IC1301 -WiPE

Wireless Power Transmission for Sustainable Electronics

- Ultra-low Cost Environmental Sensing with Scatter Radio and WIPE Opportunities

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WIPE

COST IC1301

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Technical Univ. of Crete (TUC)

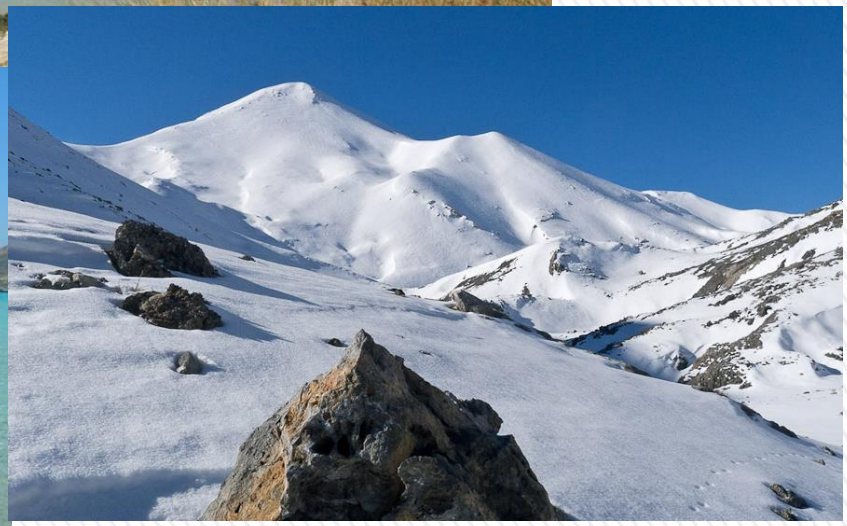
- 130 Faculty members:

Electronic & Computer Engineering,
Industrial Engineering,
Environmental Engineering,
Architecture,
Mineral Resources Engineering.

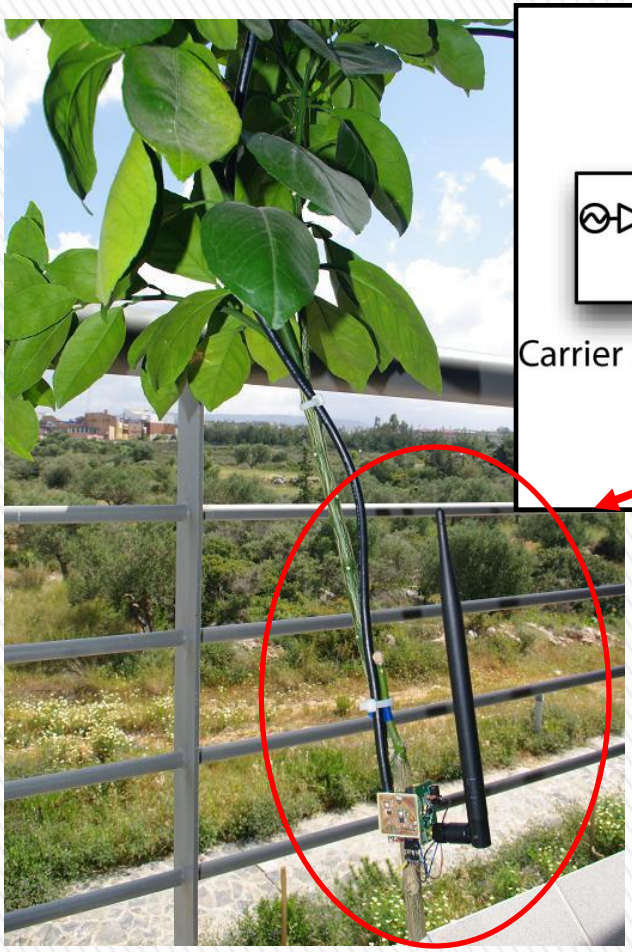
- Technical Univ. of Crete is #1 in terms of citations per journal publication among all Universities in GREECE!
(#2 was Univ. of Crete)

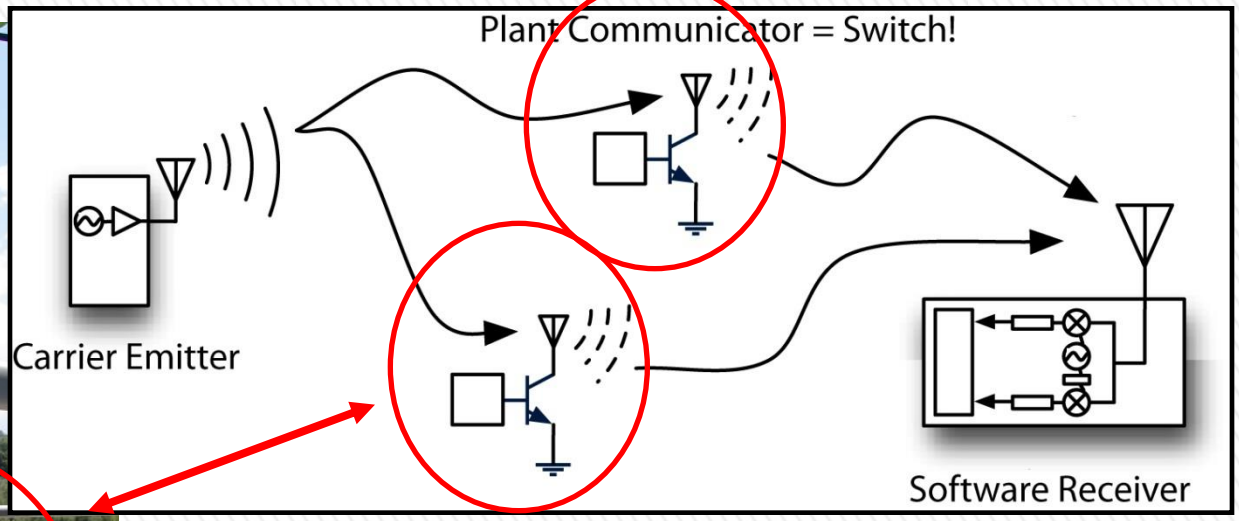
Source: National Documentation Center
http://report03.metrics.ekt.gr/el/index

Chania, Crete, Greece – Visit Us!



