IC1301 -WiPE

Wireless Power Transmission for Sustainable Electronics

March 24-25, 2014

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Dept. of Engineering

WIPE

COST IC1301

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Perugia: the Italy's barycenter.
At least geometrically speaking!

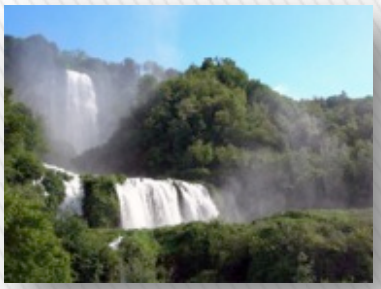
Umbria: the “green” heart of Italy

Assisi

Gubbio

Orvieto

Lake Trasimeno



Marmore waterfalls

Spoleto

UniPG – HFE lab team

Prof. Luca Roselli

Prof. Paolo Mezzanotte

Prof. Federico Alimenti

Ing. Giulia Orecchini (Post-doc)

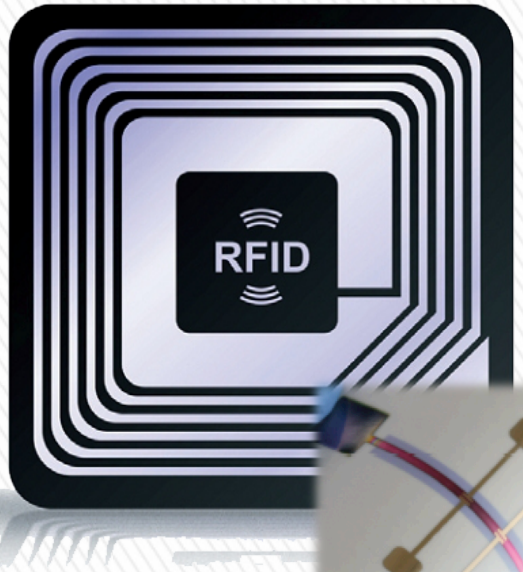
Ing. Marco Virili (Ph.D. Student)

Ing. Chiara Mariotti (Ph.D. Student)

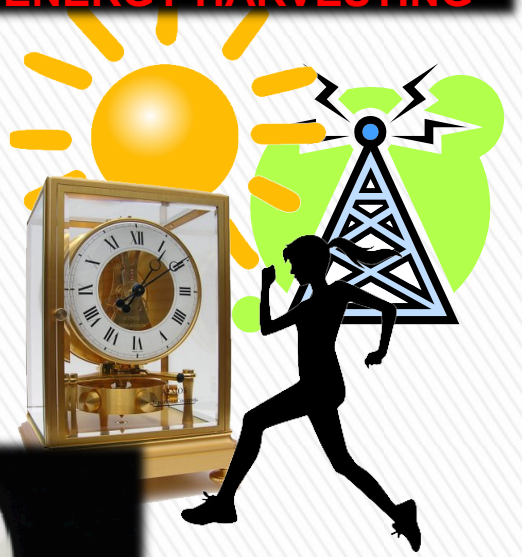
COST Action IC1301 Working Groups (WGs):

1. Far-field WPT systems
2. Near-field WPT systems
3. Novel materials and technologies
4. **Applications to health, security, agriculture, transportation systems**
5. Regulation for future WPT systems

