

**EIRP of 50 kW resonant induction wireless power transfer system
(50 kW = maximum power in FCC Application File Nos. 0775-EX-PL-2014 and 0789-EX-PL-2014)**

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Momentum Dynamics

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Method

Consider the ground side coil as a small loop antenna. The word small means small with respect to wavelength at the operating frequency. Use standard expression to find the radiation resistance R_r of a small loop antenna. Then find radiated power $P_r = (I_c)^2 R_r$ where I_c is the current in the coil.

Loop Radiation Resistance

$$R_r = \left[\frac{(177)NS}{\lambda^2} \right]^2$$

Where:

N is number of turns

S is the loop surface area

Consider a representative resonant induction wireless power transmission coil having 20 turns and a diameter of 1 meter

$$S = \pi r^2 = .785 \text{ meters square}$$

Operating Frequency = 20 kHz

$$\lambda = c/\text{frequency} = 3.0 \times 10^8 / 20,000 \text{ Hz}$$

$$\lambda = 15,000 \text{ meters} = 15 \text{ kilometers}$$

$$R_r = \left[\frac{(177 \cdot 20 \cdot .785)}{(15,000)^2} \right]^2 = 153 \cdot 10^{-12} \text{ Ohms} = 153 \text{ micro-micro Ohms}$$

Loop Current I_c

Consider a 50 kW resonant induction wireless power transmission system operating from a rectified 440vac, three phase line voltage source. The RMS voltage is 440v

$$\text{Loop Current } I_c = \text{Power/voltage} = 50,000\text{W}/440 \text{ v} = 114 \text{ Amps}$$

Effective Radiated Power P_r

$$P_r = I_c^2 R_r = (114^2) 153 \cdot 10^{-12} \text{ Ohms} = 2 \cdot 10^{-6} \text{ Watts}$$

Summary

EIRP = 2 Microwatts

The radiated power is very low because the loop antenna with a diameter of 1 meter is very, very small with respect to the 15 kilometer wavelength at the operating frequency.

In fact the actual effective radiated power is much less than 2 microwatts. The receiving coil located directly above the sending coil has about the same current as the sending coil however due to Lenz's law the receiving coil current flows in the opposite direction. This means the receiving coil radiation to the first order cancels the sending coil radiation. Furthermore the vehicle conductive underbody located directly over the send coil constitutes an effective shield further choking off radiated power at 20 kHz.