Environmental Sensing with Scatter Radio



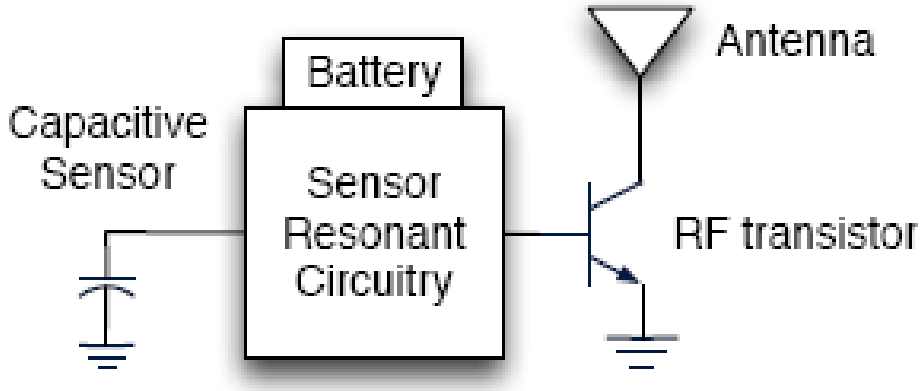


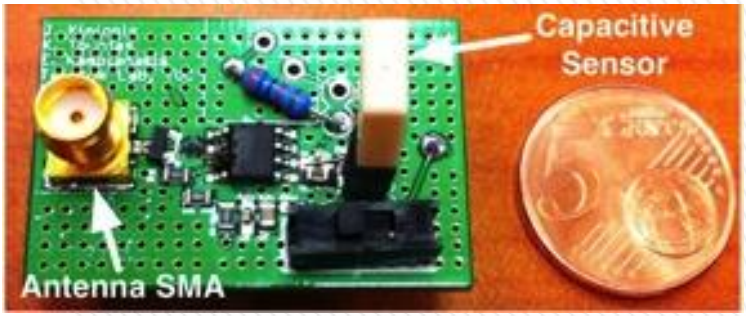
- Range: 100+ m outdoors.
- Cost Target: 1€ (or less).
- Energy Target: Battery-less.

Outline

- Environmental Humidity Sensing [1]
- “Plant is the sensor” Sensing
- RF Harvesting & WIPE Challenges

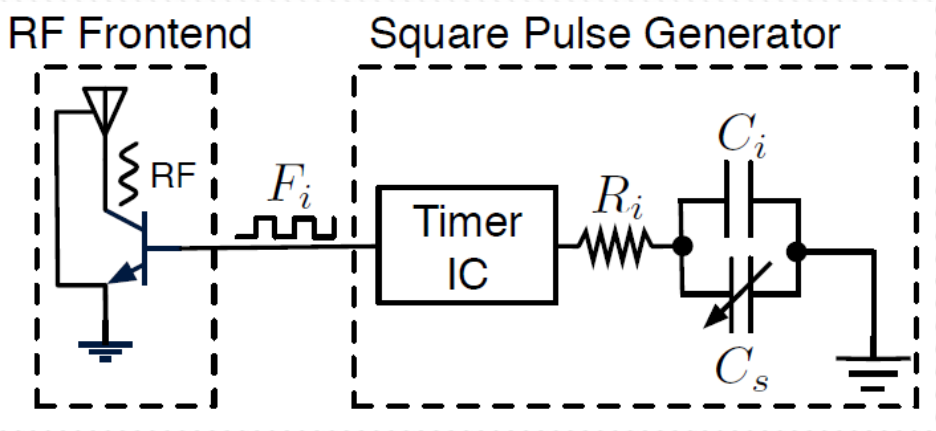
Backscatter Humidity Sensing

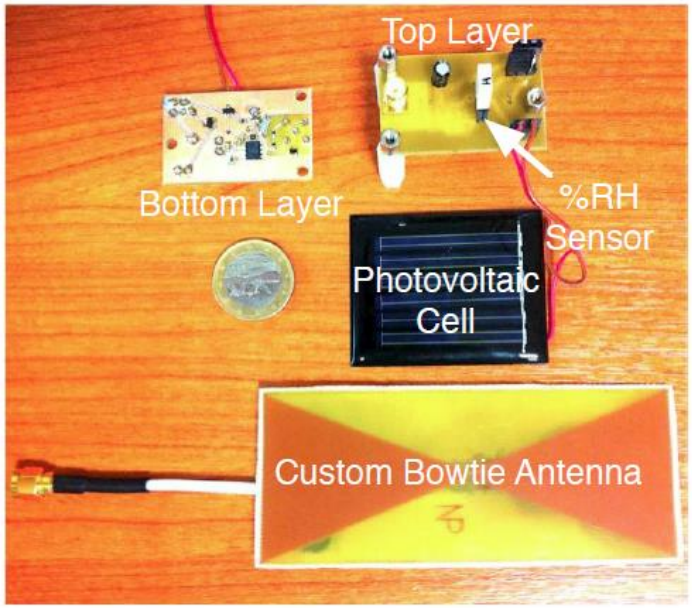




- Principle: convert capacity changes to backscattered freq!
- Power Consumption: <1.6 mWatt (ver 1), **220µWatt** (ver 3).
- Cost: ~3€ (quantity of 1)