Tecnology Summary

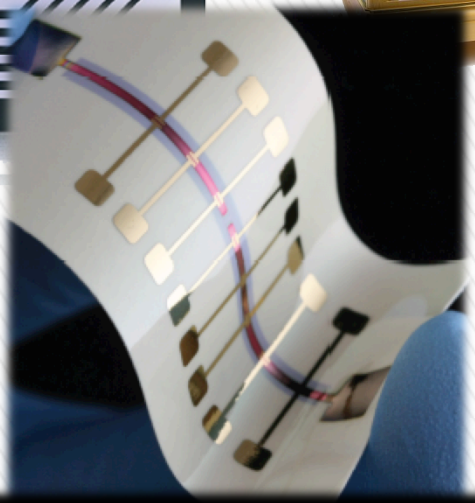


ENERGY HARVESTING



INKJET PRINTING

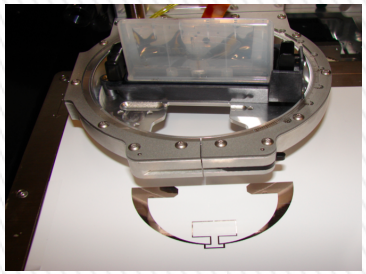
COPPER-TAPE LAMINATE

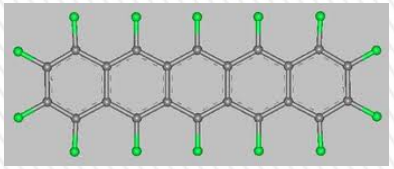


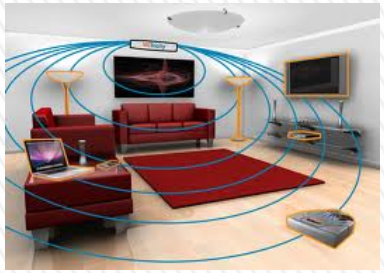
FLEXIBLE-ORGANIC ELECTRONIC

PAPER

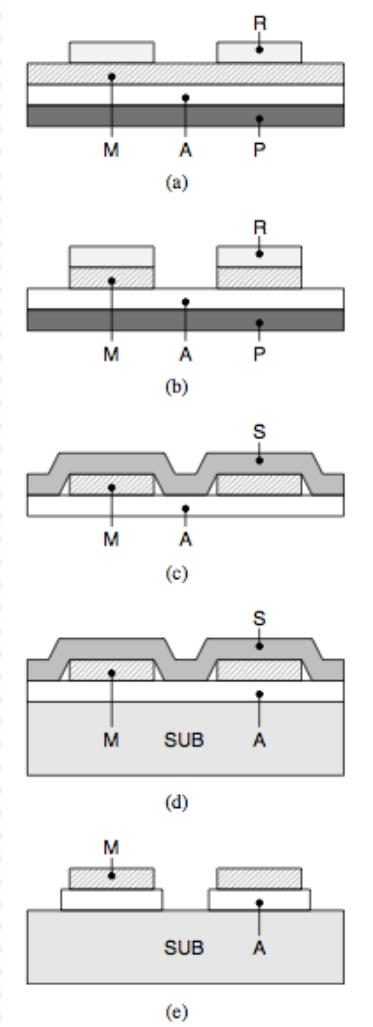
Let’s put everything together!

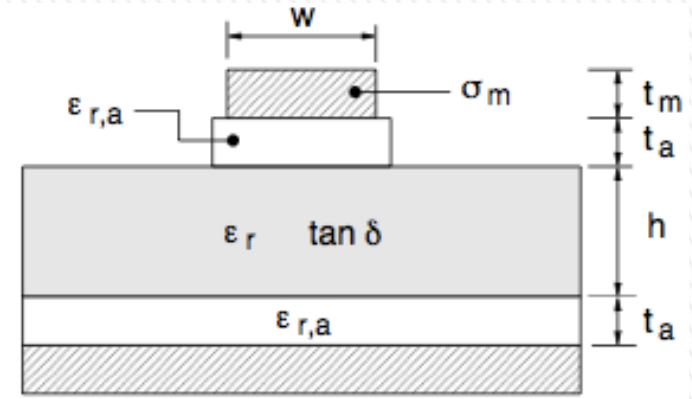




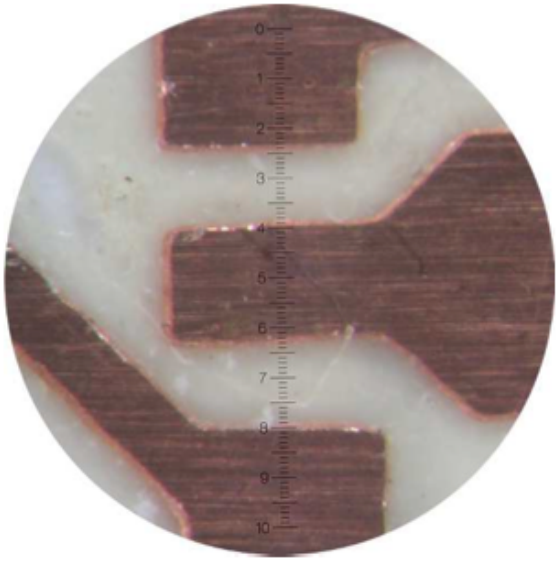


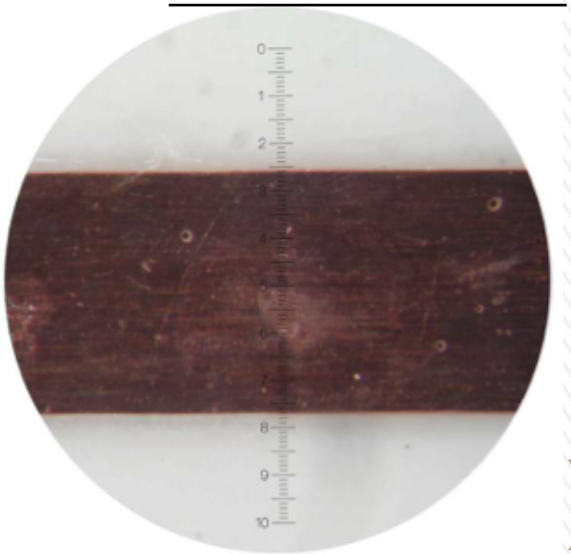
Adhesive Copper Laminate on Paper





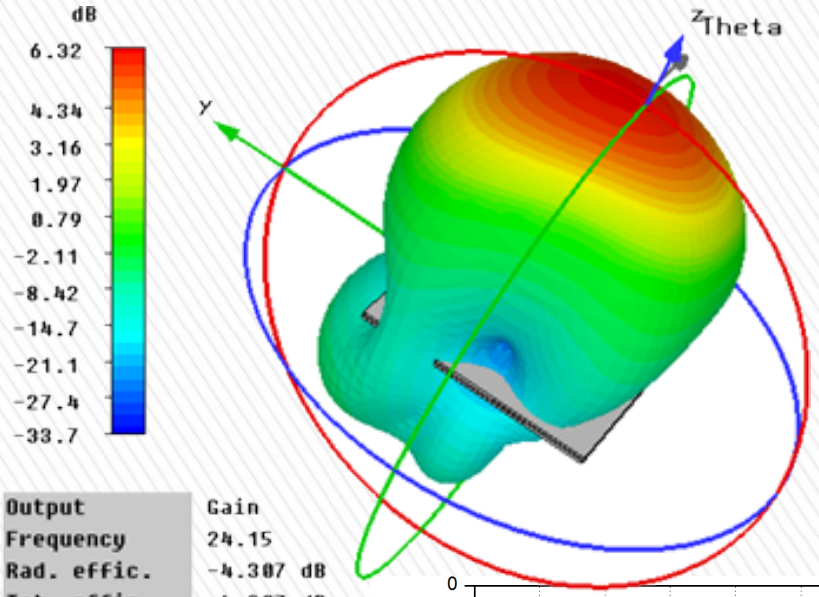
Parameter	Value
w	377 µm
h	250 µm
T_a	40 µm
t_m	50 µm
ε_r	3.2
tanδ	0.08
$\varepsilon_{r,a}$	1.3
σ_m	58 MS/m



