Experimental Study of RF Energy Transfer System in Indoor Environment

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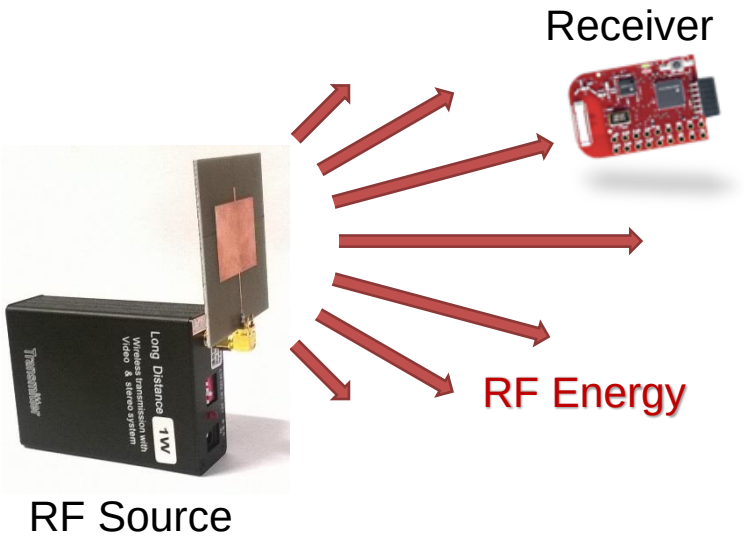
Overview

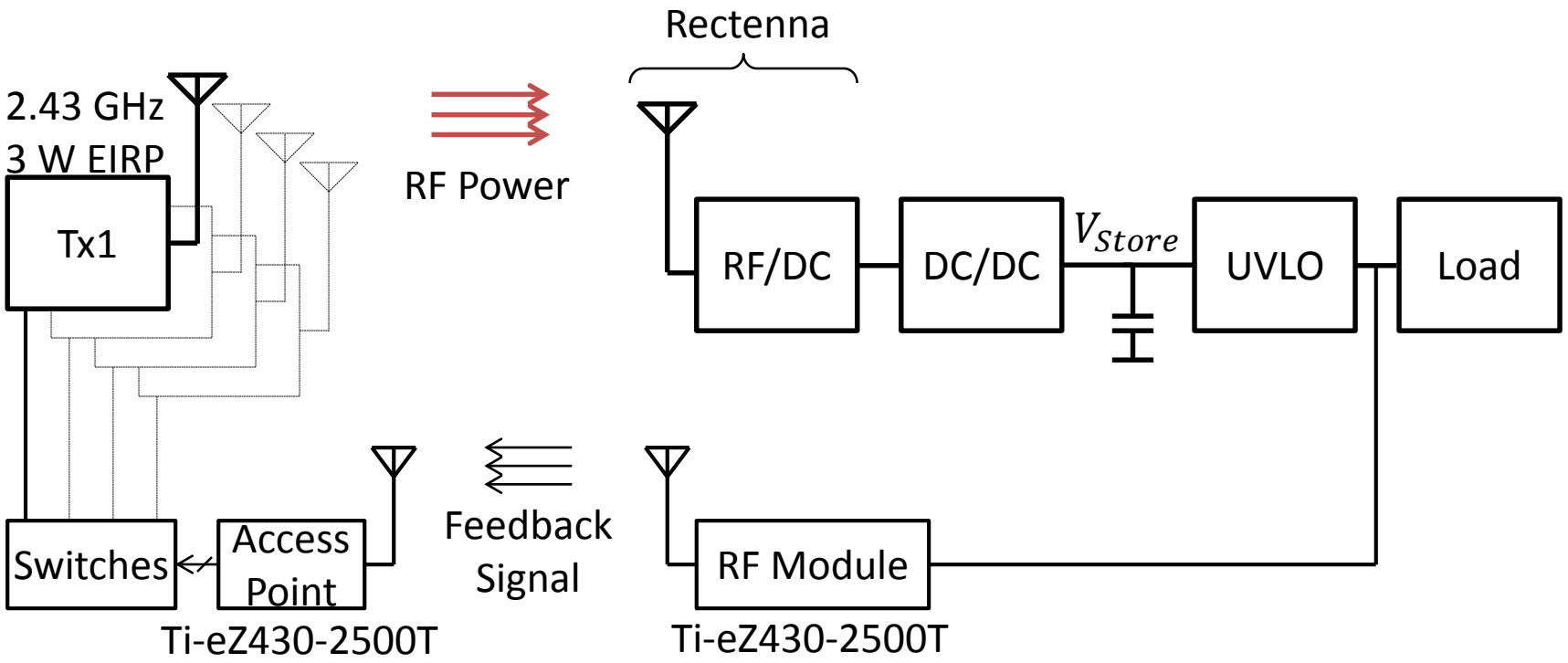
- Introduction
- Developed RF WPT System
- Rectifying Antenna (Rectenna) Design
- Characterisation and Model of Rectenna
- Indoor experimental evaluation of Received DC Power
- Power Management
- Current Research: Flexible Textile Antennas
- Conclusion