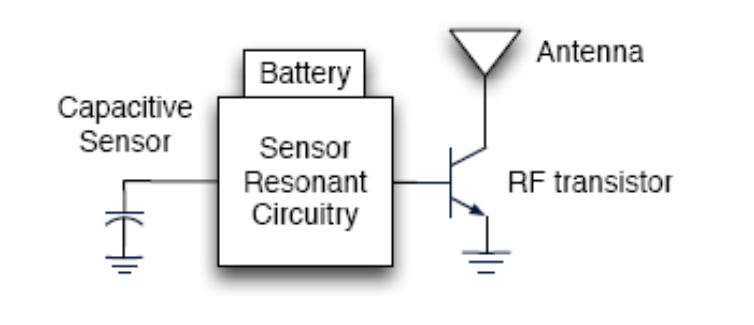
Backscatter Humidity Sensing

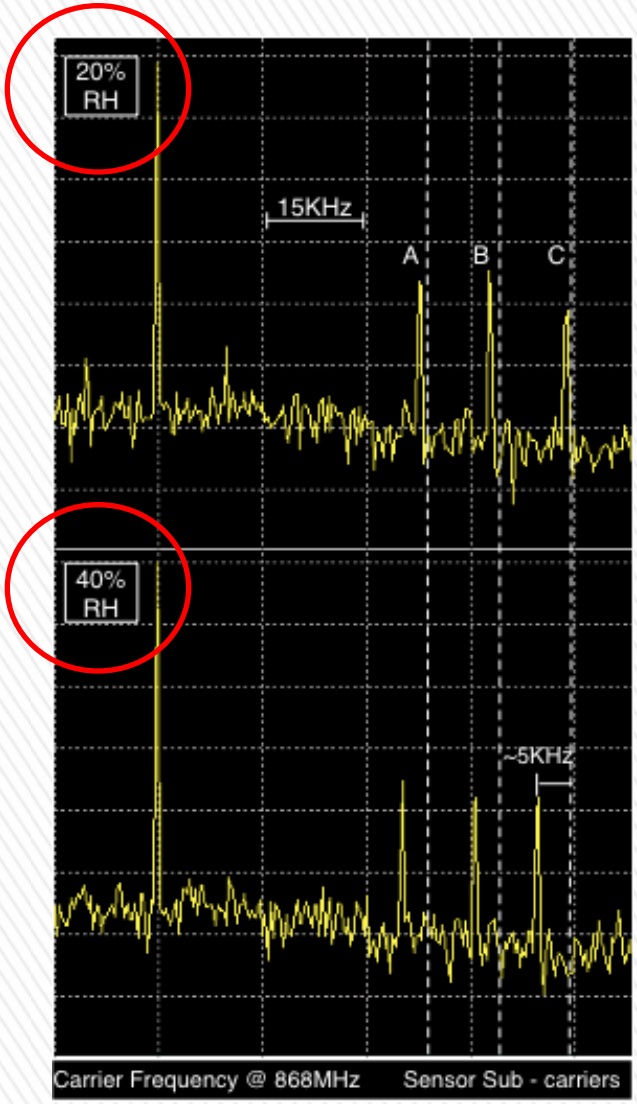




- Principle: convert capacity changes to backscattered freq!

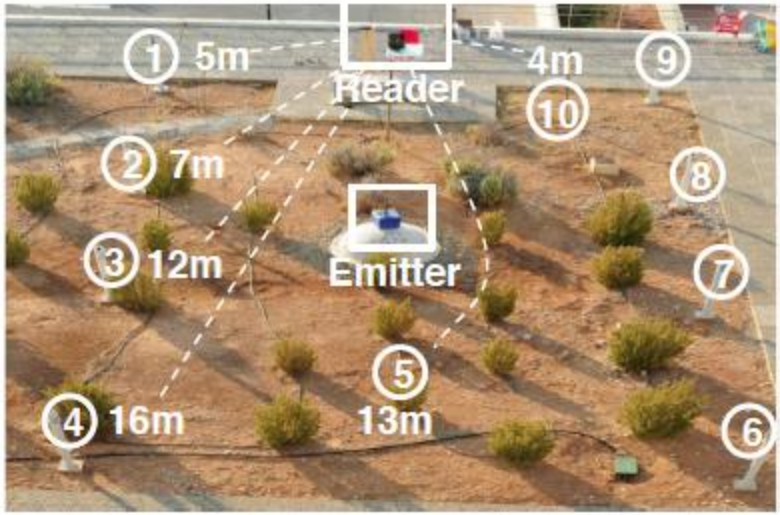
Backscatter Humidity Sensing (freq. domain)

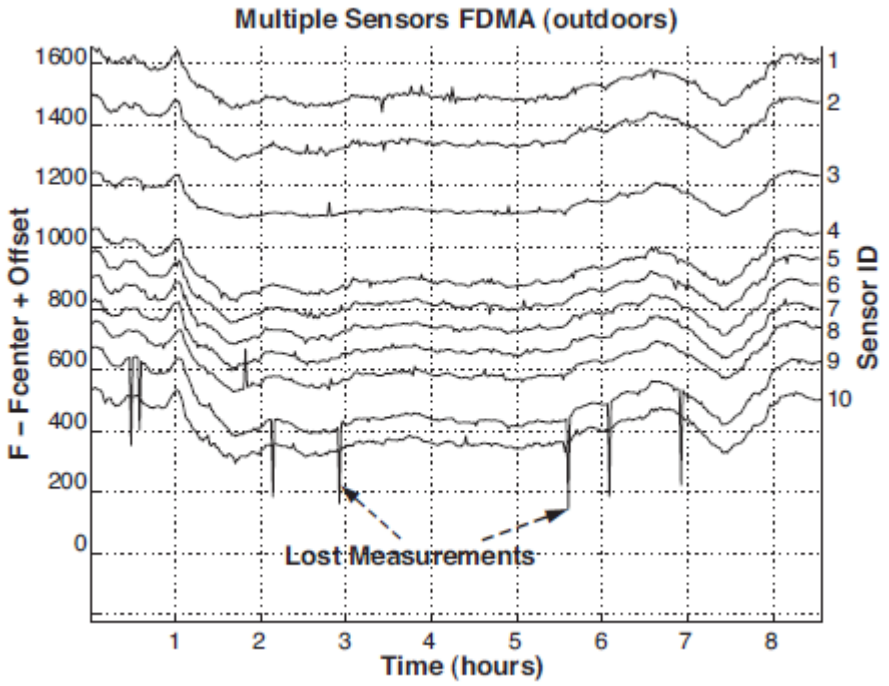




- Multiple sensors operating simultaneously (A, B and C depicted)!
- 2-5kHz per sensor; accuracy/bandwidth tradeoff.

