



IMPLEMENTATION OF A BRIDGELESS MANITOBA RECTIFIER TOPOLOGY FOR HIGH-EFFICIENCY WIRELESS POWER TRANSFER

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Abstract:

Wireless power transfer (WPT) enables the transmission of electrical energy without physical connections, commonly used in charging devices and electric vehicles. Traditional methods often face drawbacks such as limited range, inefficiencies in energy transfer, and high costs associated with infrastructure. And also electromagnetic interference can hinder widespread adoption. Therefore this project proposes a Bridgeless Manitoba Rectifier aimed at enhancing the efficiency of wireless power transfer systems for charging applications. This work presents the design and control of an isolated AC–DC power conversion system based on a high-frequency link architecture. The system converts an AC source into a regulated DC output suitable for sensitive loads while ensuring galvanic isolation, high power density, and improved efficiency. The input AC voltage is first processed through a source inductance stage and a bridgeless rectifier to reduce conduction losses and improve power factor performance. The rectified DC is then fed to a single-phase high-frequency inverter, which generates high-frequency PWM signals using DSP-based controllers and gate driver circuits (TLP250). Finally, this project is implemented by DSPIC30F4011 Controller.

1. Introduction:

Wireless Power Transfer (WPT) is a revolutionary technology that enables the transmission of electrical energy without physical connectors or wires. This method of energy transfer is based on the principles of electromagnetic induction, resonant inductive coupling, or capacitive coupling. Unlike traditional power delivery systems, WPT eliminates the need for direct electrical contact, making it a safer, cleaner, and more convenient solution for powering and charging devices. The concept of wireless energy dates back to the early 20th century when Nikola Tesla first demonstrated wireless power transmission, but only in recent decades has this technology become viable for practical and commercial applications due to advancements in power electronics, control systems, and materials science. The primary motivation behind wireless power systems is to enhance mobility and reduce dependency on bulky or vulnerable cable connections.

2. Related Works:

Various research works related to wireless power transfer systems, power conversion stages, Manitoba rectifier topology are reviewed in this section.

A. Need for Wireless Power Transformer:

The need for Wireless Power Transfer (WPT) arises from the increasing demand for convenience, safety, and efficiency in power delivery systems. Traditional wired power transmission methods, while widely used, suffer from several inherent limitations such as physical wear and tear, wire clutter, contact corrosion, and safety hazards due to exposure to electricity. WPT provides an innovative solution to these issues by enabling contactless energy transfer, offering a cleaner and more flexible alternative to conventional methods. One of the primary reasons for adopting WPT is enhanced mobility and convenience. In applications like mobile phone charging or wearable electronics, users are often constrained by the presence of cables. Wireless power allows charging without direct connection, enabling seamless user experiences and reducing cable-related failures. Similarly, in medical devices such as pacemakers or implanted sensors, wireless energy transfer is essential because wired connections through the skin are not only impractical but also pose infection risks.

B. Basic Principle of Operation:

Wireless Power Transfer (WPT) operates on the principle of electromagnetic field coupling, allowing electrical energy to be transmitted from a power source to a load without physical wires. The fundamental idea is based on Faraday's Law of Electromagnetic Induction, which states that a time-varying magnetic field can induce a voltage (electromotive force) in a nearby conductor. WPT systems typically rely on magnetic coupling (inductive or resonant) or electric field coupling (capacitive), depending on the application, range, and efficiency requirements.

C. Design and Construction:

The design and construction phase is a critical part of any Wireless Power Transfer (WPT) system. It involves the hardware layout, component selection, circuit architecture, coil design, and overall integration of the transmitter and receiver sides to ensure efficient energy transfer.

5. Results:

An AC source is used as input, with voltage boosted through a bridgeless Manitoba rectifier. The system integrates a DSPIC30F4011 controller with an isolation transformer for effective power tracking, and the performance outcomes are analyzed using a digital storage oscilloscope.

