INTEGRATED WIRELESS CHARGING RECEIVER FOR ELECTRIC VEHICLES WITH DUAL INVERTER DRIVES

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ABSTRACT

Wireless/contactless charging of electric vehicles can improve the safety and convenience of the electric vehicle charging process. However, in order to enable wireless charging on an electric vehicle, additional components need to be added to the vehicle, which increase the cost, and weight of the vehicle. Specifically, a wireless receiver coil and power electronics are required to receive the wireless power and charge the battery. This work proposes a new integrated wireless charger, which reuses the existing drive- train components, such as the traction inverters and the motor, to serve as the receiver-side power electronics for wireless charg- ing. Importantly, this topology limits the high frequency currents entering the traction components, such as the motor, which are susceptible to high frequency losses. The drivetrain can serve to control the charging rate of the batteries, which eliminates the need for transmitter side battery charging control and communi- cation. Experimental validation was done by coupling a 110 kW EV machine and dual-inverter drivetrain to a 6.6 kW wireless transmission system. A peak charging efficiency of 94.3% over a vertical coil distance of 200 mm was achieved.

Index Terms—Battery charging, dual-inverter, electric vehicle, integrated charging, motor drives, wireless charging.

1. INTRODUCTION:

Various integrated chargers have been proposed in literature, based on different drivetrain configurations. A simple solution proposed demonstrated ac charging from a single phase grid by connecting the grid through a diode bridge between the motor's neutral point and the negative dc terminal of the battery. In this case, the traction inverter was operated as a three-phase power factor correction (PFC) boost converter. Renault's commercially sold integrated charging solution involves using a current source converter front-end to interface the drivetrain to the grid. An interesting topology based on the dual-inverter drive architecture was introduced, where a silicon carbide (SiC) active front end was added to allow bidirectional ac charging at up to 19.2 kW. Peak efficiencies of 97% were reported.

2. OBJECTIVE :

The main objectives of an integrated wireless charging receiver for electric vehicles with dual inverter drives are to improve overall system efficiency, reliability, and flexibility in EV power management. The system aims to enable efficient contactless power transfer using advanced wireless charging techniques while minimizing energy losses and ensuring safe operation. Another key objective is to integrate dual inverter drives to simultaneously manage propulsion and battery charging, allowing better utilization of power and seamless switching between driving and charging modes. The design also focuses on reducing system size, weight, and cost through integration of components, thereby enhancing compactness and practicality for real-world applications. Additionally, it seeks to improve power quality, maintain stable voltage and current levels, and support bidirectional power flow where required. Ultimately, the objective is to develop a high-performance, intelligent, and scalable solution that enhances the convenience, efficiency, and sustainability of electric vehicle charging systems.

3. PROBLEM STATEMENT :

The rapid adoption of electric vehicles (EVs) has intensified the need for efficient, reliable, and user-friendly charging solutions. Conventional plug-in charging systems present challenges such as cable management, wear and tear, safety risks, and inconvenience to users. Although wireless power transfer (WPT) technology offers a promising alternative, existing wireless charging receiver systems often suffer from low efficiency, misalignment sensitivity, limited power transfer capability, and poor integration with vehicle drive systems. In particular, EVs equipped with dual inverter drives—commonly used to enhance performance, torque distribution, and energy efficiency—face additional complexity in effectively managing power flow between the wireless charging receiver and the propulsion system. The lack of a well-integrated architecture that seamlessly combines wireless charging with dual inverter drives leads to increased energy losses, control difficulties, and higher system costs. Therefore, there is a critical need to develop an integrated wireless charging receiver system for EVs that can efficiently interface with dual inverter drives, ensure stable power transfer under varying alignment conditions, optimize energy utilization, and enhance overall system performance while maintaining safety and reliability.

4. EXISTING SYSTEM:

The existing system of an Integrated Wireless Charging Receiver for Electric Vehicles (EVs) with dual inverter drives typically consists of an inductive power transfer (IPT) mechanism combined with power electronic converters to enable efficient energy transfer and motor operation. In this setup, a primary coil embedded in the charging infrastructure transmits power wirelessly to a secondary coil mounted on the vehicle. The received alternating current (AC) is then rectified into direct current (DC) and regulated using power conditioning circuits. This DC power is shared between the battery charging unit and the dual inverter drive system, which independently controls two electric motors or a dual-motor configuration for improved traction and performance. The dual inverter drives enhance system reliability and flexibility by allowing independent speed and torque control, while also supporting regenerative braking. However, the existing systems often face challenges such as misalignment losses between coils, reduced efficiency under variable load conditions, increased system complexity, and higher cost due to multiple converters and control strategies.