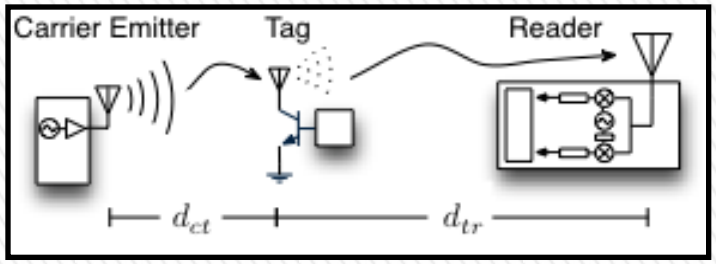
Backscatter Humidity Sensing (time domain)

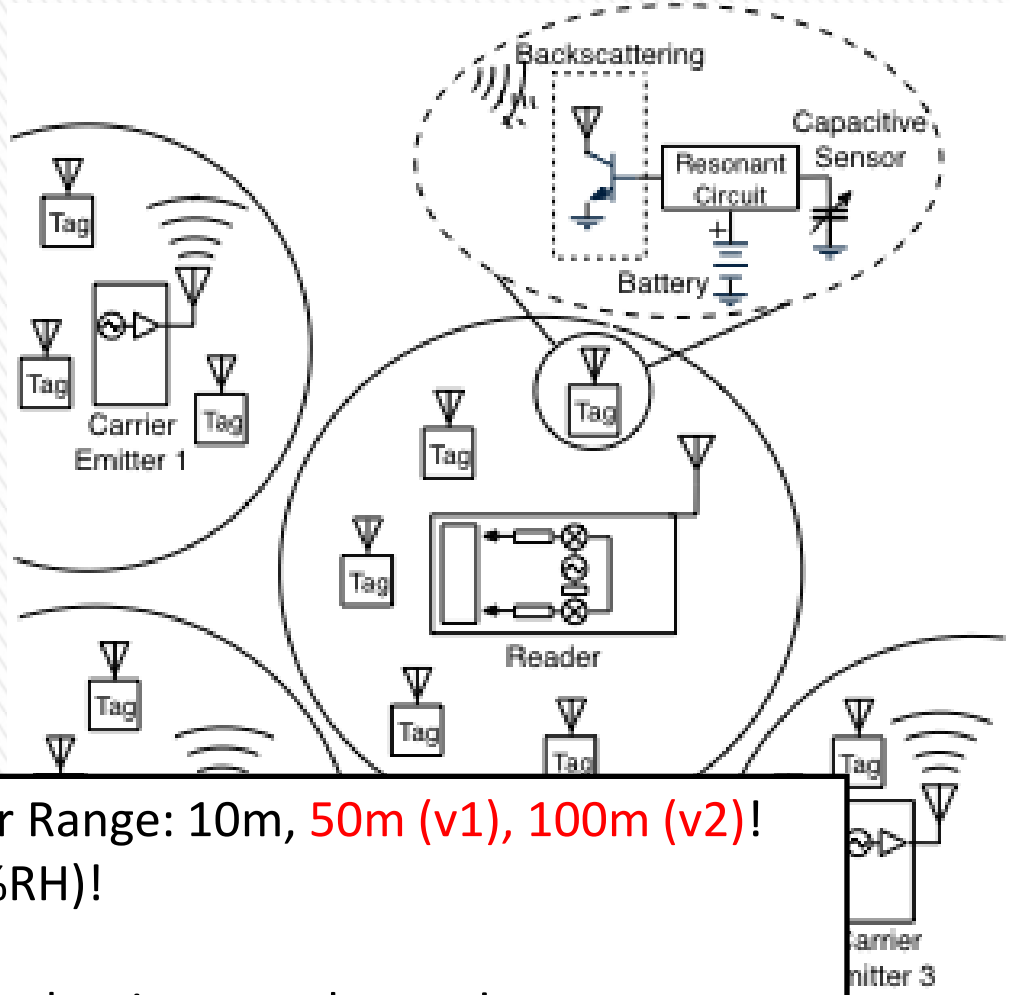




- time vs subcarrier frequency for 10 sensors, simultaneously operating.

Backscatter Humidity Sensing





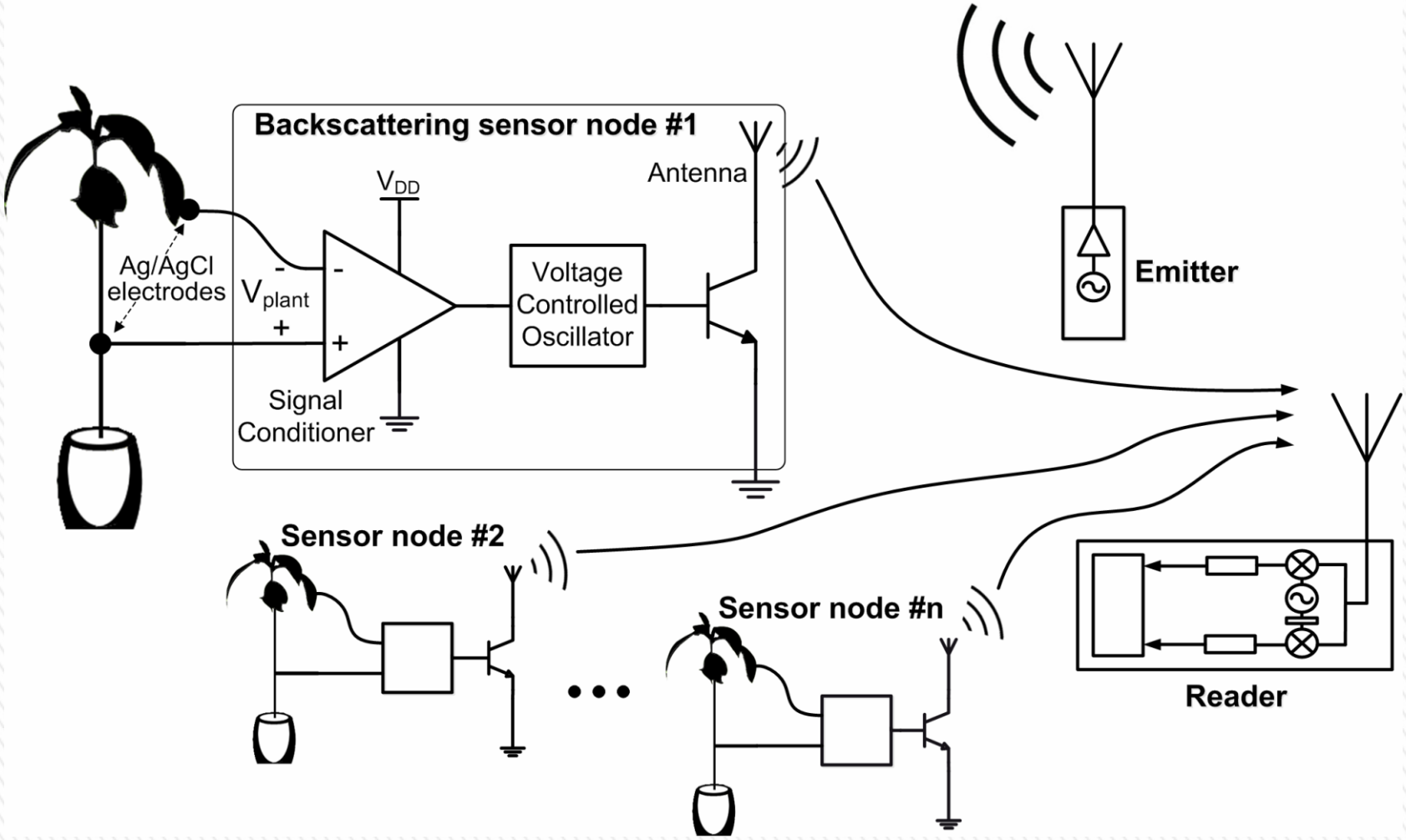
- Emitter-Sensor, Sensor-Reader Range: 10m, 50m (v1), 100m (v2)! (for 0.9 %RH RMS error @30 %RH)!
- New designs underway with further increased range!

