UNIVERSITY OF FLORIDA

Non-Contact Energy Delivery for PV System and Wireless Charging Applications

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Description: Innovative non-contact energy delivery method will be used in photovoltaic energy generation system to accelerate the system deployment. Instead of delivering electric power using cables penetrating through building structures, magnetic field coupling allows power to be transferred wirelessly through building walls and roofs. In the meantime, the DC electric energy from photovoltaic cells is converted to AC energy. This enables the photovoltaic system to be quickly set up or relocated, and the collected solar energy from outdoor system can be conveniently delivered to indoor appliances. Techniques to achieve high efficiency at high power delivery through different building structures will be studied for this plug-and-play architecture.

In addition, the technique and the system can also be used for non-contact charging of electric vehicles. The transmitter/charger can be placed as a mat on garage floor or parking space. The receiver inside vehicle will pick up the energy delivery through magnetic coupling. This eliminates the need of connecting charging wires to vehicles and exposed metal contacts, which is a safer method of charging electric vehicles.

Budget: $252,000
University: UF

Progress Summary

Simulations and measurements were performed with various amplifier topologies, shown in figure 1, in order to explore the advantages and disadvantages of each topology. Previous work was done with the Class E amplifier topology. Advantages of this topology include theoretical 100% efficiency, simple driving requirements and the use of a single active device. The major disadvantages of this topology, for the application of wireless power, are the tuning requirements. For a system with a fixed transmission distance, a single tuning is sufficient and has few disadvantages. For a variable transmission distance, the tuning circuit must be made to change in order to compensate for the variable load. Failure to adjust the tuning will lead to a decrease in efficiency, and if the amplifier falls out of zero voltage switching (ZVS) the active device can be destroyed. An additional constraint comes from the high drain voltage of the Class E topology. This limits the maximum power the system can transmit for a given V_{ds} breakdown voltage.

Class D amplifiers and variations, including the full bridge class D, are investigated as alternatives. The tuning circuit in this configuration is less sensitive to variations in

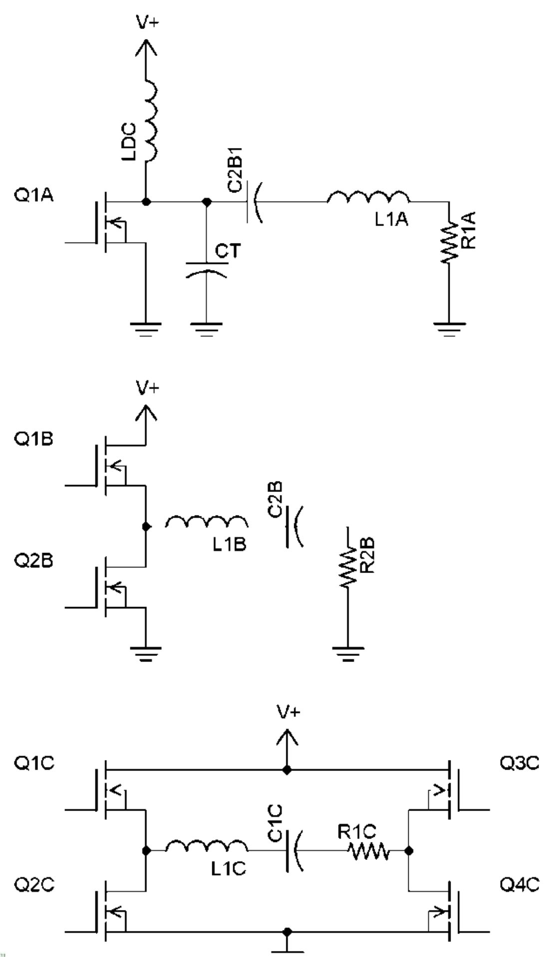

Figure 1. From top to bottom, Class E, Class D and Full-Bridge Class D amplifier topologies.

distance, as there is no requirement for ZVS, so as long as the tuning circuit is optimized for the correct frequency. Since the system is already operated at a series resonance determined by the self-inductance of the coils and a tuning capacitor, this can be used as the tuning circuit of the Class D amplifier. For Class D type amplifiers, there will be a minimum load Q below which efficiency drops sharply. Because of the way the load impedance is reflected to the transmit side, the Q requirement becomes an issue at short distances.

