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Design and Implementation of a WPT System for Industrial Application.

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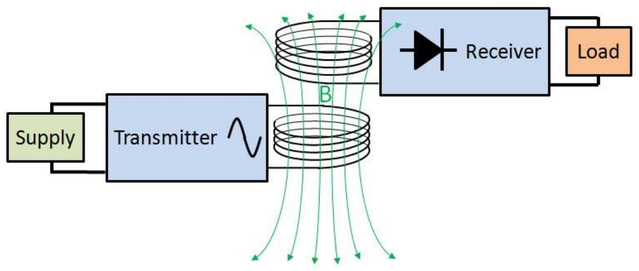
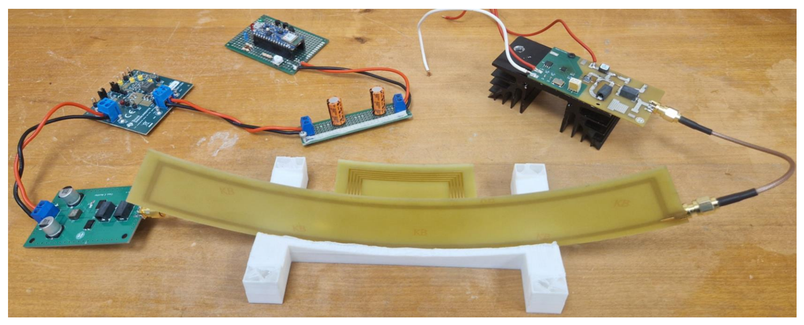
ABSTRACT: The paper presents the design and implementation of a WPT system operating at $13.56\ \mathrm{MHz}$, which is an ISM band, composed by a Class-EF power amplifier based on a GaN FET and a Class-E rectifier. The system is designed to provide power to an IoT node (power range of $1 \div 10$ W). Additionally, a dynamic application of the system is also presented.

KEYWORDS: Power Amplifier (PA), Wireless Power Transfer (WPT), Industrial Scientific and Medical Band (ISM), Internet of Things (IoT)

System description.

- Class-EF Load-Independent Power Amplifier
- $13.56\ MHz$ resonant coils system (inductive coupling)
- Class-E resonant rectifier
- Average power consumption of the IoT node $\cong 0.3W$
- WPT duty cycle $\cong 10\%$
- Peak power transmitted by the WPT system $\cong 10W$
- Achieved P.A. efficiency 90%
- ZVS kept throughout the specified load range



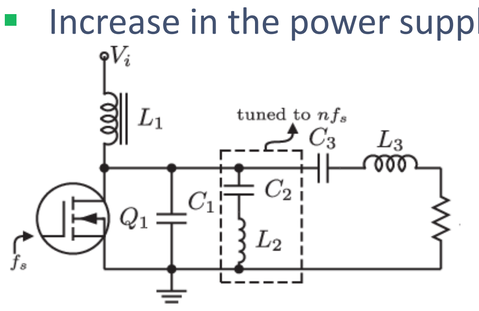


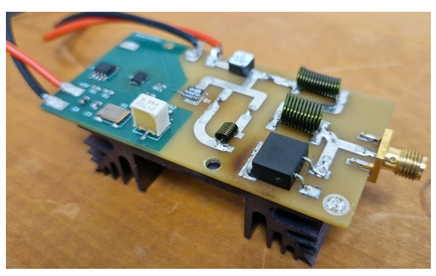
Class-EF Power Amplifier.

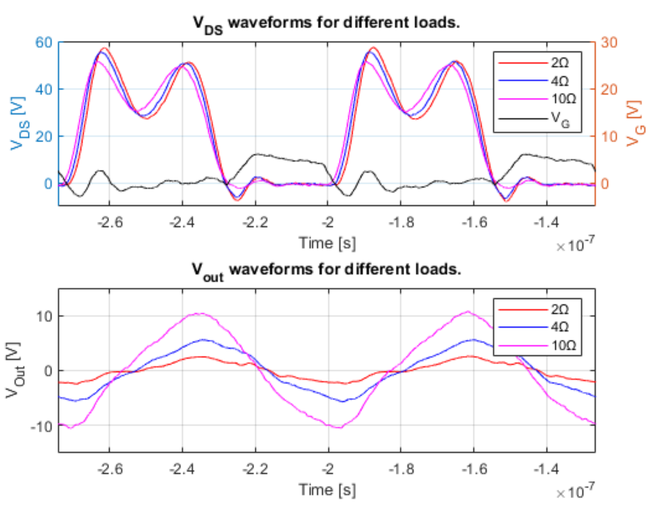
- Primary coil resonanting at f_s (C3 and L3)
- Shunt branch tuned to $\mathrm{n}f_s$ (L2 and C2)
- Single GaN-System GS61004B ($100V\ 38A$) as switching device
- Shunt capacitance C_1: including the device output capacitance