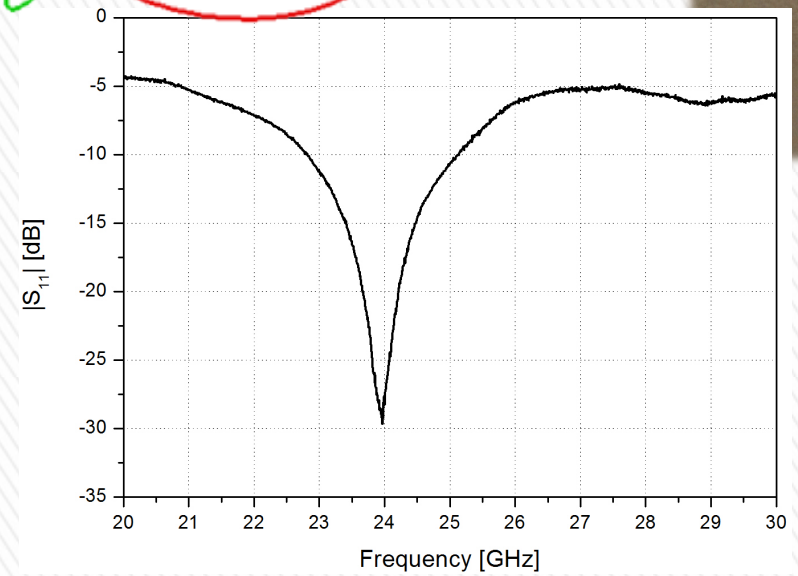


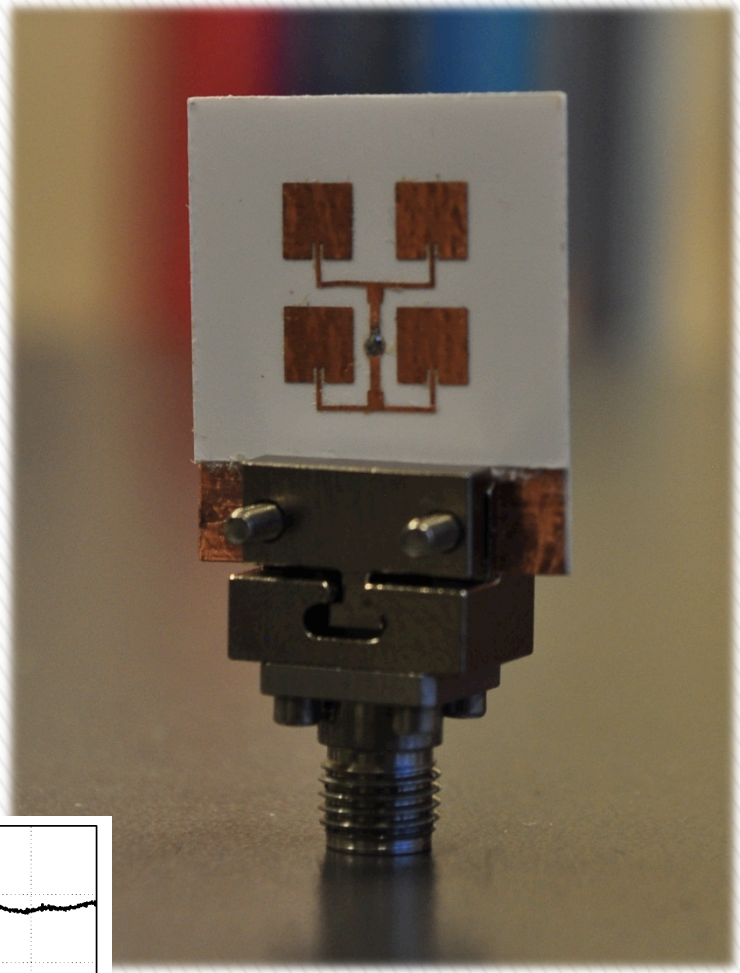
F. Alimenti, P. Mezzanotte, M. Dionigi, M. Virili, and L. Roselli, "**Microwave Circuits in Paper Substrates Exploiting Conductive Adhesive Tapes**," IEEE Microwave and Wireless Components Letters, vol. 22, no. 12, pp. 660–662, 2012.

SiPoP Antenna



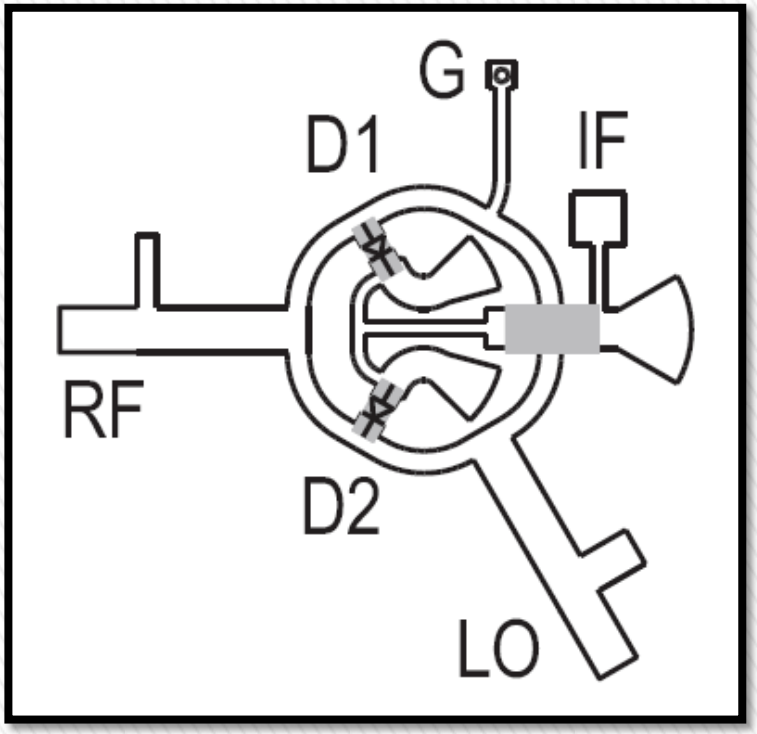
Output	Gain
Frequency	24.15
Rad. effic.	-4.307 dB
Tot. effic.	-4.307 dB
Gain	6.319 dB



