INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:

Applications of Metamaterials in Far-field Microwave Wireless Power Transfer at 2.45 GHz

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SHORT ABSTRACT

Wireless power transfer (WPT) is a technology that enables the transmission of electrical energy from a power source to a receiver without wired electrical connections. This technology has gained significant attention recently due to its potential applications in various industries, including consumer electronics, healthcare, transportation, and aerospace. There are several WPT techniques, including inductive coupling, magnetic resonance, laser power, and far-field microwave technologies. Each method has advantages and limitations regarding efficiency, range, and power transfer capacity. The technology can potentially revolutionise how we charge electronic devices, mobile ground and aerial vehicles, power medical implants, and transport energy over long distances.

Metamaterials (MMs) are engineered materials with unique properties that can manipulate electromagnetic waves, making it possible to transmit power without wires over long distances. MMs have found various applications in the lens, partial or complete reflectors, transmitters, and absorption media. Far-field microwave WPT using metamaterials is a promising technology that can revolutionise power-beaming methods for mobile vehicle powering scenarios, e.g., robots, aerostats, drones, IoT devices, and sensors in the far field.

This thesis describes applications of MMs in far-field microwave WPT at 2.45 GHz operating frequency. Chapter 1 introduces WPT, its types, and its applications. A literature survey on WPT types, microwave WPT, and its efficiency improvement using MM is provided. Chapter 2 presents the findings based on electromagnetic modelling and gradient refractive index (GRIN) lens testing at 2.45 GHz far-field microwave WPT. The system efficiency is improved by including the MM GRIN lens at the focus of the transmitting antenna. This creates a baseline study of utilising MMs to boost the output at the receiving side. Chapter 3 describes a methodology for enhancing the electric field using an MM GRIN lens and MM reflector. A WPT system charging a rover at 3 meters with an 800-watt magnetron is studied. The electric field with MM lens at Tx and MM reflector at Rx is enhanced by a factor of two compared to a typical system without MM. Chapter 4 presents a novel dual-reflector antenna based on a planar metasurface sub-reflector (MSSR) for simultaneous power beaming at distinct angles. The main lobe and sidelobe power distribution of the MSSR array can be changed by adjusting the focal distance. The proposed antenna with the sidelobes is a suitable choice for simultaneous powering multiple receivers spaced at different angles. Chapter 5 introduces an innovative machine-learning (ML) technique using random forest regression (RFR) to predict radiation properties in a planar metasurface reflector (PMSR) antenna at 2.45 GHz. The RFR model is trained using PMSR parameters, and results closely align with experimental and computer simulation data. Chapter 6 presents the future scope and applications of microwave WPT technology using MM.