4.1. DISADVANTAGES:

High System Complexity

The integration of wireless charging with dual inverter drives increases circuit complexity, making design, control, and maintenance more difficult.

Increased Cost

Dual inverters and wireless power transfer components (coils, compensation networks) significantly raise the overall system cost compared to conventional wired charging systems.

Lower Efficiency Under Misalignment

Wireless charging efficiency drops when there is misalignment between transmitter and receiver coils, leading to power losses and reduced performance.

Thermal Management Issues

High-frequency operation and power electronics generate heat, and managing temperature in both the wireless receiver and dual inverter setup becomes challenging.

5. PROPOSED SYSTEM:

The proposed system for an integrated wireless charging receiver for electric vehicles (EVs) with dual inverter drives focuses on enhancing efficiency, flexibility, and seamless energy transfer. In this design, a wireless power transfer (WPT) system is employed using resonant inductive coupling between a ground-side transmitter coil and a vehicle-mounted receiver coil, eliminating the need for physical connectors. The received AC power is rectified and conditioned through a high-efficiency power electronic interface, which is then fed into a dual inverter drive system. The dual inverter configuration enables independent or coordinated control of two electric motors, improving traction performance, fault tolerance, and energy utilization. Additionally, the system incorporates advanced control strategies to regulate power flow, maintain voltage stability, and optimize charging under varying alignment and load conditions. By integrating wireless charging with dual inverter drives, the proposed system supports dynamic charging capability, reduces charging downtime, and enhances overall vehicle performance, making it a suitable solution for next-generation smart and sustainable electric mobility.

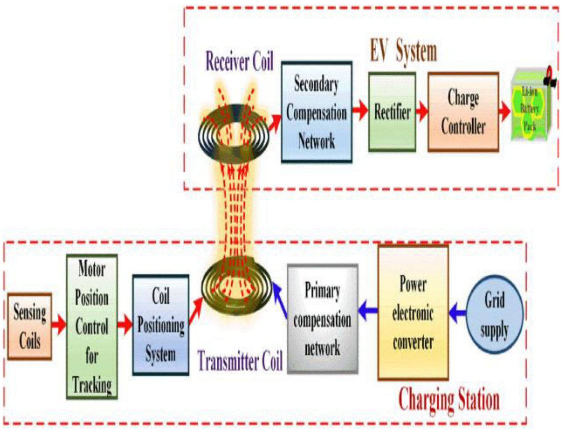

Fig.1. ARCHITECTURE DIAGRAM

5.1. WORK DESCRIPTION:

The diagram illustrates an integrated wireless charging system for electric vehicles (EVs), consisting of two main sections: the charging station (transmitter side) and the EV system (receiver side). On the charging station side, power from the grid supply is first processed through a power electronic converter and then passed through a primary compensation network to enhance efficiency. The conditioned power is supplied to the transmitter coil, which generates an alternating electromagnetic field. This field is wirelessly transferred to the receiver coil mounted on the EV through inductive coupling.

On the EV side, the receiver coil captures the transmitted energy and feeds it into a secondary compensation network to stabilize and maximize power transfer. The output is then rectified into DC power using a rectifier, which is further managed by a charge controller to safely charge the vehicle's battery. Additionally, the system includes sensing coils and a motor position control mechanism on the transmitter side to ensure proper alignment (tracking) between the transmitter and receiver coils, which is critical for efficient energy transfer. Overall, the system demonstrates a contactless, efficient, and intelligent wireless charging solution for EVs.

5.2. ADVANTAGES:

The integrated wireless charging receiver system for electric vehicles with dual inverter drives offers several important advantages. Firstly, it enables contactless power transfer, eliminating the need for physical plugs and reducing wear, maintenance, and safety risks such as electric shocks or sparking. The use of resonant inductive coupling ensures efficient energy transfer even with slight misalignment between transmitter and receiver coils, making it user-friendly and reliable.

Another key advantage is the dual inverter drive system, which allows independent control of multiple motors. This improves vehicle performance, enhances torque distribution, and increases fault tolerance—if one inverter fails, the other can continue operation, ensuring reliability. The system also supports dynamic charging, meaning vehicles can be charged while in motion, significantly reducing downtime and extending driving range.

6. LITERATURE SURVEY:

1. Semsar, Luo, Nie, Lehn (2025)

- Title: Integrated Wireless Charging Receiver for Electric Vehicles With Dual Inverter Drives
- Authors: Sepehr Semsar, Zhichao Luo, Shuang Nie, Peter W. Lehn
- Contribution:
    - Proposed an integrated wireless charging receiver using dual inverter drives.
    - Reuses existing EV components (traction inverter + motor) for charging.
    - Enables high power transfer (>100 kW) and reduces additional hardware cost.
    - Eliminates need for separate onboard chargers, improving efficiency and compactness.