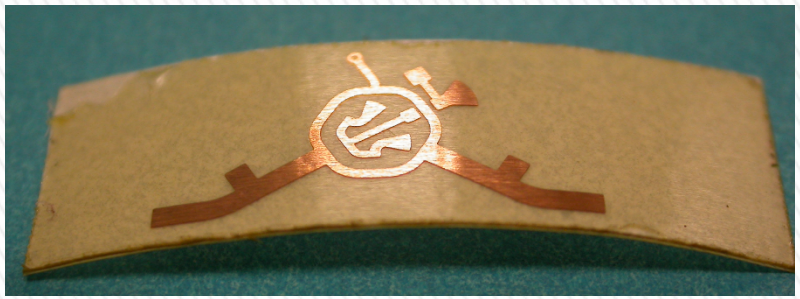


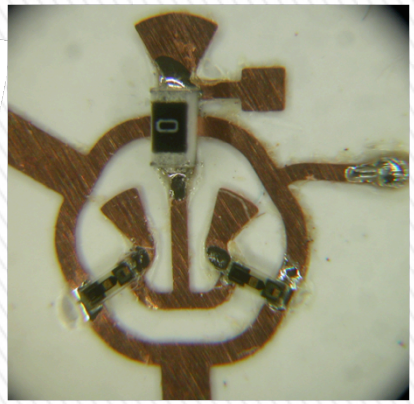
SiPoP 24 GHz Mixer

Layout



Fabricated Prototype

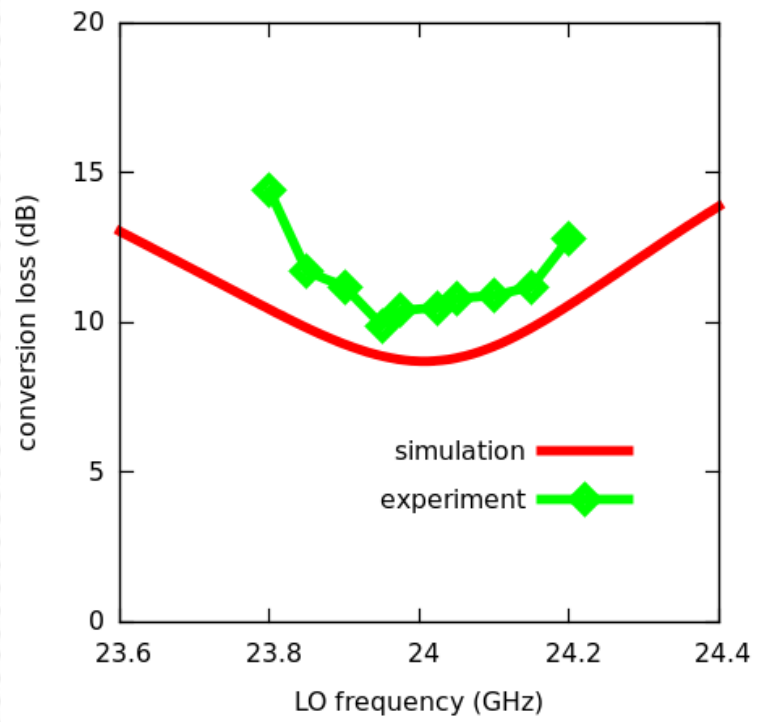




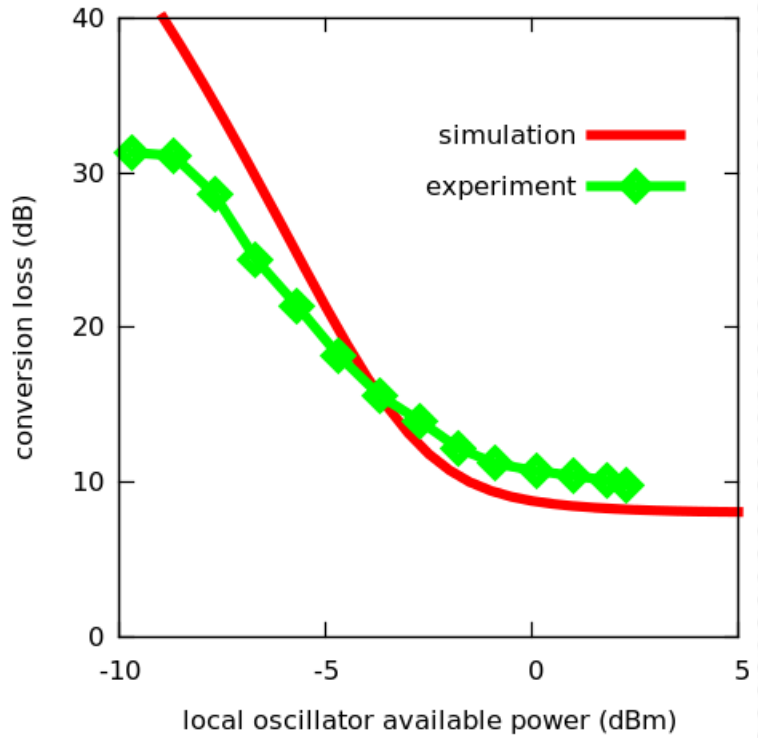
F. Alimenti, P. Mezzanotte, S. Giacomucci, M. Dionigi, C. Mariotti, M. Virili, and L. Roselli, "**24 GHz Single-Balanced Diode Mixer Exploiting Cellulose-Based Materials**," IEEE Microwave and Wireless Components Letters, Oct. 2013.