Introduction: RF Wireless Power Transfer

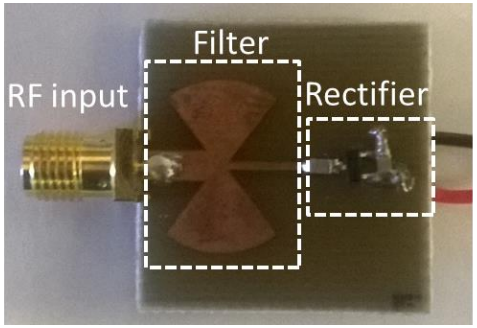


- Advantages:
  - Controllable remote power supply.
  - Relatively wider range than inductive.
  - Compact transceivers: GHz band.
  - Flexible: multi-transmitter, multi-receiver.
- Issues:
  - High attenuation by obstacles, body, etc.
  - Unpredictable received power: receiver location, user behaviour, environment, etc.
  - Low transmitter power: safety limitations given by EIRP (Equivalent Isotropic Radiated Power).
  - Low RF/DC conversion efficiency at low power levels.

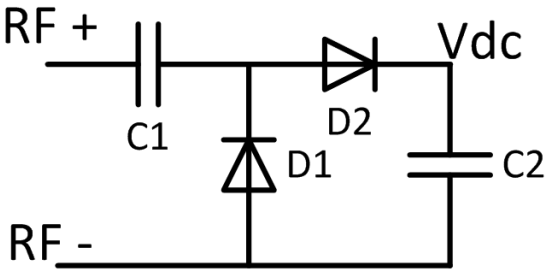
RF WPT System: Dynamic selection of the optimal transmitter.



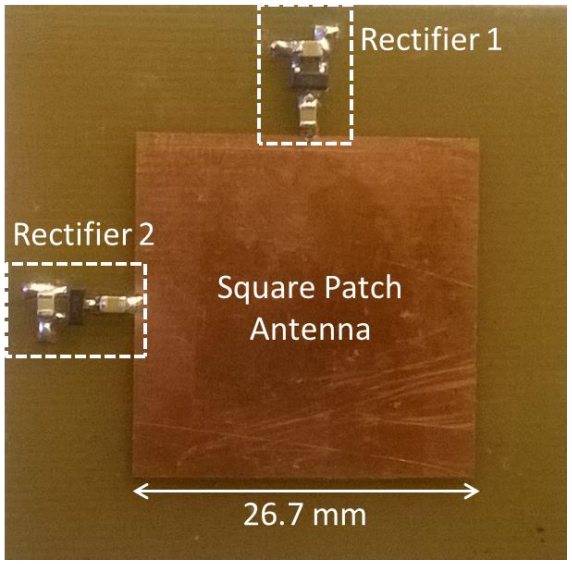
Rectenna (Rectifying Antenna) Design



Rectifier with 50 Ω matching

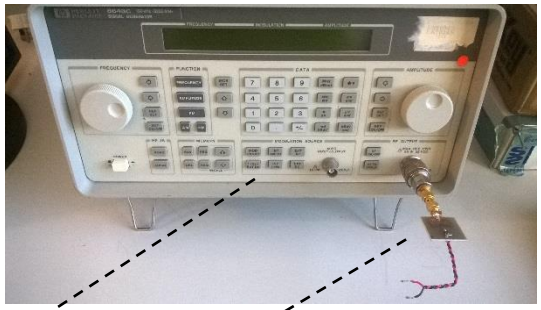


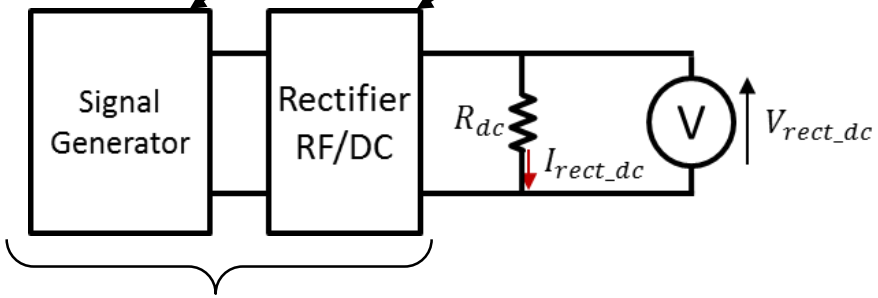
Voltage doubler
Schottky diode HSMS-2852