2. Mubarak et al. (2024)

- Title: Wireless power transfer for deep-cycle lithium-ion batteries in EVs
- Authors: Ansa Mubarak, Arslan Ahmed Amin, Muhammad Ahmad, Muhammad Furqan Shafique, Muhammad Shaheer Zafar
- Contribution:
    - Designed a resonant inductive wireless charging receiver system.
    - Focus on efficient receiver coil design and impedance matching.
    - Used simulation tools (ANSYS, MATLAB) for optimizing receiver performance.
    - Highlights importance of receiver circuit design in WPT efficiency.

3. Ramakrishnan et al. (2024)

- Title: High misalignment-tolerant wireless charger for EVs
- Authors: V. Ramakrishnan et al.
- Contribution:
  - Developed a receiver system tolerant to coil misalignment.
  - Implemented constant current/constant voltage (CC/CV) charging control.
  - Improves reliability of wireless charging under real-world parking conditions.
  - Important for practical deployment of integrated wireless receivers.
  - Emphasizes future need for high-power inverter-based receiver systems.
  - Relevant for extending dual inverter receiver concepts to dynamic charging.

7.IMPLEMENTATION METHODOLOGY:

1. System Architecture Design

- Develop a unified architecture combining wireless power transfer (WPT) receiver and dual inverter drive system.
- Key components: receiving coil, compensation network, rectifier, DC link, and dual inverters for motor drives.
- Ensure compatibility between charging and propulsion modes.

2. Wireless Power Transfer Receiver Design

- Design the secondary (receiver) coil optimized for high efficiency and alignment tolerance.
- Implement resonant compensation topology (Series-Series or LCC) to maximize power transfer.
- Tune the system for operating frequency (typically 85 kHz for EV standards).

3. AC–DC Conversion and DC-Link Integration

- Convert received AC power into DC using a high-efficiency rectifier (diode or active rectifier).
- Stabilize voltage using a DC-link capacitor.
- Integrate battery charging and inverter supply through a common DC bus.

4. Dual Inverter Drive Configuration

- Use two inverters to drive dual motors or improve torque control.
- Implement control strategies like:
  - Field-Oriented Control (FOC)
  - Space Vector PWM (SVPWM)
- Ensure smooth transition between charging and driving modes.

5. Control and Energy Management System

- Develop a central controller (DSP/FPGA/microcontroller).

- Functions include:
    - Power flow management between battery and motors
    - Mode switching (charging ↔ driving)
    - Load balancing between dual inverters
- Include feedback loops for voltage, current, and efficiency optimization.

6. Safety, Efficiency, and Testing

- Implement protection mechanisms:
    - Overvoltage, overcurrent, thermal protection
- Ensure electromagnetic compatibility (EMC) and alignment detection.
- Test under various conditions (misalignment, load variation, efficiency analysis).

8.RESULTS AND DISCUSSION:

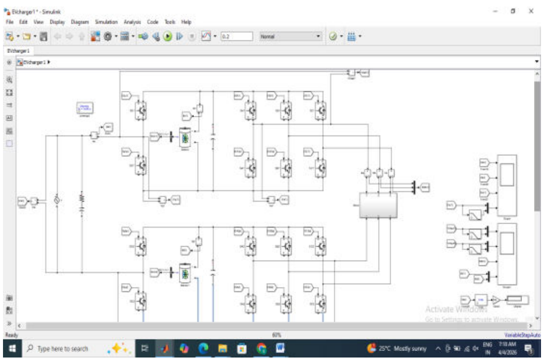

Fig 8.1 Main Diagram

The proposed system is simulated in order to show the prin- ciple of operation. The full-switched model of the system was simulated in MATLAB/SIMULINK with the parameters given in Table. These parameters are extracted from the developed full-scale experimental system.

SIMULATION AND EXPERIMENTAL PARAMETERS

Integrated Charger Parameters	Symbol	Value
Machine dc phase resistance	R_s	45 mΩ
Machine leakage inductance	L_s	0.5 mH
Battery voltages (nominal)	V_{b1}, V_{b2}	350 V
Rectifier Capacitors	C_1, C_2	20 μF
Traction inverter switching frequency	$f_{sw,inv}$	10 kHz
Wireless Parameters	**Symbol**	**Value**
Transmitter DC link	V_{in}	650 V
Transmitter full bridge switching frequency	f_{TX}	85 kHz
Transmitter Dimensions	-	650 mm × 410 mm
Transmitter Self-inductance	L_p	515 μH
Transmitter Compensation Capacitor	C_p	6.8 nF
Transmitter-Receiver Mutual inductance	M	21.5 - 24.6 μH
Receiver Dimensions	-	330 mm × 330 mm
Receiver Self-inductance	L_s	101 μH
Receiver Compensation Capacitor	C_s	34.5 nF
Misalignment (worse case)	$\Delta x, \Delta y$	75 mm, 100 mm
Coil-to-Coil Distance	z	200 mm