SiPoP 24 GHz Mixer

Conversion loss in dB versus LO frequency in GHz

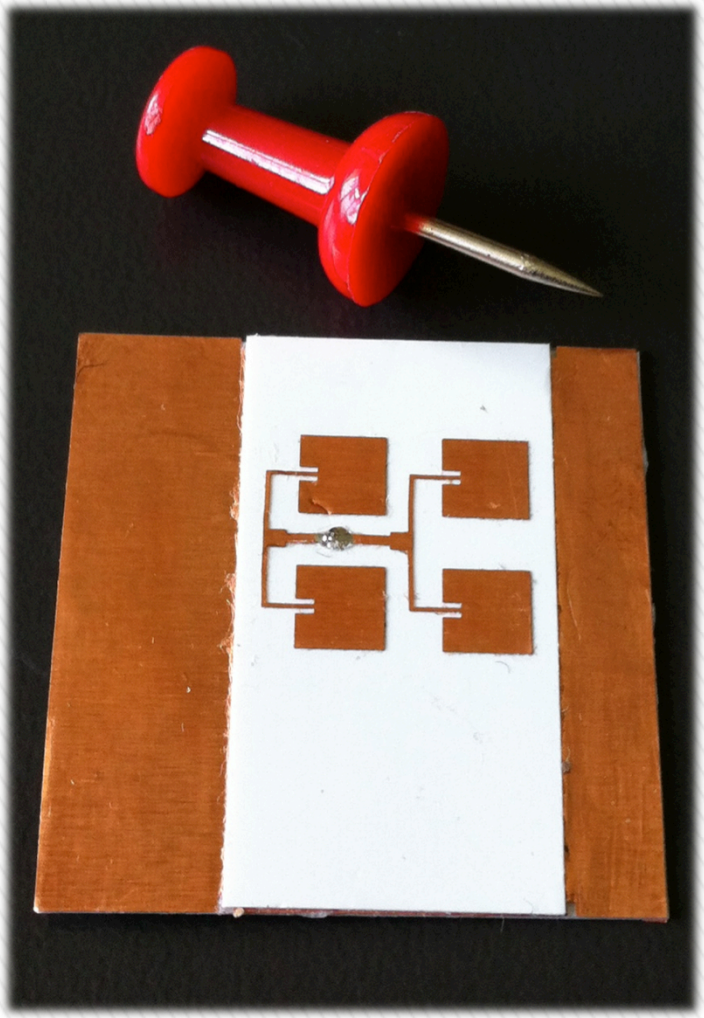


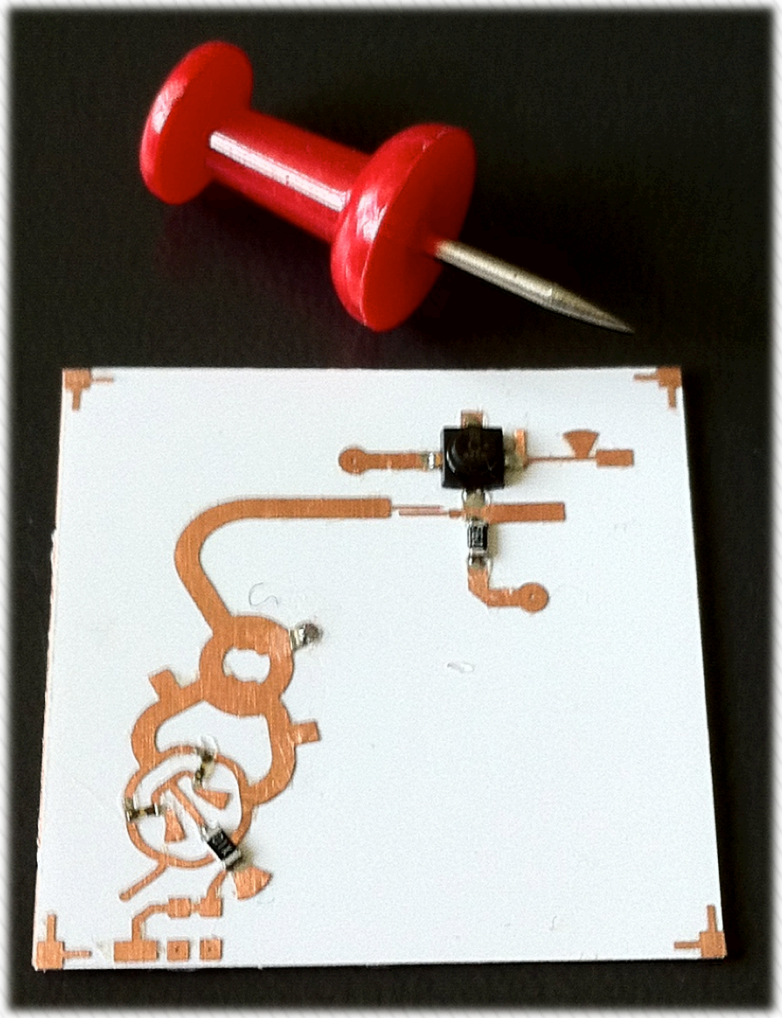
Conversion loss in dB versus LO power in dBm



