A Smart Energy Harvesting System for Wireless Charging Applications

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Objectives

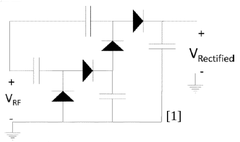
- Design a smart energy harvesting system for 5.8 GHz
- Adaptive to varying loads, input powers, and transmitter locations
- On-board microcontroller for maximum power tracking

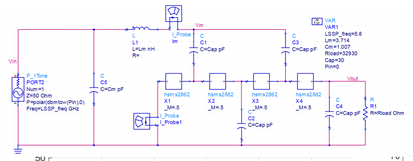
Motivation

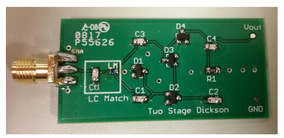
- Improve infrastructure of Internet of Things (IoT)
- Increase capabilities of existing harvesting circuitry

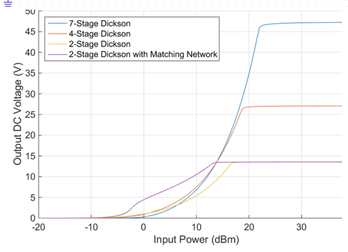
Rectifier Design

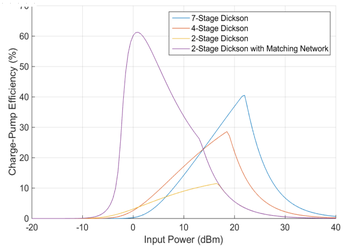
- Multi-stage Dickson multiplier
- HSMS-2860 Schottky diodes
- Include L-matching network
- Simulated in Advanced Design System (ADS)



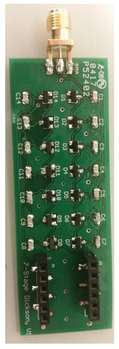


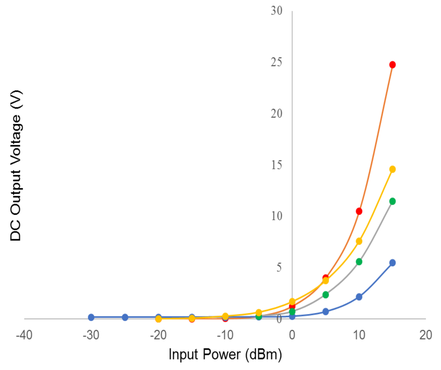




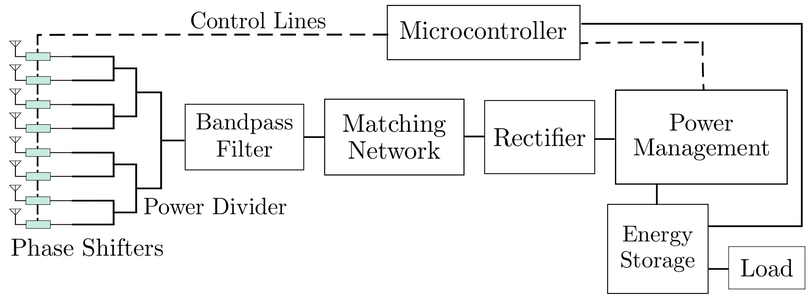


Seven-Stage Dickson Fabrication





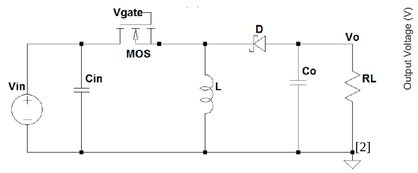
System Design

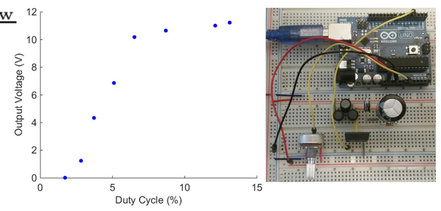


Power Management

- Typically used between rectifier and load
- Increase efficiency under varying input and load conditions
- Implemented with inverting buck-boost converter in DCM
- Used for resistor emulation to match optimal system load