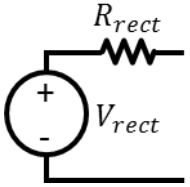


Dual-polarisation rectenna
(Antenna directly matched to the rectifier)

Rectenna output Characteristics



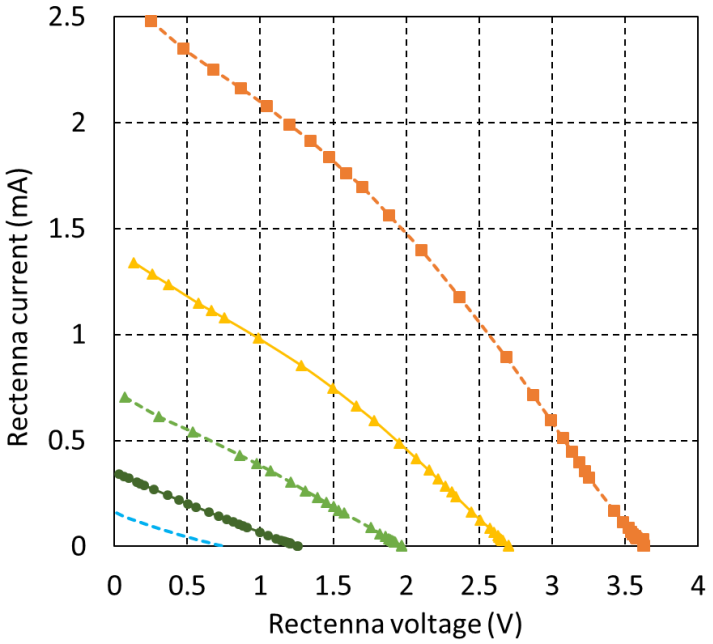


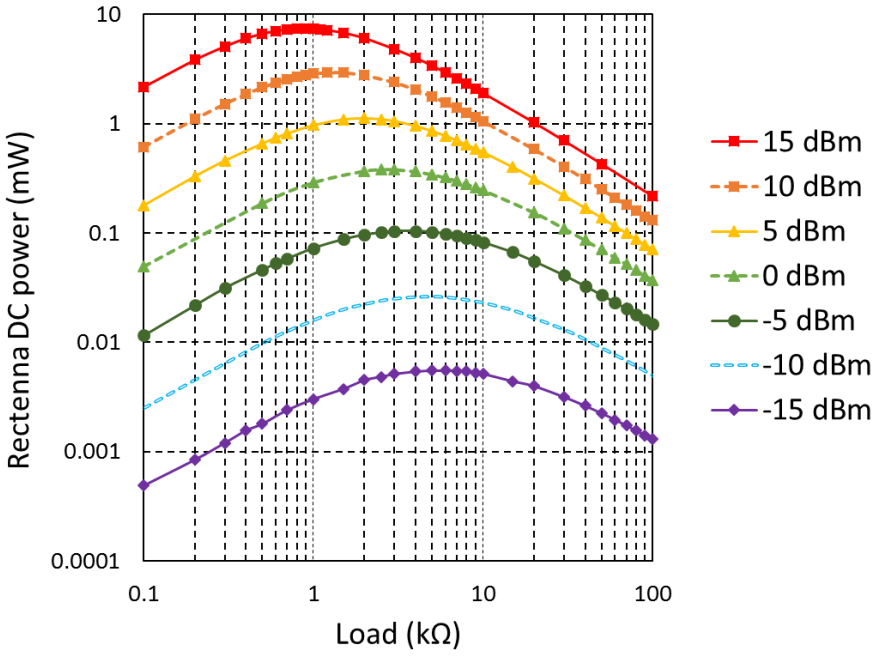


Rectenna model

