A Different Approach to a Highly Efficient Wireless Energy Harvesting Device for Low-Power Application

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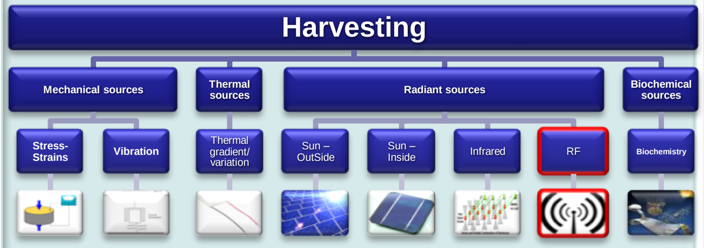
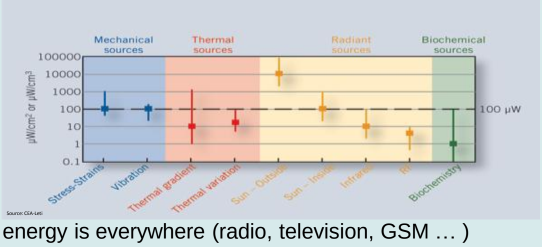
I. Introduction

➢What is energy harvesting?

"the collection and conversion of ambient energy into usable electric power".

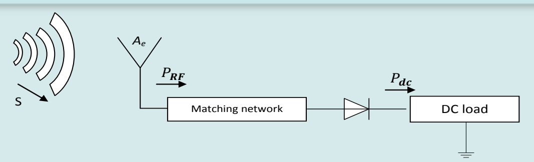


➢Why RF energy harvesting?



- RF energy is everywhere (radio, television, GSM …)
- Wire-free Operation:
  - Untethered placement and mobility
  - Eliminates wires, cables, connectors
- Low-cost Set-up and Maintenance:
  - No battery replacement required
  - Life-time solution
  - Unaccessible locations
- Reliable and Controllable
  - The power source can be controlled
  - Available on demand
  - Minimal effects from weather / time-of-day
- ***"Green" solution***

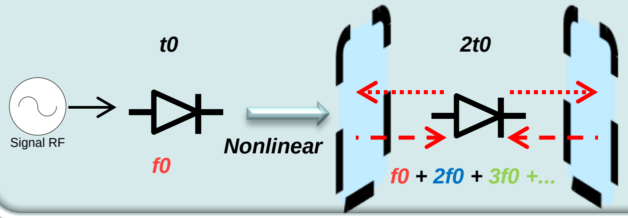
II. Wireless energy harvesting (WEH)



RF available power: $$P_{RF} = S.A_e = P_{EIRP}\,\eta_{ant}\,D_{ant}\,\frac{\lambda^2}{(4\pi d)^2}$$

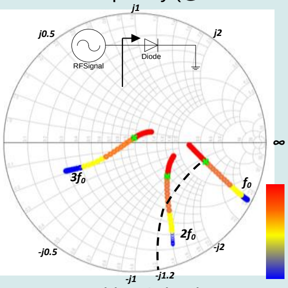
Conversion efficiency RF-DC: $$\eta = \frac{P_{DC}}{P_{RF}} = \frac{V_{DC}^{\;2}}{R_L P_{RF}}$$

a) *Analysis of the electromagnetic resonance phenomena in a rectifier circuit:*

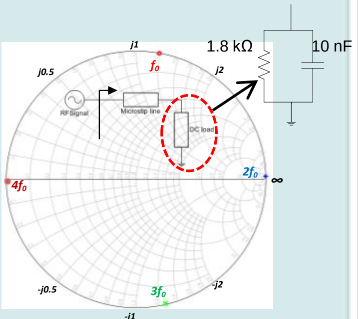


b) *Zero-bias Schottky diode modeling and optimum DC load optimization:*

- DIODE nonlinear characteristics→the matching network is more complex
- Optimum DC load
- Correct frequency (@ 2.45 GHz)

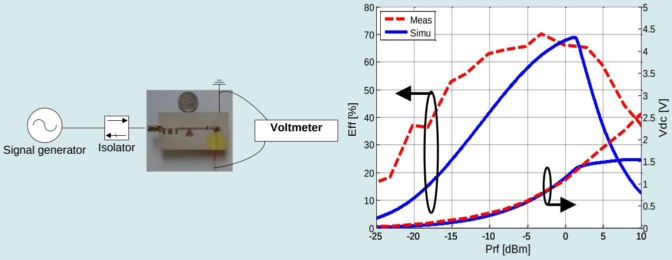


Zero-bias Schottky

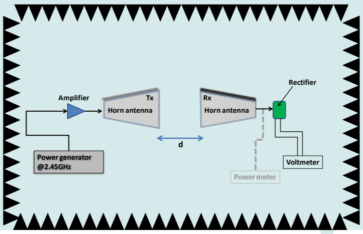


Optimum load

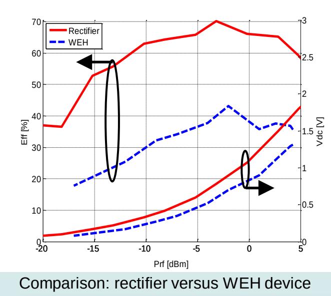
c) *Final optimized rectifier circuit :*



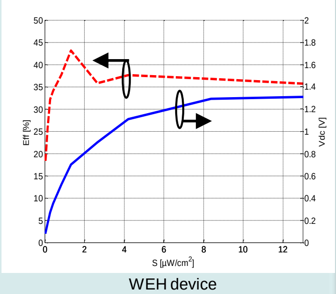
d) *Wireless energy harvesting device measurements:*



- Measurements were done in an anechoic chamber.
- P_{RF} and V_{DC} ?
- *d* = 130cm (> farfield criteria)
- RF power from the generator was varied to obtain different power density *S* values



Comparison: rectifier versus WEH device



WEH device

III. Conclusion

- The harvesting from low-power RF energy was demonstrated achievable (µW/cm2).
- Predicting a correct model for a Schottky diode is not obvious, due to nonlinear characteristics.
- For a low-power density of 1.3 µW/cm² (-4dBm), the rectifier has a maximum conversion efficiency of 70% and when connected to an antenna of 43%.
- In future work, a compact highly efficient antenna will be developed through a co-design process to create a high-efficiency *rectenna*.

[1] B. R. Franciscatto et al., *"High-Efficiency Rectifier Circuit at 2.45 GHz for Low-Input-Power Energy Harvesting"*, to be published in European Microwave Conference (EuMC) 2013, 6-11 October 2013, Germany.
[2] B. R. Franciscatto et al., "Circuit de conversion RF-DC à 2.45 GHz à fort rendement pour les applications de récuperation d'énergie RF", JNM 2013, Paris – France.

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