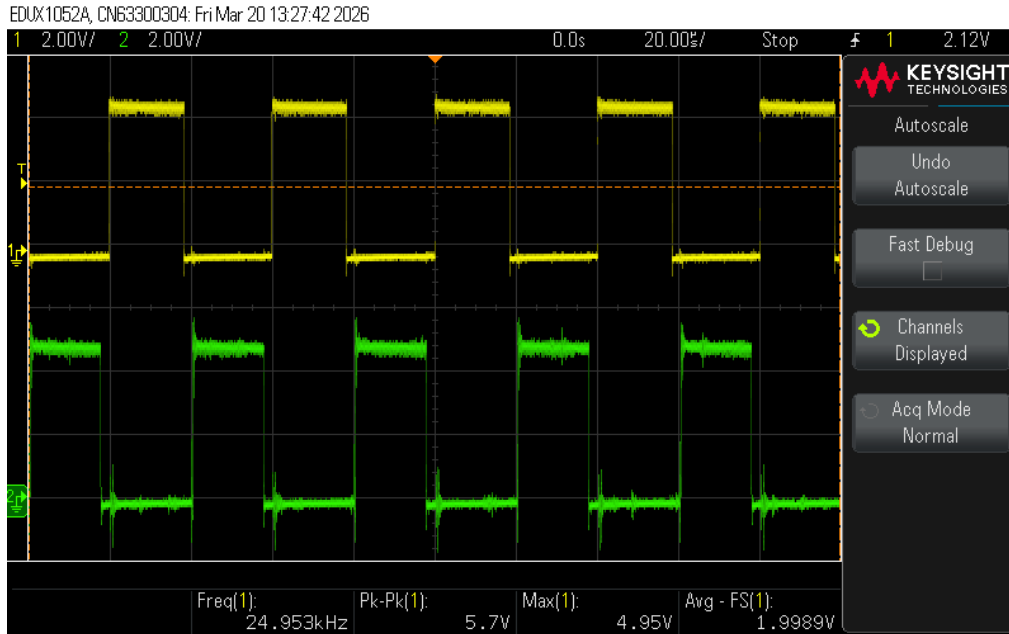


Figure 3: High frequency Inverter PWM 1&2

The measured waveform indicates a frequency of approximately 50 Hz. This AC input is supplied to the converter, where it is processed and boosted to obtain a higher voltage output for the proposed system.

The low input voltage obtained from the AC source is boosted using the proposed rectifier. The corresponding waveform indicates a clear rise in voltage level, demonstrating effective conversion, with the output voltage reaching approximately 32.4 V.

The waveforms exhibit synchronized switching across both inverter legs, ensuring balanced operation. Uniform pulse timing and amplitude indicate stable modulation, confirming effective control of the voltage source inverter for reliable and efficient high-frequency power conversion.

S.No	Device Name	Range / Specification
1	dsPIC30F4011 (Controller)	Operating Voltage: 5 V, 10-bit ADC
2	TLP250 (Driver Circuit)	Supply Voltage: 35 V, Output Current: 1 A
3	MOSFET IRF840 (Switch)	Voltage: 500 V, Current: 8 A, 150 MHz
4	1N4007 Diode	Voltage: 1000 V, Current: 1 A
5	Switching Frequency	50 kHz

6. Conclusion:

In conclusion, the proposed wireless power transfer system using a bridgeless Manitoba rectifier demonstrates significant improvements in efficiency, power quality, and overall system performance. By eliminating conventional diode bridge losses, the system enhances energy conversion efficiency and reduces thermal stress. The integration of a high-frequency link with an isolated AC–DC converter enables compact design, reduced transformer size, and improved power density. The use of a DSP-based controller (DSPIC30F4011) with PWM generation ensures precise control and stable operation under varying load conditions. Additionally, the implementation of dual PI controllers provides effective regulation of both voltage and current, maintaining system reliability. The inclusion of an interleaved synchronous rectifier further minimizes ripple and enhances output stability. Overall, the system successfully addresses the limitations of traditional wireless power transfer methods, such as inefficiency and electromagnetic interference, making it suitable for modern charging applications including electric vehicles and portable devices.

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