Microwave Power Transmission by Electromagnetic Surface Wave Propagation for Wireless Power Distribution

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The concept of wireless power transmission at microwave frequencies has recently generated much excitement for the development of new battery charging techniques, stations for wireless power distribution, and other consumer products that operate by means of remote energy transfer. Not only has this excitement generated a new paradigm of research and development for engineers and scientists, but more importantly, improved the general awareness of the public regarding the practicality and feasibility of green energy technologies. One popular example includes the charging of mobile devices, laptops, and other portable electronic equipment by the recycling of parasitic electromagnetic energy from the local environment. Additional applications of this approach to green technologies can include the control and system operation of low-power medical devices, environmental monitors for security and surveillance, and other sensors for home automation. Concepts can also be applied to more directive and high-power systems for space applications and the related telecommunications, as well as the powering and control of remote robots for disaster control and electric cars for terrestrial transportation.

The well developed engineering approaches for the design of circuits, antennas, and systems for wireless communications at microwave frequencies can be easily adopted when designing these green technologies for wireless power transmission. Moreover and as outlined in the literature, these microwave techniques are generally categorized into three main methodologies, specifically, by the distance R from the green device receiving power to the source as well as the physical mechanism of energy transport. These three main branches include electromagnetic coupling and magnetic resonance, which are considered more near-field techniques, and microwave transmission by electromagnetic wave propagation in free-space. This far-field approach is dictated by Friis's free-space equation such that the received power is inversely proportional to the square of the separation distance $(\sim 1 / R^2)$. On the other hand, when considering electromagnetic surface waves as the mechanism of propagation, energy is contained to a guiding surface or host medium such that the field strength is inversely proportional to the square root of the distance $(\sim 1 / R^{1/2})$. This suggests that improved power transfer rates can be achieved when surface wave are considered as the physical mechanism of energy transport, versus free-space waves where energy is unbounded.

In this work we propose to study electromagnetic surface waves for wireless power transmission, mainly in effort to enable a more efficient energy transfer system. Possible consumer applications include the charging of electronics devices when placed on a specially designed surface. This offers some advantages to more conventional near-field techniques since effectiveness is not limited to a specified charging station, when electromagnetic surface waves are employed, but rather, an enlarged planar surface such as a countertop, desk, or workbench. Some new high-power and directive applications can include the melting of ice on planar and conformal surfaces such as airport runways and airplane fuselages. To the authors knowledge, electromagnetic surface waves have not been employed for the aforementioned green technologies and thus can provide a new and efficient alternative to the more conventional approaches that achieve wireless power transmission.