Outline

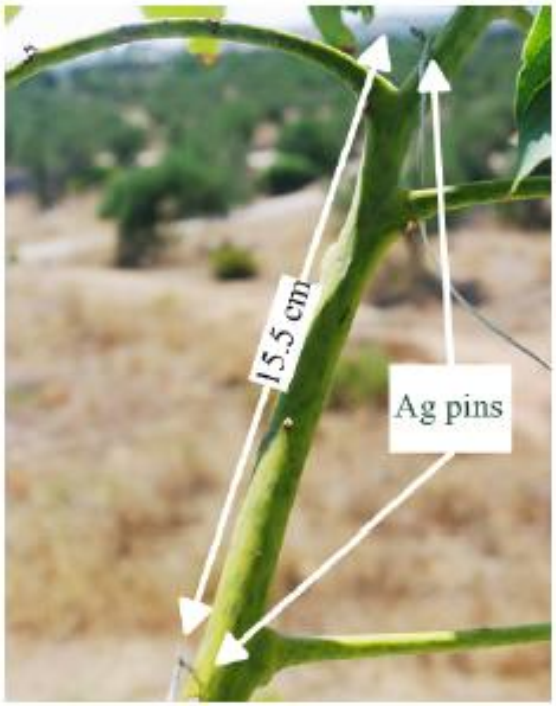
- Environmental Humidity Sensing
- “Plant is the sensor” Sensing [2]
- RF Harvesting & WIPE Challenges

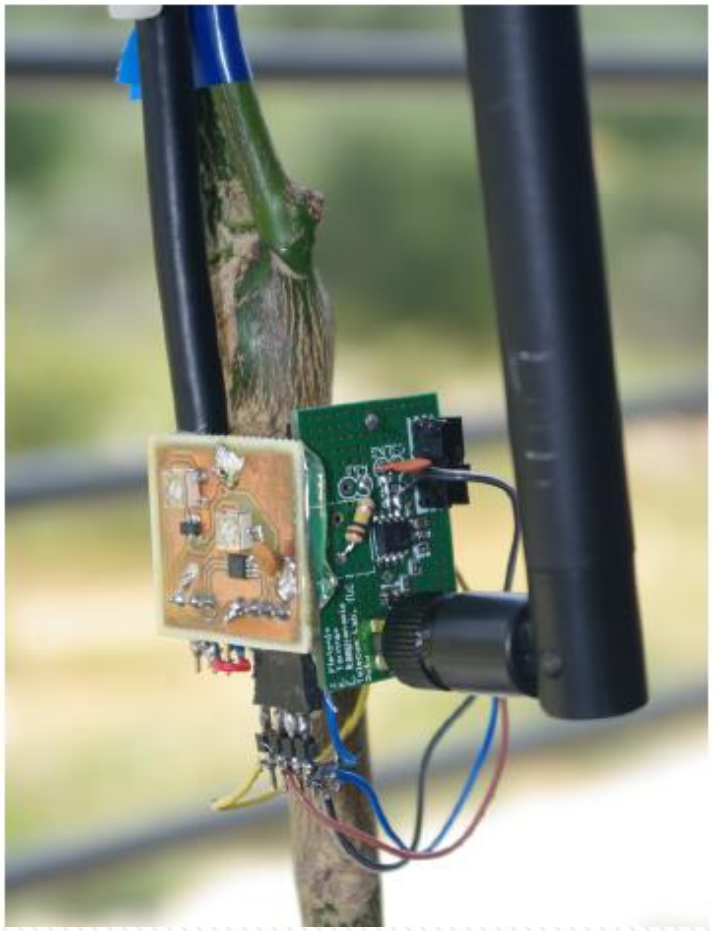
Backscatter Sensing: Plant is the sensor!

- Replace capacitor/timer circuit with a low-power VCO!



Backscatter Sensing: Plant is the sensor!