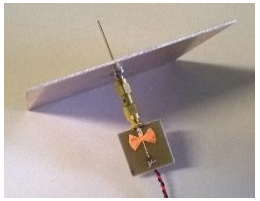
R_{rect}: internal impedance

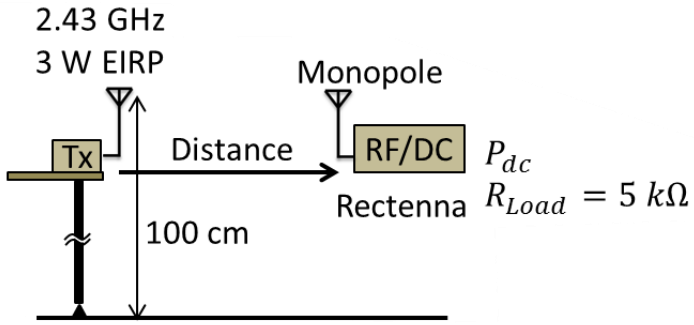
V_{rect}: open-circuit dc voltage





Measured Received DC Power vs. distance

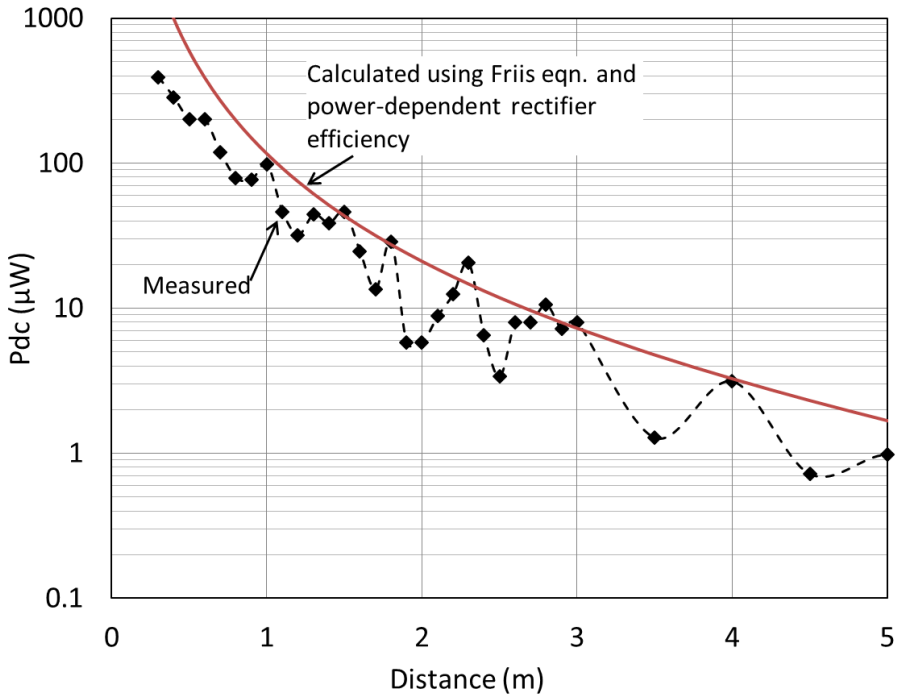




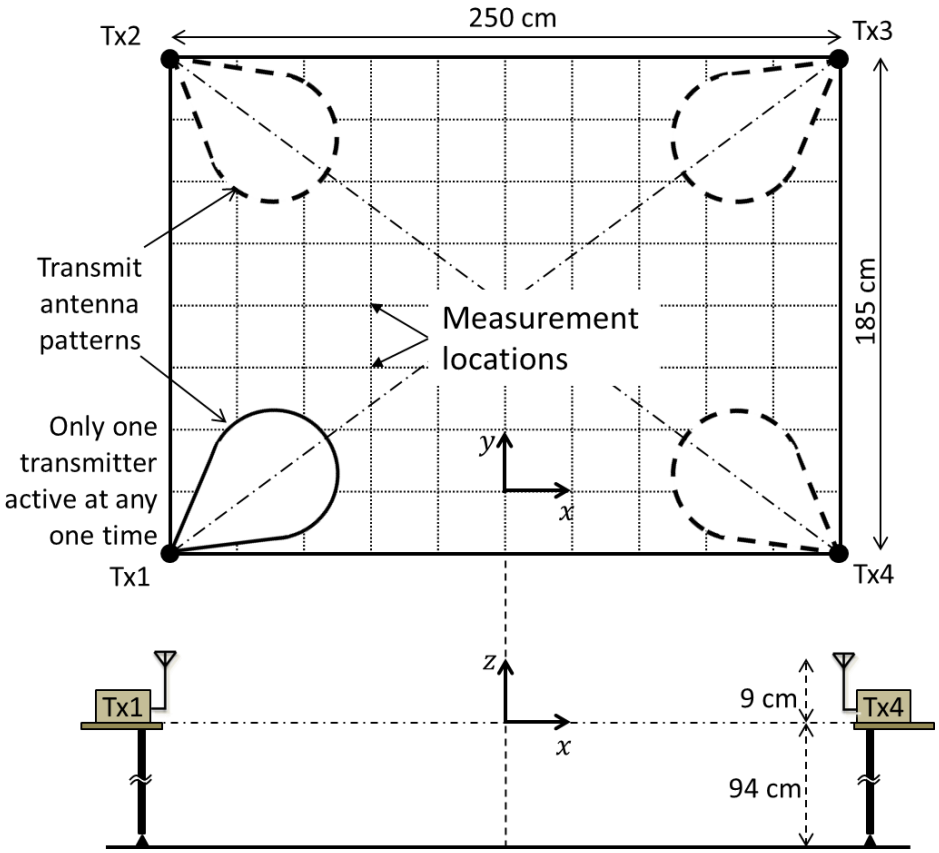
P_{dc}

