Design of a Tri-Band Wireless Power Transfer Receiver

RF Energy Harvesting at 900 MHz, 2.45 GHz, and 3.5 GHz

Student

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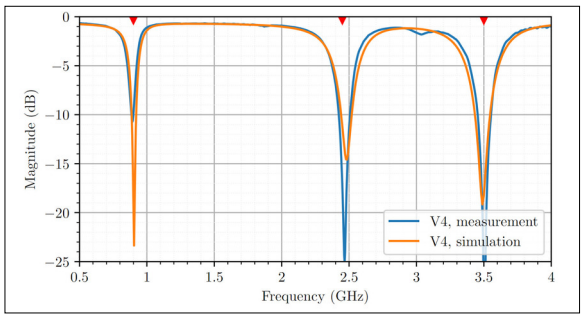
Introduction: In the context of Industrial Internet of Things (IIoT), smart cities, and Industry 4.0 environments, there is a growing demand for low-power sensor solutions to monitor diverse processes. Despite their low energy consumption, these sensors still require maintenance due to battery replacement. Integrating RF energy harvesting enables wireless powering or recharging, thereby reducing maintenance requirements.

This work focuses on the design of a tri-band RF energy harvester optimised for 900 MHz, 2.45 GHz, and 3.5 GHz for low-maintenance sensor networks.

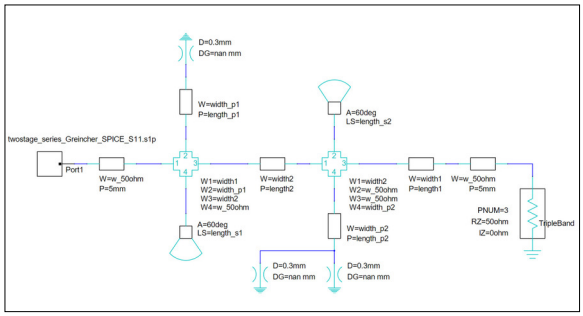
Approach / Technology: Initially, a rectifier previously designed at the institute, is examined in detail to identify the cause of a significant discrepancy between ADS circuit simulation and measurement results. Subsequently, an improved version of the previously proposed rectifier topology is designed and optimised for the target frequencies. In addition, a transmission line-based multi-band matching network is introduced and optimised using both analytical and evolutionary methods. The structures are first optimised using ANSYS circuit simulator and the open-source Quite Universal Circuit Simulator (Qucs), and subsequently verified through full-wave simulation in ANSYS HFSS. Finally, the most promising rectifier structures are manufactured and tested.

Conclusion: Both transmission line- and lumped element-based matching networks were manufactured and tested. The rectifiers showed strong agreement between simulation and measurement results. Furthermore, the proposed design process for transmission line-based matching networks was successfully verified. Evolutionary methods as well as systematic tuning and optimisation approaches yielded good results. While using a genetic algorithm may find suitable solutions relatively quickly, the systematic approach provides greater insight and facilitates easier retuning.

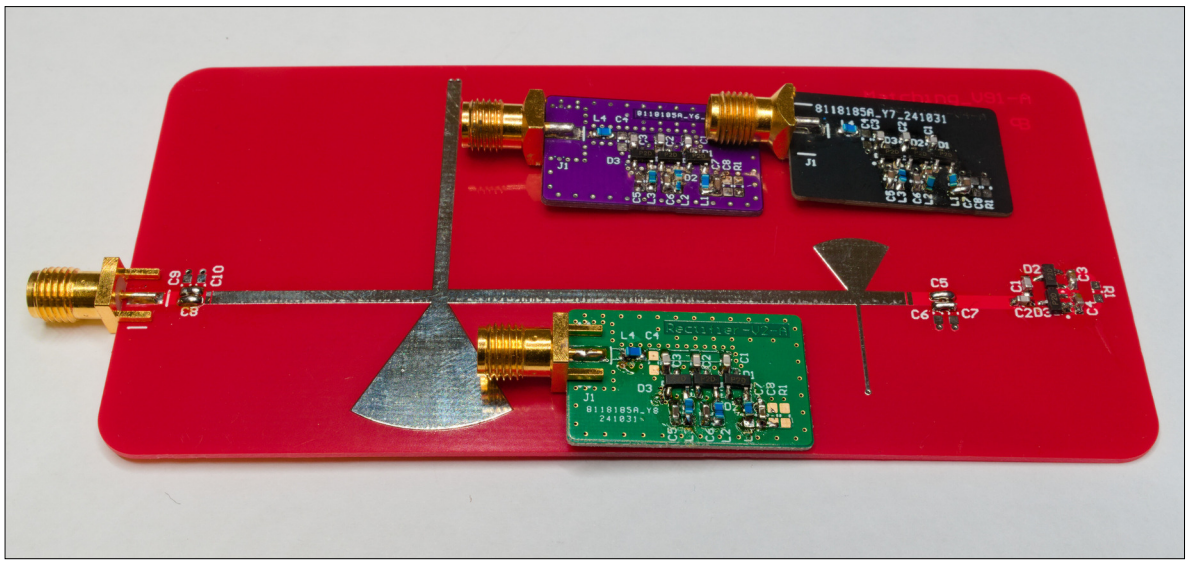
S11 measurement and simulation of the optimized rectifier using a lumped element matching network.
Own presentment



Ansys Circuit simulation used to tune the tri-band matching network before conducting fullwave simulation in HFSS.
Own presentment



Collection of the manufactured rectifier structures using different lumped element structures and transmission lines.
Own presentment



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