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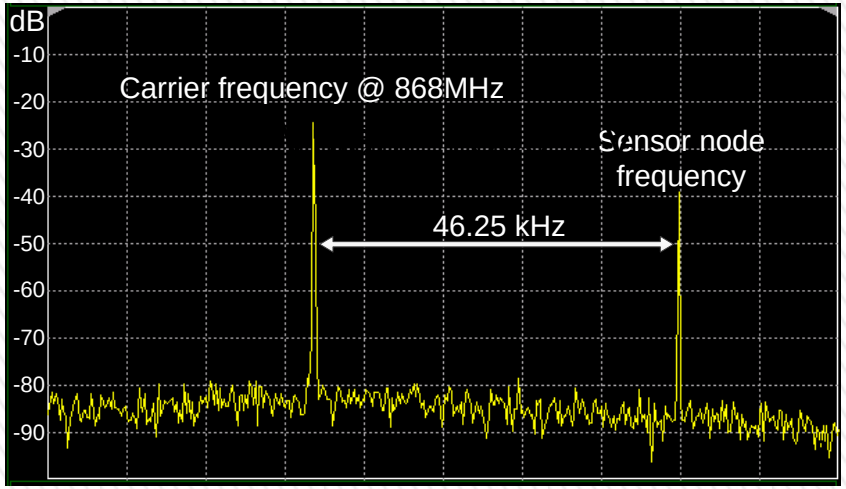
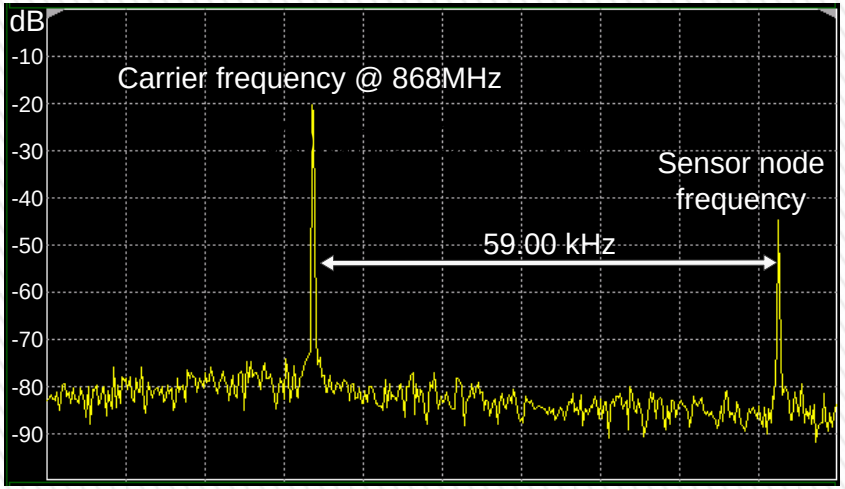
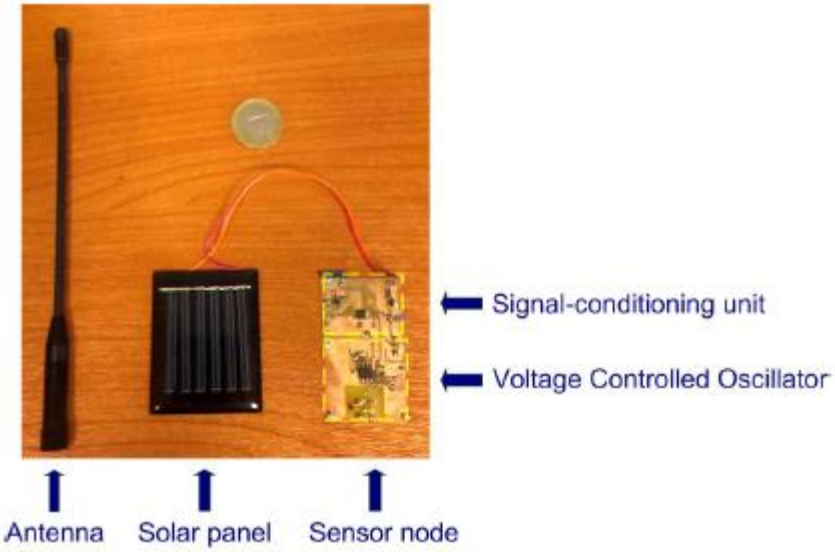


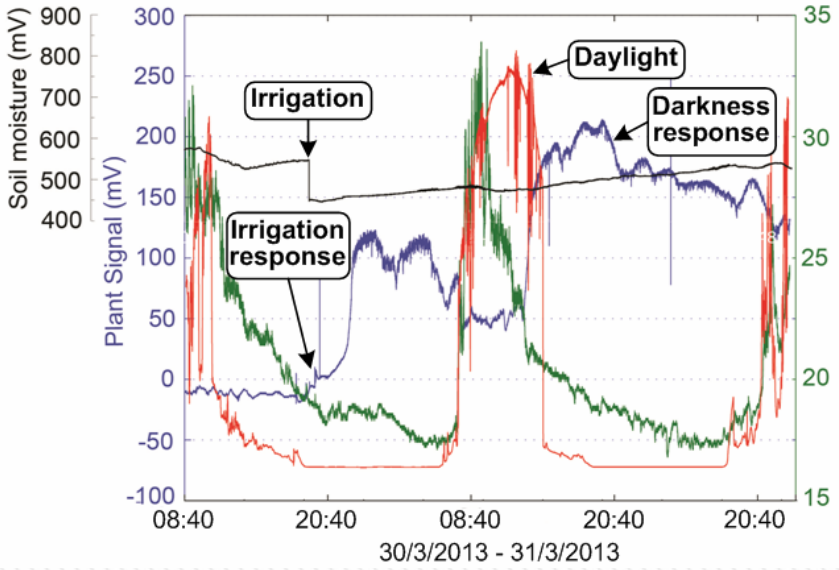


- **Plant Voltage to freq. convesion.**
- BW/sensor: 12.75kHz.
- Consumption: **240 µWatt**.

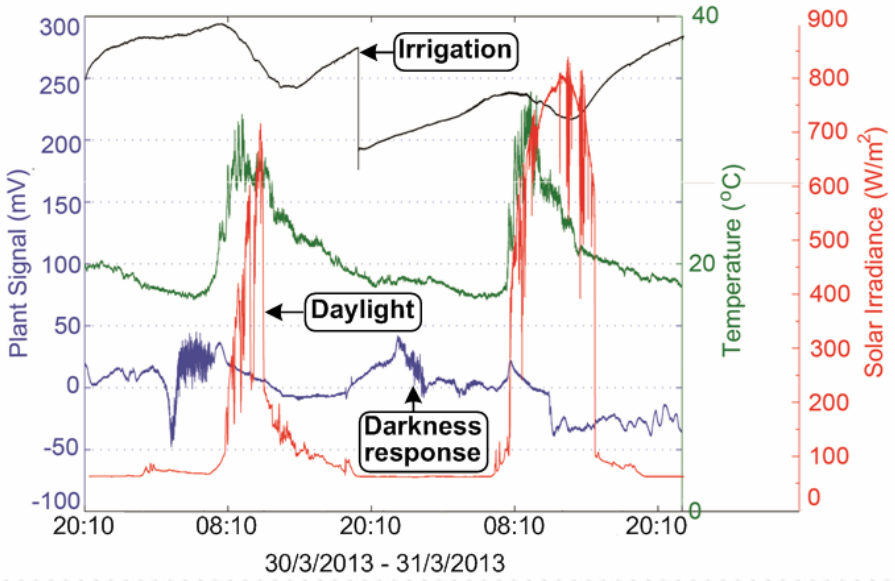


Backscatter Sensing: Plant is the sensor!