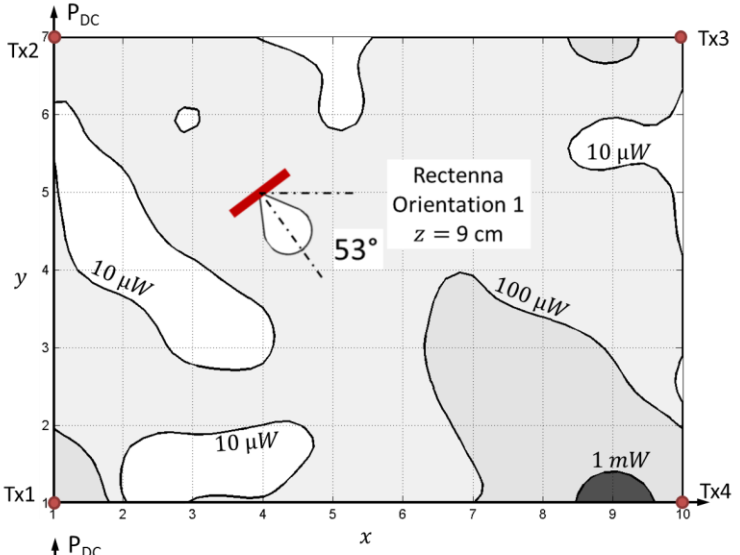
$R_{Load} = 5\ k\Omega$

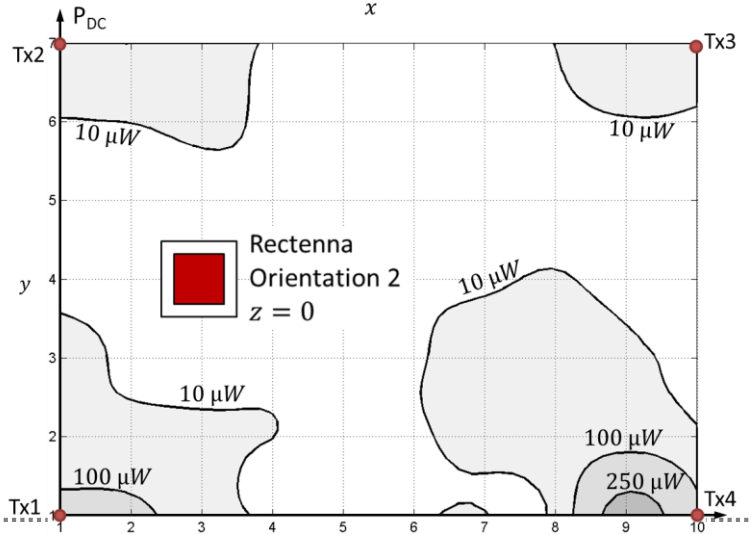
$$P_{dc} = \eta_{RF/dc}[P_{EIRP} G_r (\frac{c}{4\pi r f})^2]$$



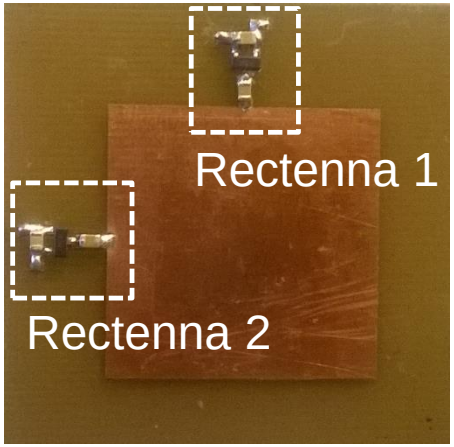
Measured DC Power in Indoor Laboratory Environment