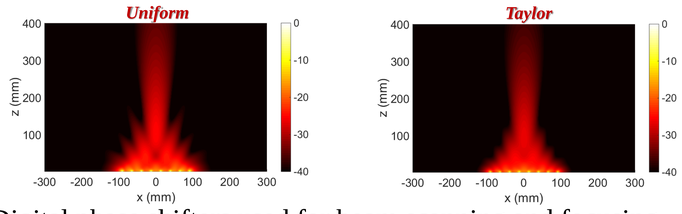
$$V_o = -\frac{D^2 T}{2LI_o} V_{in}^2 \qquad R_{in} = \frac{2Lf_{sw}}{D^2}$$



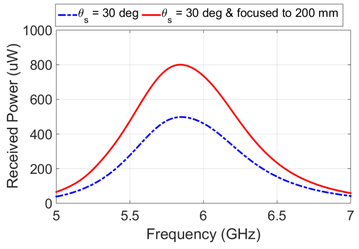


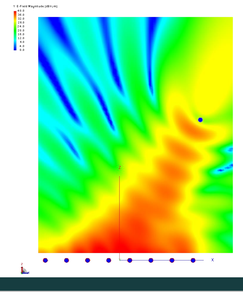
Beamforming

- Use 20 dB Taylor taper to reduce side lobes



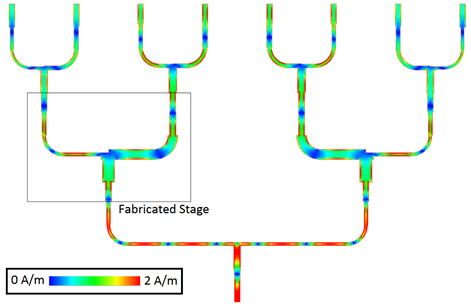
- Digital phase shifters used for beam scanning and focusing
- Ex: 200 mm focal point

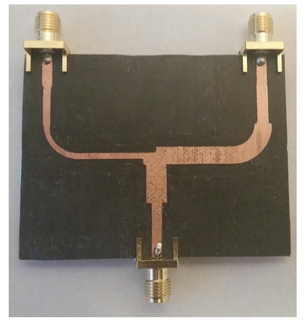




Feed Network

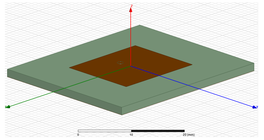
- Eight-input single output corporate feed
- Implemented with T-junction power dividers
- Designed with 20 dB Taylor taper distribution
- Half-wavelength spacing between outputs

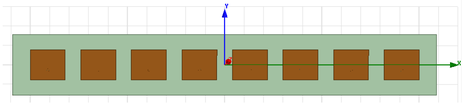


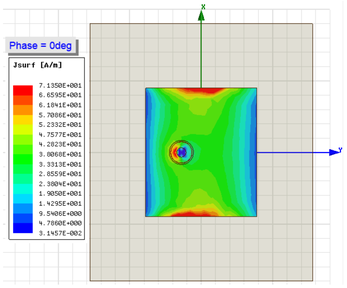


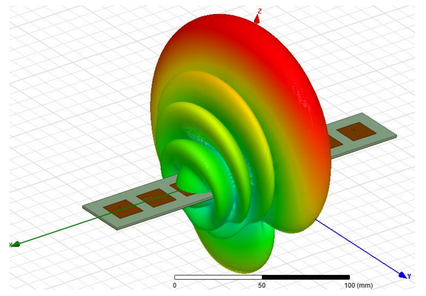
Antenna Array Design

- Designed using patch antennas with coaxial feed in HFSS
- Length: 15.55 mm, Width: 18 mm, Feed Offset: 5 mm
- 62 mil Rogers 5880 Duroid for substrate
- Patch gain of 7.77 dB and array gain of 15.09 dB









References

[1] P. Nintanavongsa, U. Muncuk, D. R. Lewis and K. R. Chowdhury, "Design optimization and implementation for RF energy harvesting circuits," in IEEE Journal on Emerging and Selected Topics in Circuits and Systems, vol. 2, no. 1, pp. 24-33, March 2012

[2] Y. Huang, N. Shinohara, and T. Mitani, "Impedance matching in wireless power transfer," in IEEE Transactions on Microwave Theory and Techniques, in Press.