An Eminent Design for Wireless Power Transfer Using Rectenna Module Using Interleaved Boost Converter to Increase the Power Efficacy Delivered to the Biomedical Device

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Abstract. In recent "on-the-go (OTG)" trend people depend heavily on wireless technologies which made human life much ease in accessing the data with reduced latent speed. Today, all gadgets including portable music players, headphones, smart watch, gaming console, etc. are wireless. With booming technological development, transferring power in wireless mode is always a challenging task from ancient period. One of the eminent techniques in wireless power transfer is transmitting the power via electromagnetic signals. In this paper, a receiver which receives this wireless power is designed with an antenna module called Rectenna. Using this rectenna an inverter module is also designed which can deliver power to the practical load connected with it. In addition, this Rectenna module is simulated in the MATLAB Simulink environment with an eminent "Interleaved Boost Converter" to boost the signal to higher level to power the load/biomedical device.

Keywords - Rectenna, Wireless Power Transfer, Interleaved Boost Converter

1. Introduction
The term wireless involves in transmitting the information to longer distance without any physical medium [1]. In recent years, wireless technologies become an integral part for several communication devices viz. cordless telephones, mobiles, Zigbee Technology, etc. Much advancement has been made in wireless technology in the development of latent.

1.1. Basic Rectenna Design

The above Figure 1 depicts the basic block module of Rectenna Design and its internal components are explained below.
Antenna Design - Dipole/Rhombic patch/Helical/Loop/Strip antennas can be used depending on the gain factors which is capable of receiving the ISM signal [2].

RF Filter/Matching Circuit – Signal when travel in free space it procures noise factor this RF Filter design is used to eliminate the noise factor in the signal and makes it to be ripple free for rectification process [3]. This also provides a perfect impedance matching with the Rectification circuit.

Rectification – Signals travel in free space are of alternating in its types and this block converts the alternating signal to DC Signal which is suitable for battery charging [4]. The main components in the rectification unit is Diode, basically Schokkty Diodes are used for effective rectification because of its Low voltage drop, Short recovery time & Fast switching characteristics [5].

In this paper, the novel Rectenna design is formulated as Signal generator (Antenna), Filter Mask (RF Filter) & Diodes (Rectification). These components are depicted to simulate the function of Rectenna design.

This research article focuses on converting wireless electromagnetic signals into electrical signals by using a rectifying antenna design called “Rectenna” which consists of internal Schokky diodes for its operations. The converted electrical signals are then boosted with “Interleaved Boost Converter” and the resultant power is then delivered to load especially it can be a biomedical device [6].

1.2. Block Diagram of proposed model

![Proposed Block Diagram](image)

**Figure 2 Proposed Block Diagram**

In this proposed model Figure 2, initially the electromagnetic signal is converted into electrical signal by a rectenna module, after the rectification process the signal is boosted to a higher order value by an eminent interleaved boost converter circuit. Finally, the boosted DC signal is again converted into AC signal by an IGBT based inverter module to power-up the load.

2. Elucidation of the proposed module by Rectenna

The major principle of rectenna design is to receive electromagnetic signal via antenna strip and pass it to a rectifying unit which contains diodes for rectification [7-10]. To formulate this design in MATLAB environment we use Signal Generator as a model of Rectenna which produces the signal corresponding to electromagnetic frequency [11-14]. After rectification process the signal is boosted to a higher level by interleaved boost converter and then finally it is passed to an inverter design to power up the load [15-16].
2.1. Simulink model of the proposed design

In the above Figure 3, it clearly depicts the overall Simulink design of the proposed model which consists of Rectification unit, Interleaved Boost Converter unit, Inverter Unit for its effective energy conversion.