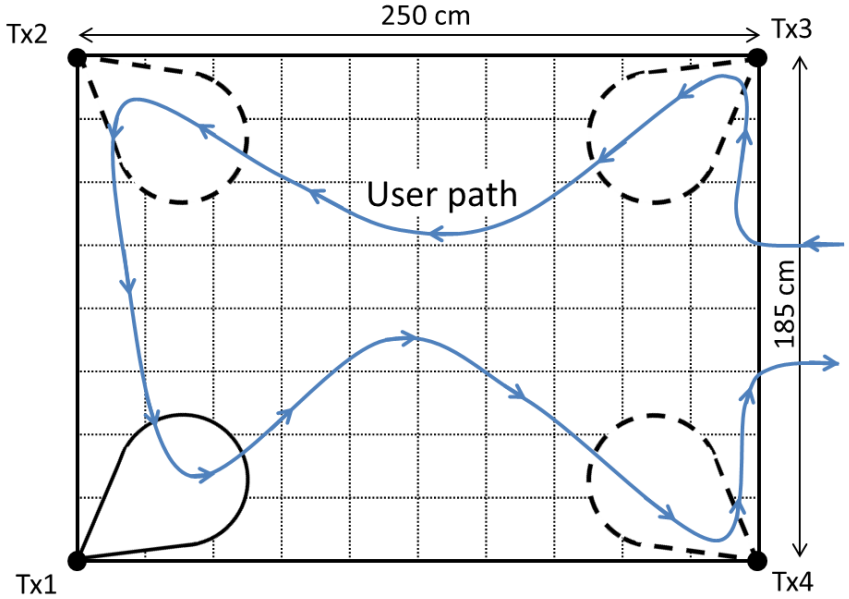


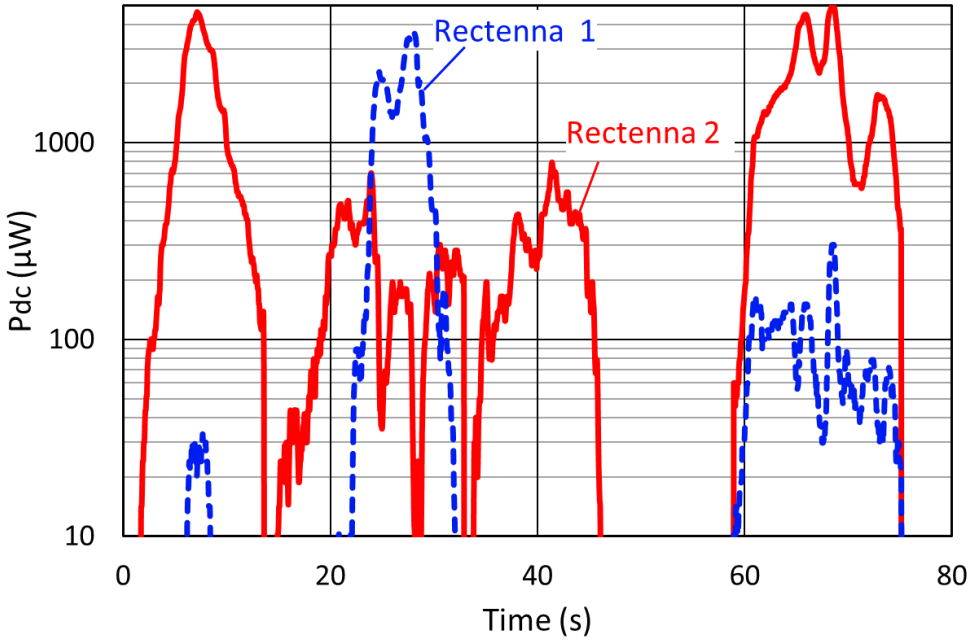




Typical User Case: Received DC Power Intermittency

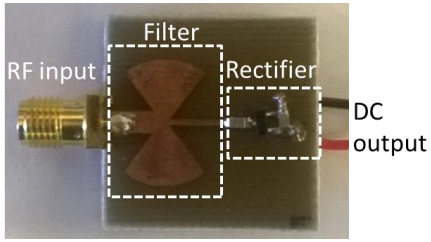


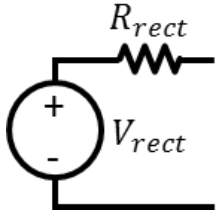




Power Management: Inductive Boost DC-DC Converter

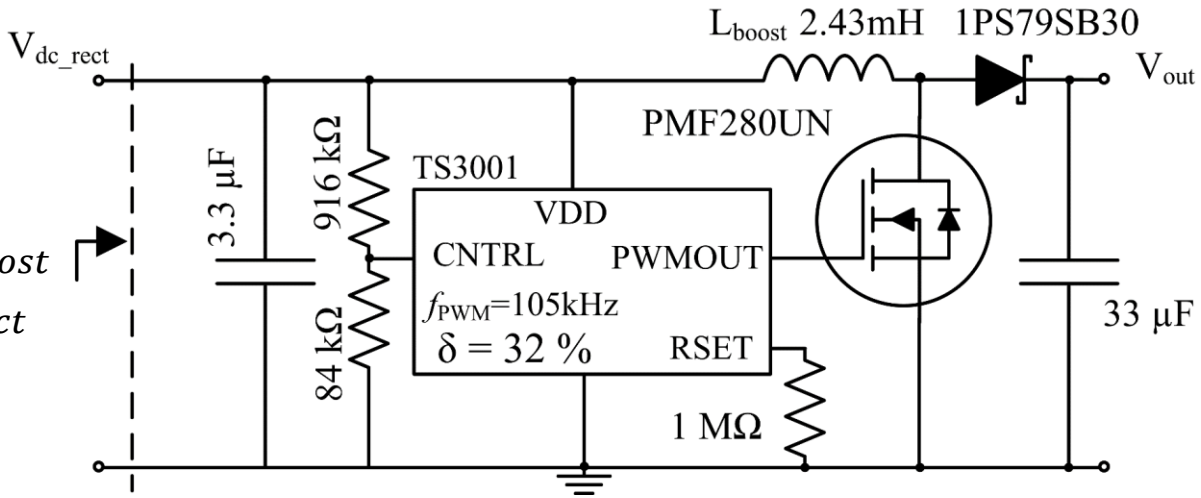
DCM: Discontinuous-Conduction Mode ➡ $R_{in\_boost} = \frac{L_{boost} \cdot f_{PWM}}{\delta^2}(1 - \frac{V_{dc\_rect}}{V_{out}})$





