution for EV applications. The absence of abrupt changes in voltage and current profiles indicates minimal electromagnetic interference and system stability, making it a viable solution for real-world implementation. Future enhancements could focus on improving the efficiency of inductive coupling, optimising coil design, and integrating adaptive control strategies to further refine power transfer characteristics. Additionally, experimental validation can be conducted to bridge the gap between simulation and practical implementation, ensuring a seamless transition of WPT technology into commercial EV charging infrastructure.

Acknowledgment: The authors declare that there is nothing to disclose for this study.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request. All authors confirm that the data have been handled with integrity and transparency.

Funding Statement: This research work was conducted without any external financial assistance or funding. All authors contributed equally to the study, utilizing both institutional resources and personal efforts.

Conflicts of Interest Statement: The authors declare that there are no conflicts of interest related to this work. The study is an original contribution by the authors, and all references and citations have been appropriately acknowledged.

Ethics and Consent Statement: This research complies with all relevant ethical standards. Informed consent was obtained from all participants involved in the study, and all authors jointly affirm adherence to institutional and ethical research guidelines.

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