2.2. Conversion of Electromagnetic Signal to Electrical Signal

This process is depicted with signal generator and rectification unit which is shown in Figure 4, initially the signal generator is pre-set by a sinusoidal waveform with amplitude level 5v and frequency 5 KHz, then the signal is fed to controlled voltage source which converts the Simulink voltage to equivalent voltage source. Then the signal is passed to a bridge rectifier circuit which has four diodes (D1, D2, D3 & D4) in parallel with RC snubber circuit. The internal diode circuitry has resistance of 0.001 (R) ohms, forward voltage (Vf) of 0.8V, snubber resistance (Rs) 500 and snubber capacitance (Cs) of 250 x e^-9. This assembly converts the sin wave of 5V/5Kh into a voltage.

3. Interleaved Boost Converter

The design of Inter-leaved boost converter comprises of two boost convert circuit which operates at 180 out of phase which is shown in Figure 5. The current at the input side is the sum of two inductors L1 and L2, this is because the inductors ripple current is out of phase and they cancel each other which reduces the input-ripple current. The effective inductor-ripple current occurs at 50% duty cycle.

The output-capacitor current is the sum of two diodes currents ((D1 + D2) – DC output current), which reduces the output-capacitor ripple, “Iout” as a function of duty cycle. As the duty cycle approaches 0,50 and 100% the sum of two diode currents approaches DC. At this point the output capacitor filters the inductor ripple current. In addition, this interleaved
The boost converter is powered by two MOSFET (1&2) with the FET resistance of 0.1 ohms, internal diode resistance of 0.01 ohms in which the gate is pulsed with a pulse generator (1&2) of amplitude level of 4 with 80% of its duty cycle.

### 3.1 Interleaved Boost Converter Design

![Figure 5 Simulink design of Interleaved Boost Converter Design](image)

### 3.2 Pulse Generator – (Scope 1)

![Figure 6 Output of Pulse Generator](image)

### 3.3 Output of Interleaved boost converter – (Scope 2)

![Figure 7 Output of Interleaved Boost Converter](image)

With this boost circuit design, it is more evident that the applied voltage of 4.857 V is boosted to 40V with an initial peak of 68 V and settles down point of 40V which is shown in the Figure 6 & Figure 7. Finally, this depicts that the boosting factor is of ~10 times of the input signal.
4. Inverter Design

In Figure 8, the signal from the boost converter is fed to an inverter model which comprises of four “IGBT/Diode” (D1, D2, D3, and D4) with internal resistance of 1e-3 and the snubber resistance of 1e5. The gate of IGBT diode is triggered by a 2-arm bridge pulse generator with carrier frequency of 1080 Hz, modulation index of 0.4 and output frequency of 60 Hz. This diode arrangement converts the boosted DC signal to AC signal of 40V and 1.8 Amps. The circuit model and the simulated results are shown below.

![Simulink model of Inverter Design](image)

**Figure 8** Simulink model of Inverter Design

4.1 Output of the Scope 3 – (Waveform Corresponding to Voltage)

The Figure 9 depicts the “Voltage” level of 40V in its upper peak from the simulation model in Simulink.

![Waveform corresponding to Voltage](image)

**Figure 9** Waveform corresponding to Voltage

4.2 Output of the Scope 3 – (Waveform corresponding to Current)

This waveform in Figure 10, depicts the “Current” level of 1.8 A in its peak factor.

![Waveform corresponding to Current](image)

**Figure 10** Waveform corresponding to Current
5. Conclusion

Since wireless power transfer is of great interest nowadays, transferring power wirelessly still remains as challenging task. Research on transferring power via electromagnetic signal is of great interest in current scenario. In this paper a novel approach of converting electromagnetic signal to electrical signal is achieved by Rectenna design (depicted as signal generator) and thus obtained power is boosted to a higher value with an eminent boost converter circuit with interleaved concept. As a result, the entire model is simulated in MATLAB Simulink with 5v/5Khz as an input and achieved the output of 40V/1.8A with interleaved boost converter formulating the boosting factor (~8 times) than the input. The results and the output waveforms are the evidence for the conversion factor.

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