Load-Independent condition in the Load range of $2 \div 10\Omega$ achieved by setting n to 1.8 and increasing value of L_3:

- Constant current to the primary coil
- Stability of the P.A. (Zero Voltage Switching kept throughout the specified load range) in condition of coil misalignment
- Increase in the power supplied as the load increases

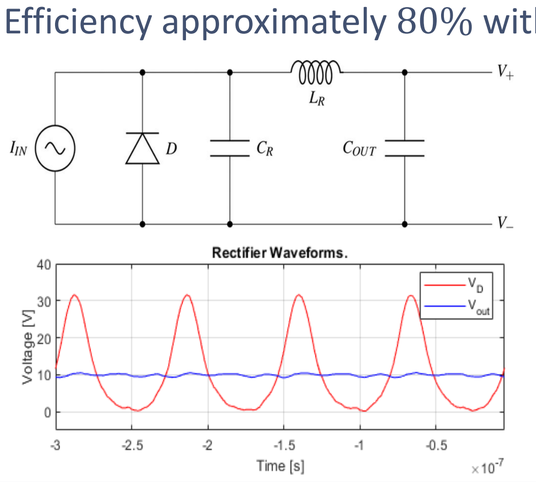


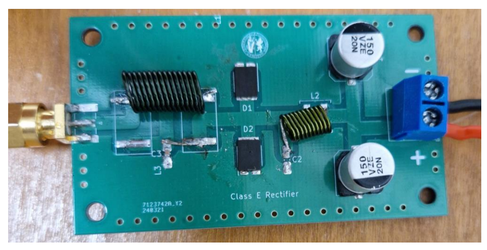




Class-E Rectifier.

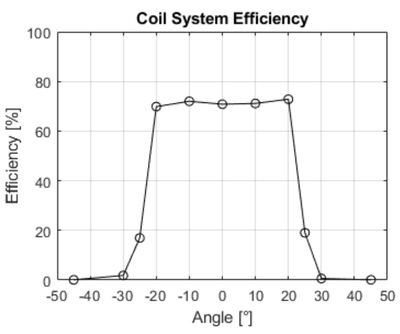
- Nexperia PMEG60T50ELP Schottky Diode ($60V\ 5A$);
- C_R (including diode capacitance) and L_R resonating $13.56\ MHz$
- C_{out} electrolytic capacitor for output voltage stabilization
- Efficiency approximately 80% with a 50Ω fixed load.





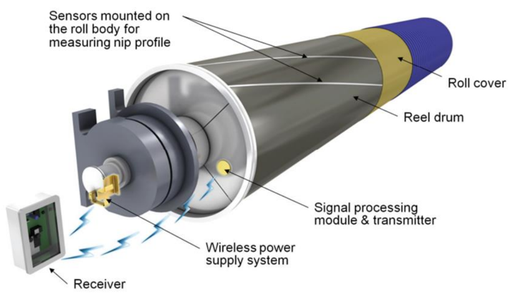
Coils System.

- Spiral covering an angular sector of a circular crown
- Impedance transformation $\cong 1:10$
- Inductance $\cong 1\mu H$
- Series-series compensation network (resonance at $13.56\ MHz$)



Summary information and conclusions.

The presented system is an upgrade of a previous WPT system working at $6.78\ \mathrm{MHz}$. The previous P.A. was an evaluation board with two GS61004B GaN FET in Push-Pull configuration, and the rectifier was based on a full bridge. The new system was made operate at 13.56 MHz to allow for both power and data (NFC protocol) transfer with the same coil system. The geometry of the coils is instead due to the application, since the WPT system is designed to supply power to an IoT node, used to provide pressure and sensor data while mounted on a spinning roll.



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