A full-bridge class D amplifier is constructed to drive the system. The full-bridge configuration is chosen because the total power capability is four times that of the half-bridge configuration for devices with the same ratings, or similar power from lower rated devices that may have other advantages, such as lower on resistance, lower C_{gs}, or lower C_{ds}. As before, the operating frequency is chosen to be near 500kHz. Tests performed at 508.5kHz with a full bridge class D amplifier showed efficiencies of 76% for transmitted power levels of up to 40W, up from a previous maximum power of 5.6W. The efficiency is fairly constant regardless of power level, and should remain so until the power dissipated in the windings of the coils reaches levels sufficient to increase the temperature of the wire. Figure 2 shows the efficiencies at different transmitted power levels.

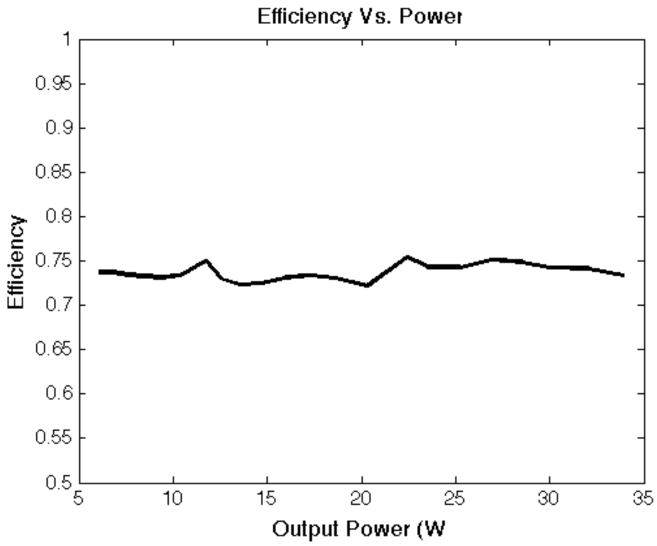

Figure 2. Measured efficiency for varying output power.

Testing at various distances was performed to verify the circuit model. Better than 50% efficiency is measured for a range of 50cm to 130cm, and a peak efficiency of 85.3% is measured at a distance of 76cm. The efficiency drops rapidly at short distances due to the lower Q_L seen by the amplifier.

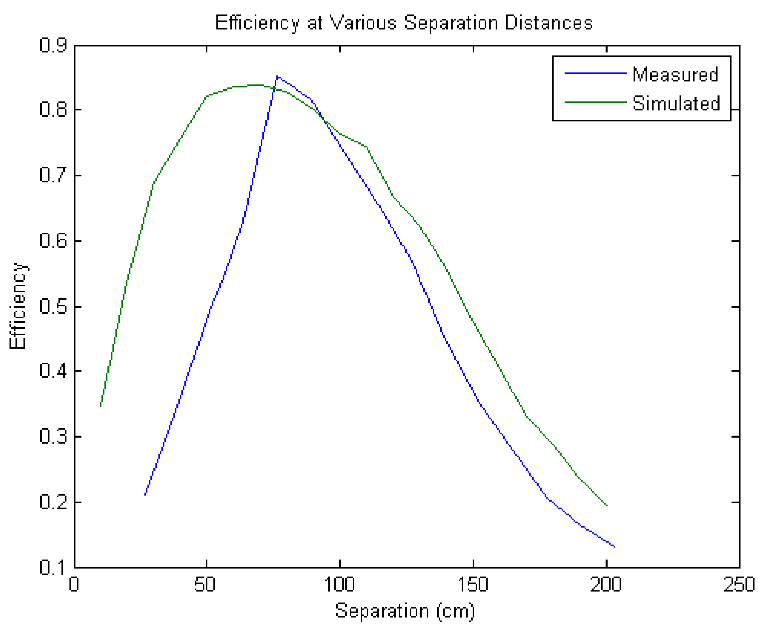

Figure 3. Comparison of measured and simulated efficiencies for a range of 0m to 2m.