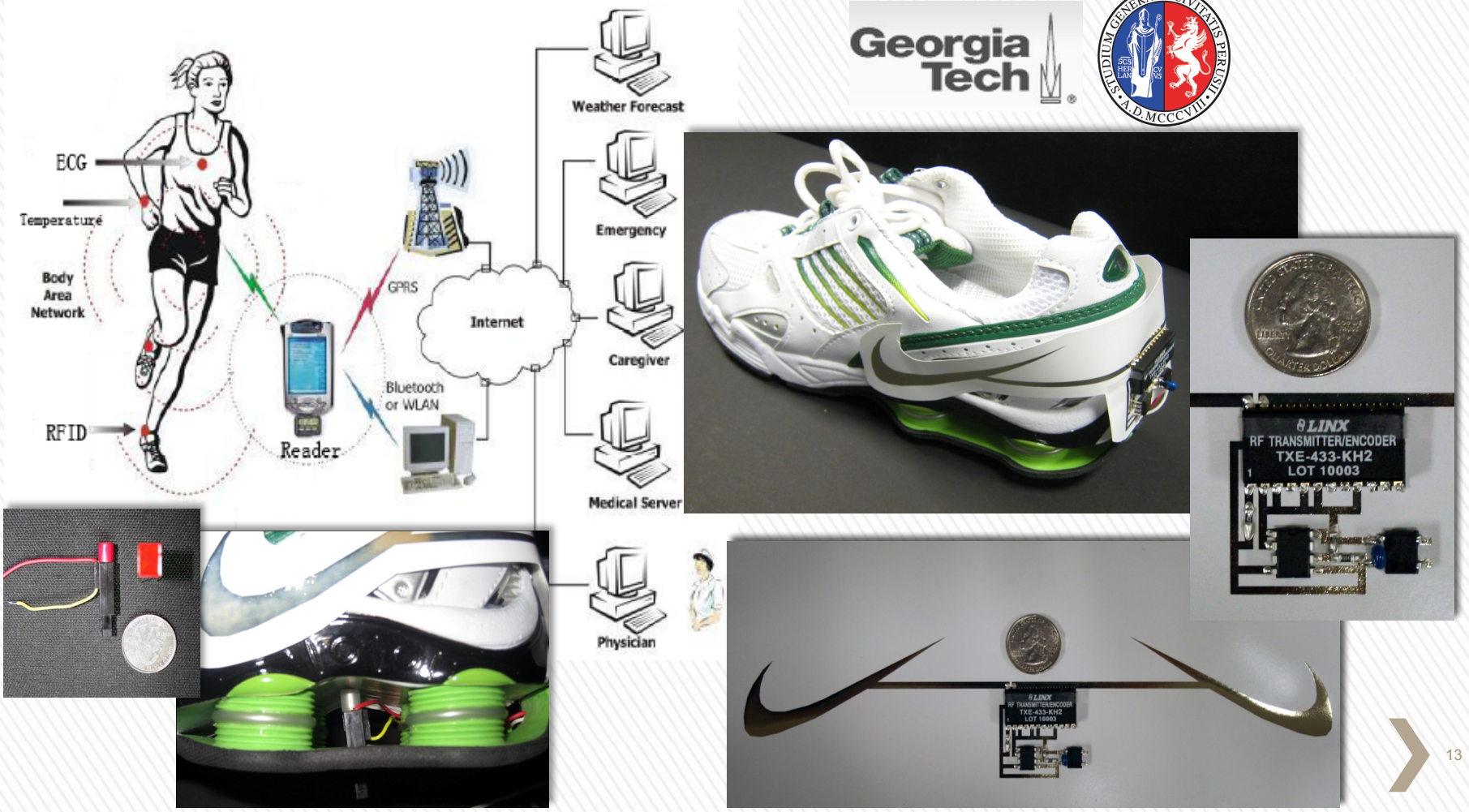
F. Alimenti, P. Mezzanotte, S. Giacomucci, M. Dionigi, C. Mariotti, M. Virili, and L. Roselli, "**24 GHz Single-Balanced Diode Mixer Exploiting Cellulose-Based Materials**," IEEE Microwave and Wireless Components Letters, Oct. 2013.

SiPoP 24 GHz Doppler Radar Sensor Front-End





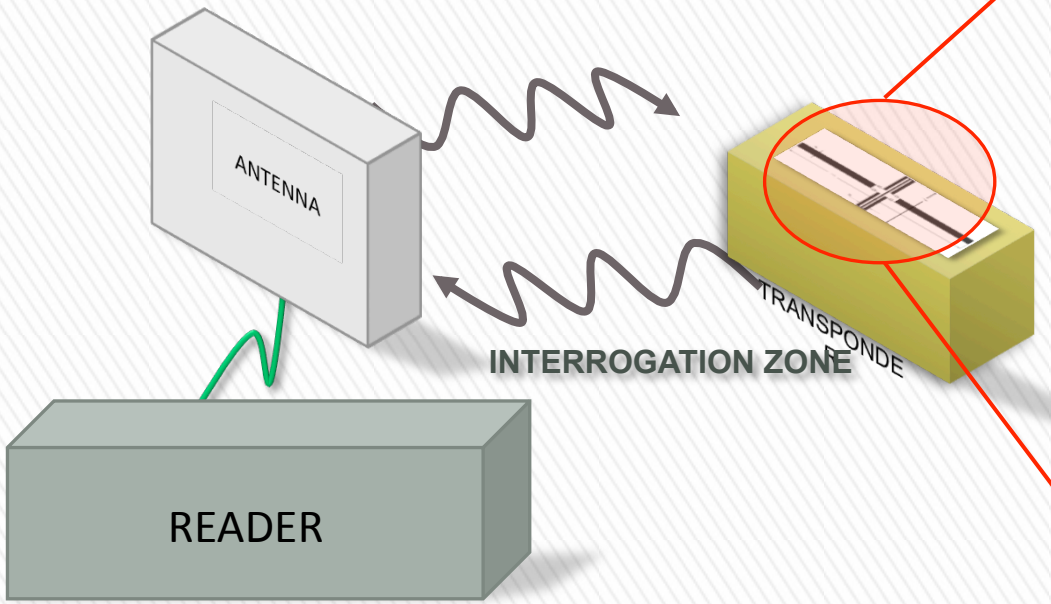
Inkjet Printed Battery-Less RFID Transmitter