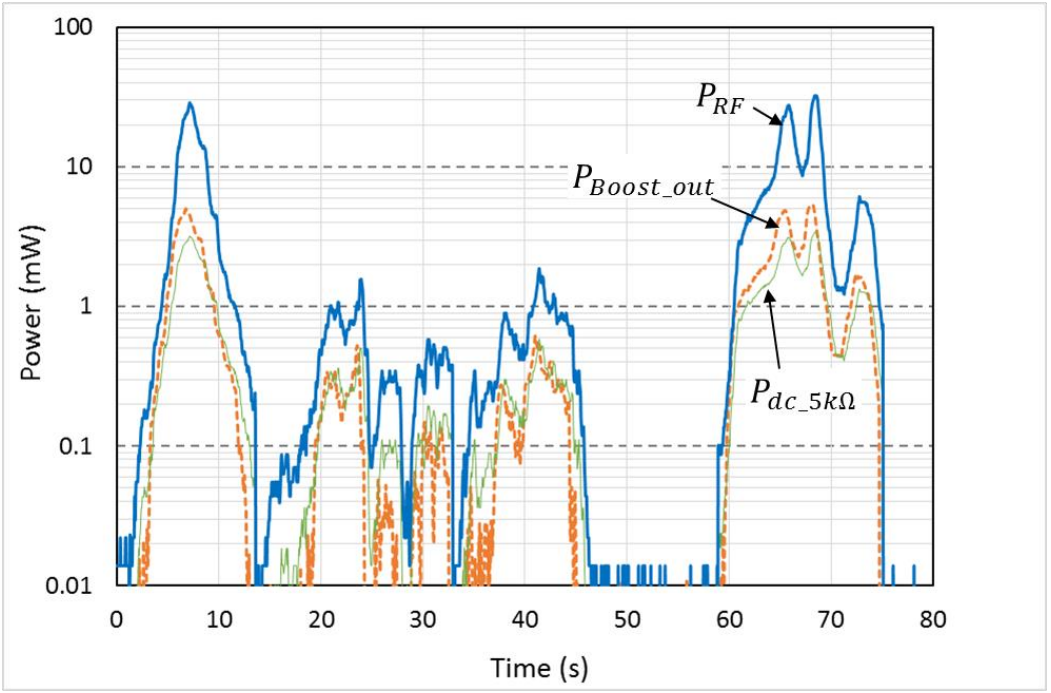
Rectenna

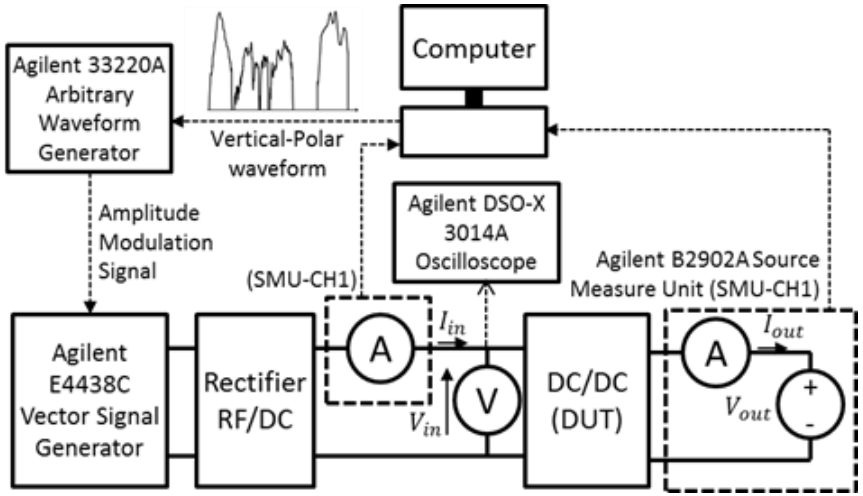
$R_{in\_boost} = R_{rect}$



- Inherent behaviour of inductive boost converter dynamically follows rectenna impedance.

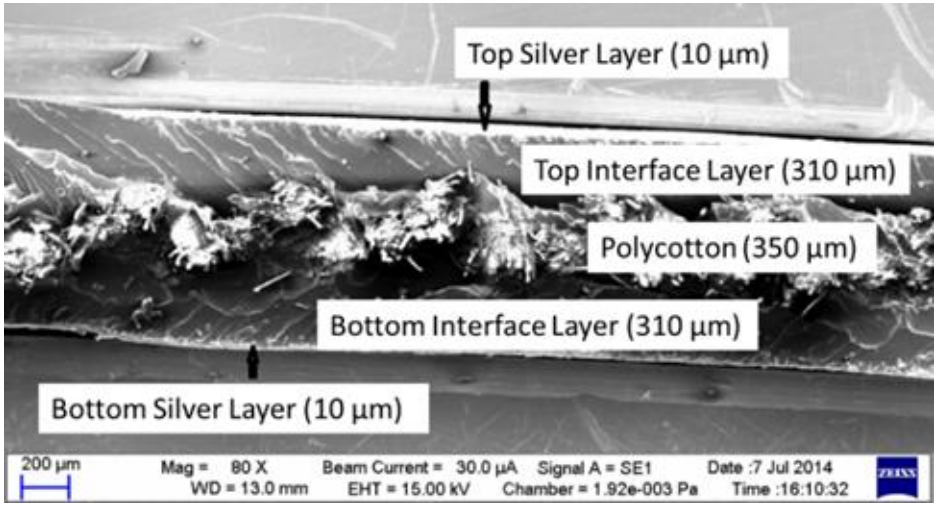
Performances of the Boost Converter Under Power Intermittency

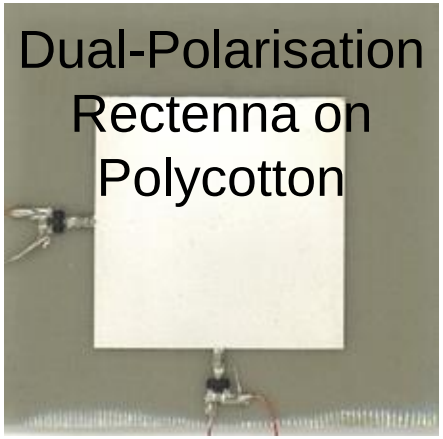




- **0.65 V** cold start-up voltage
- **80 %** efficiency at **400 µW**
- Inherent behaviour of inductive boost converter dynamically follows rectenna impedance.

Current Research (With the University of Southampton): Textile Flexible Antennas/Rectennas





- Flexible screen-printed antenna/rectenna on textile
- Different commercially-available textile material under investigation

Conclusion

- Multi-transmitter system: optimizes coverage while minimises EIRP to respect safety limitations.
- Dual polarisation rectenna design: uncertain dominant polarisation direction.
- Characterisation of rectenna: high DC impedance to be matched.
- Indoor evaluation of received dc power: high intermittency depending on transmitter configuration, user behaviour and environment.
- Power management: inductive DC-DC boost converter developed which step-up voltage and match rectenna impedance.
  - 0.65 V cold start-up voltage
  - 80 % efficiency at 400 µW
  - Inherent behaviour of inductive boost converter dynamically follows rectenna impedance.
- Current Research (With the University of Southampton): Textile Flexible Antennas/Rectennas

Thank you for your attention!

Questions?

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Reference: Experimental study of RF energy transfer system in indoor environment. / Adami, S. E.; Proynov, P. P.; Stark, B. H.; Hilton, G. S.; Craddock, I. J. In: Journal of Physics: Conference Series, Vol. 557, No. 1, 012005, 01.01.2014. Online available: http://iopscience.iop.org/1742-6596/557/1/012005/