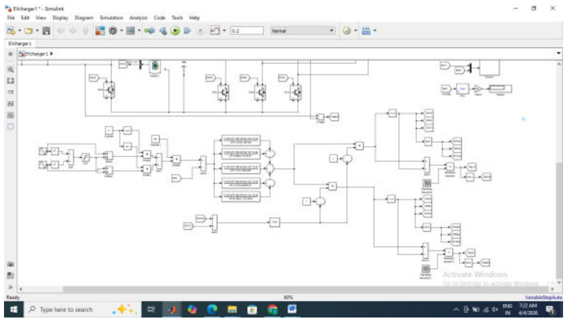

Fig 8.2 Control Diagram

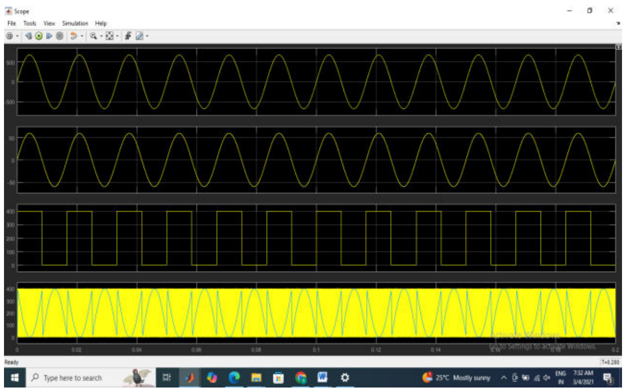

Fig 8.3 a.Vac b.Iac c.Vab d.Vg

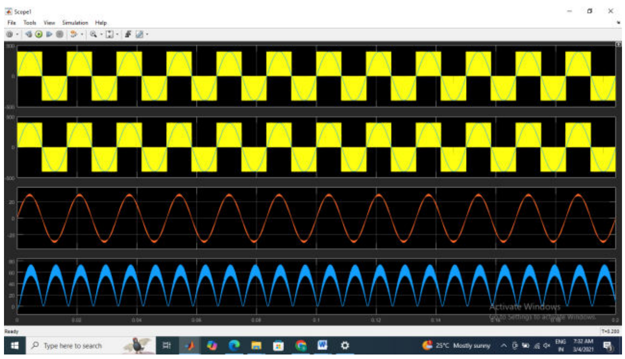

Fig 8.4 a.Vcharge1 b. Vcharge2 c.Isabc d.Ib1&Ib2

9. CONCLUSION :

The proposed integrated wireless charging receiver combined with dual inverter drives represents a significant advancement in electric vehicle (EV) power systems. By merging wireless power transfer with propulsion control, the system enhances overall efficiency, compactness, and functionality.

The use of dual inverter drives enables improved motor control, better torque distribution, and increased reliability, especially in applications requiring high performance and redundancy. Simultaneously, the wireless charging receiver eliminates the need for physical connectors, offering greater convenience, reduced wear and tear, and improved safety in charging operations.

The integration of these two systems allows for optimized energy management, reduced component count, and better utilization of onboard power electronics. This results in improved system efficiency, lower maintenance requirements, and enhanced user experience.

Furthermore, the design supports bidirectional power flow, making it suitable for advanced applications such as vehicle-to-grid (V2G) systems. Despite challenges like alignment sensitivity, electromagnetic interference, and cost considerations, ongoing advancements in power electronics and control strategies continue to address these limitations.

In conclusion, this integrated approach provides a promising solution for next-generation electric vehicles by combining efficient wireless charging with robust motor drive control, paving the way for smarter, more reliable, and user-friendly EV systems.

10.FUTURE SCOPE:

The future scope of an integrated wireless charging receiver for electric vehicles with dual inverter drives is highly promising, particularly with advancements in high-frequency power electronics, smart grid integration, and autonomous mobility. Future developments may focus on improving power transfer efficiency through advanced resonant topologies and better alignment techniques, while reducing electromagnetic losses and system cost. Integration with vehicle-to-grid (V2G) technology can enable bidirectional energy flow, allowing EVs to act as mobile energy storage units. The use of artificial intelligence and IoT can further optimize charging control, fault detection, and energy management in real time.Additionally, scaling the system for dynamic wireless charging—where vehicles charge while in motion—along with enhanced battery technologies and standardized infrastructure, will significantly expand the practical adoption and performance of such systems in next-generation electric mobility.

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