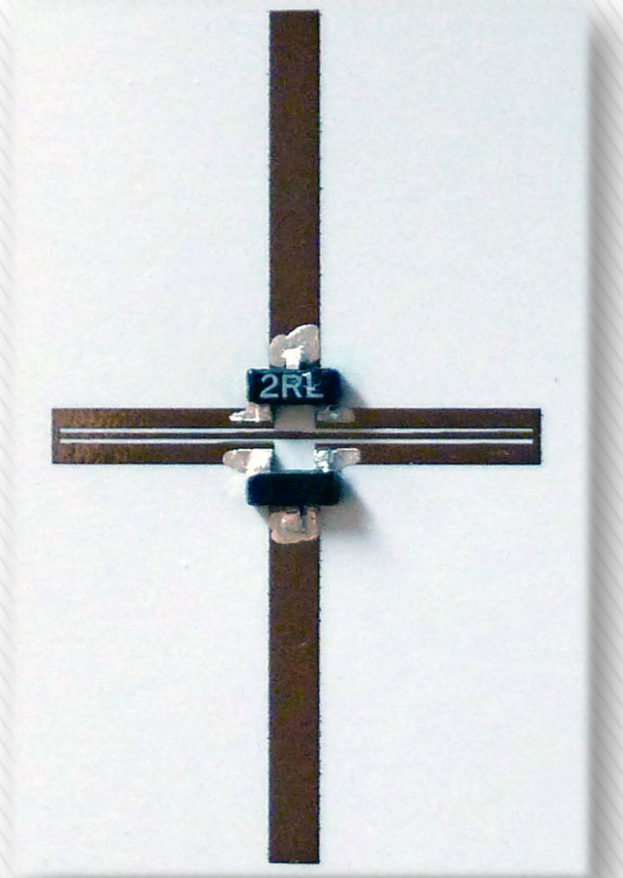


G. Orecchini, M. M. Tentzeris, L. Yang, and L. Roselli, "**Smart Shoe: An autonomous inkjet-printed RFID system scavenging walking energy**," in 2011 IEEE International Symposium on Antennas and Propagation APSURSI, 2011, pp. 1417–1420.

Injet Printed Chip-less Tag

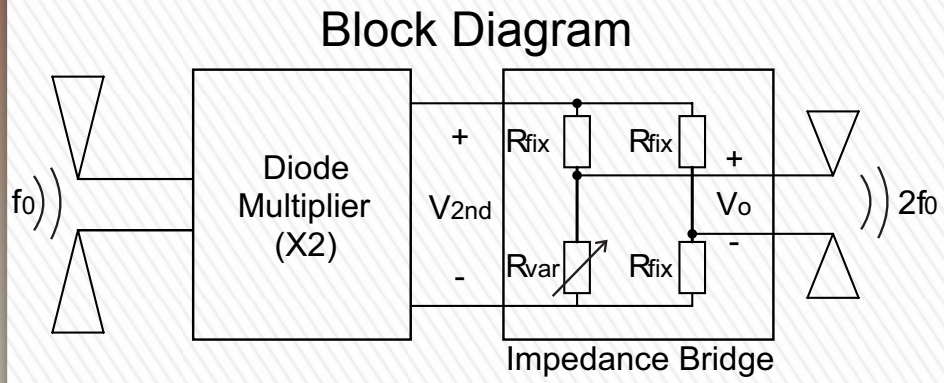
One-bit of information without modulation

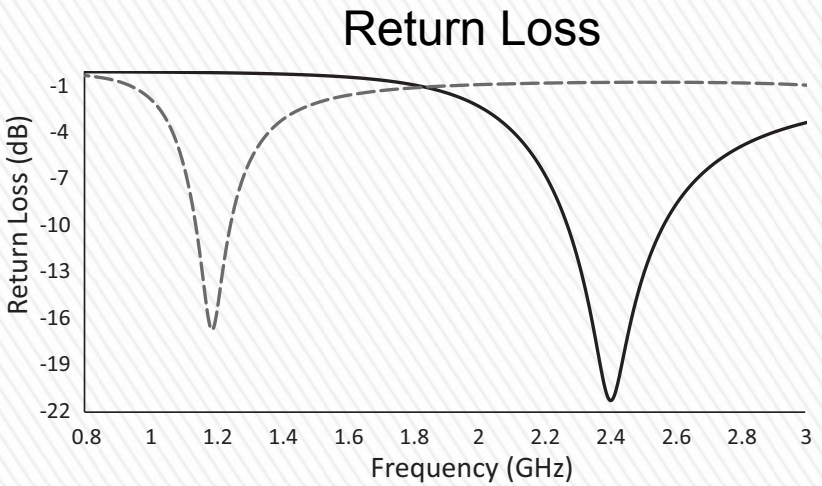




G. Orecchini, F. Alimenti, V. Palazzari, A. Rida, M. M. Tentzeris, and L. Roselli, "**Design and fabrication of ultra-low cost radio frequency identification antennas and tags exploiting paper substrates and inkjet printing technology**," IET Microwaves, Antennas & Propagation, vol. 5, no. 8, p. 993, 2011.