Avocado tree

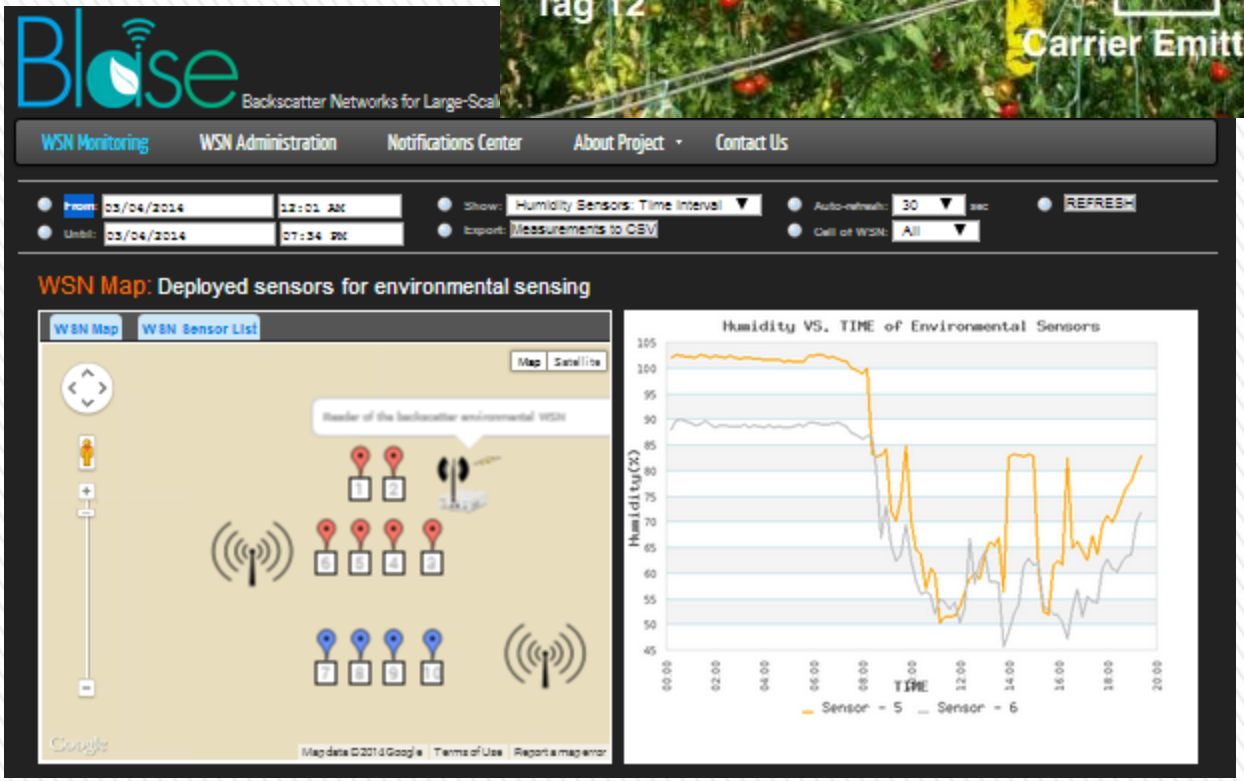


Orange tree



- Plant voltage is correlated with environmental conditions and soil moisture.
- 2-days data…

Greenhouse Deployment

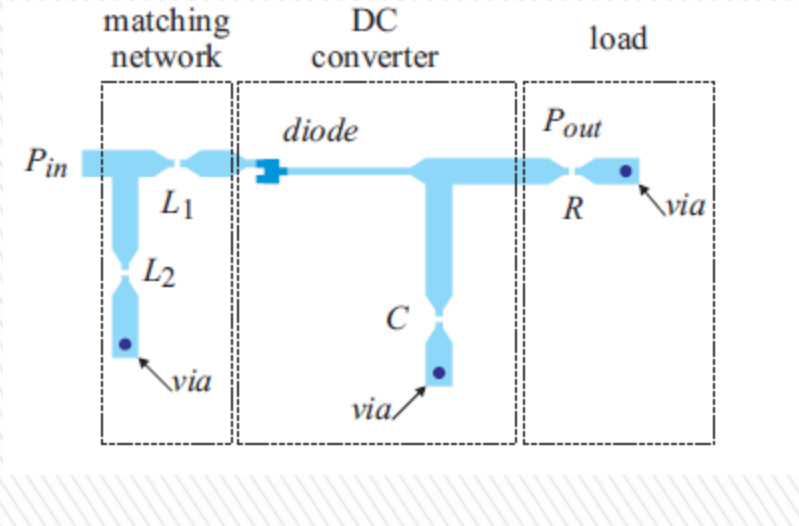


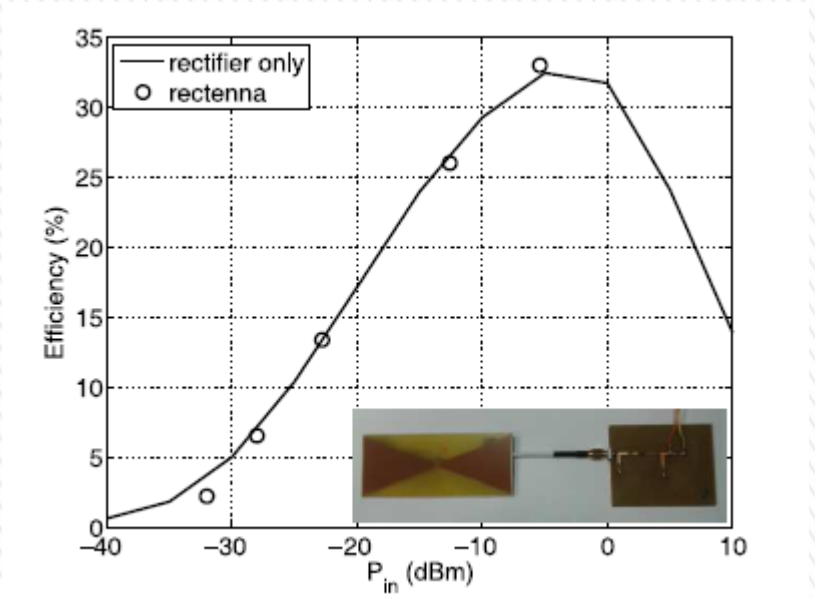
… and reporting to a web site, real time!

Outline

- Environmental Humidity Sensing
- “Plant is the sensor” Sensing
- RF Harvesting [3] [4]
  & WIPE Opportunities

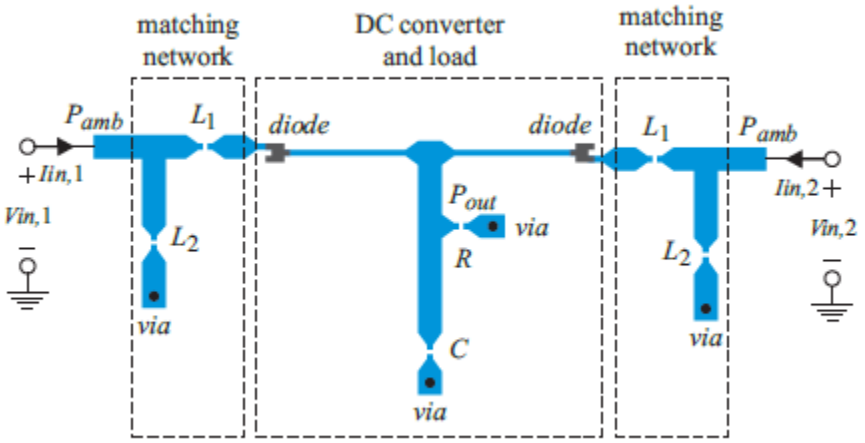
(Low-cost) FR4 microstrip Rectenna

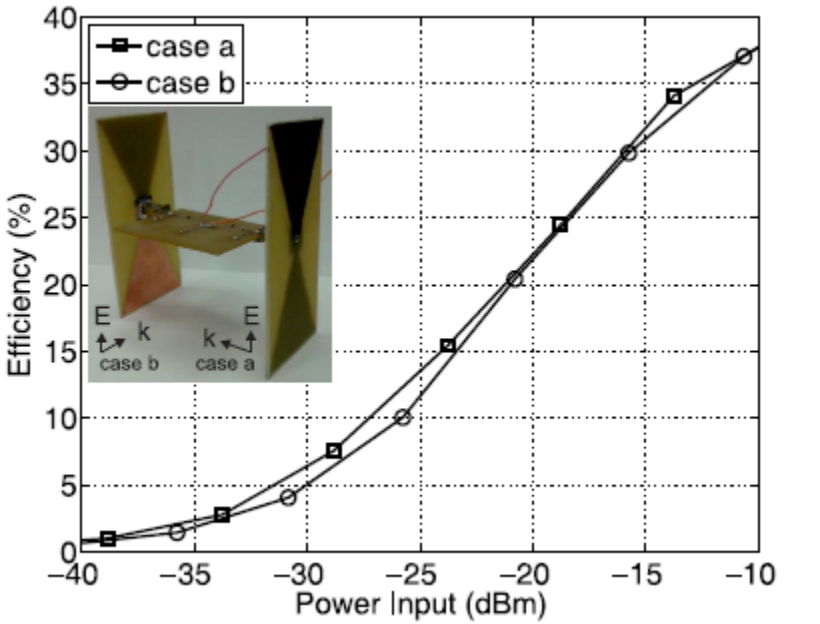


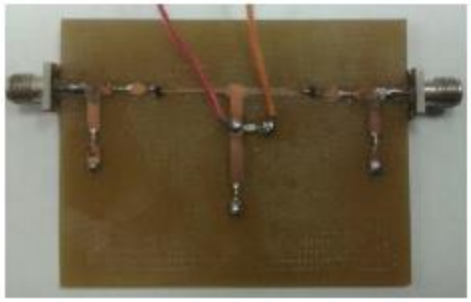


- Efficiency @ -10dBm input: 30%
- Efficiency @ -20dBm input: 17%

(Low-cost) FR4 microstrip Rectenna Grid







- Similar efficiency but larger harvested power:

-8.7 dBm at load @ -30 dBm/cm^2

-33.7 dBm at load @-50 dBm/cm^2

WIPE Opportunities

- (+) …environmental sensing = ULTRA LOW duty-cycle (100msec/60secs)!
- (-)…need to operate in smaller ambient RF density…
- (+) …can trade harvesting efficiency with sensitivity…
- (+-)…perhaps, hybrid modes with RF harvesting need to be exploited (solar, thermal, wind etc)!
- (+++)…need you!

References

[1] E. Kampianakis, I. Kimionis, K. Tountas, C. Konstantopoulos, E. Koutroulis, A. Bletsas, "Backscatter Sensor Network for Extended Ranges and Low Cost with Frequency Modulators: Application on Wireless Humidity Sensing", IEEE Sensors, November 2013, Baltimore, USA. **Selected as one of the best papers of the conference.**

[2] C. Konstantopoulos, E. Kampianakis, E. Koutroulis and A. Bletsas, "Wireless Sensor Node for Backscattering Electrical Signals Generated by Plants", IEEE Sensors, November 2013, Baltimore, USA.

[3] S. D. Assimonis and A. Bletsas, "Energy Harvesting with a Low-Cost and High Efficiency Rectenna for Low-Power Input", IEEE Radio Wireless Week Conference, January 2014, Newport Beach CA, USA.

[4] S. D. Assimonis, S. N. Daskalakis, and A. Bletsas, “Efficient RF Harvesting for Low-Power Input with Low-Cost 3D Rectenna Grid”, submitted to European Microwave 2014.

http://blase.tuc.gr

Thank you!

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