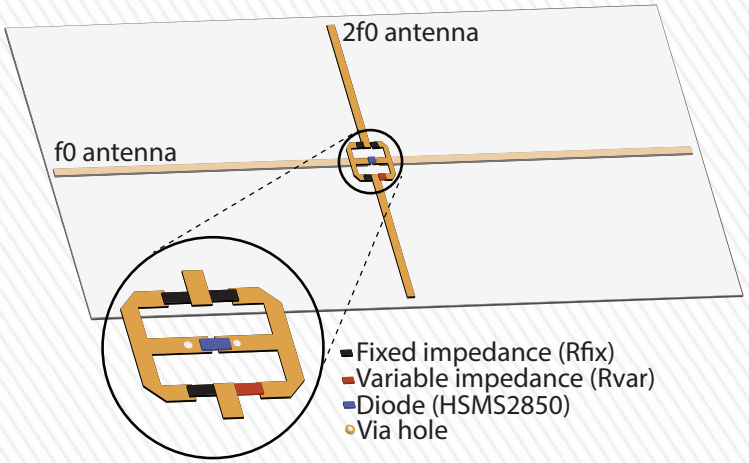
Adhesive Copper Laminate on Paper: Chipless Sensor

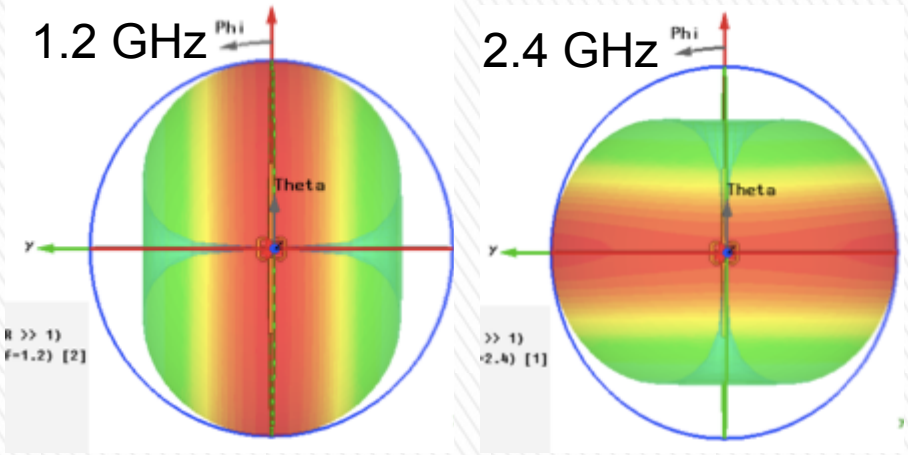




Simulations

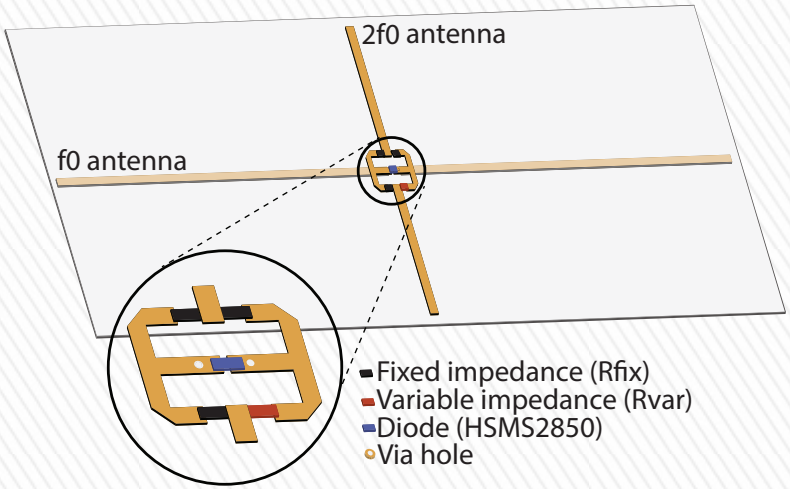
Design





C. Mariotti, F. Alimenti, M. Virili, G. Orecchini, P. Mezzanotte, L. Roselli, "**Harmonic Chipless Sensor Exploiting Wireless Autonomous Communication and Energy Transfer**", accepted at WPTC 2014 (Korea)

Adhesive Copper Laminate on Paper: Chipless Sensor

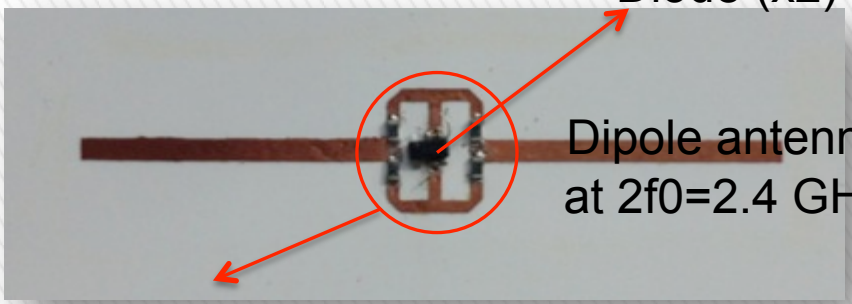


Realized Prototype

Back side

Dipole antenna at f0=1.2 GHz

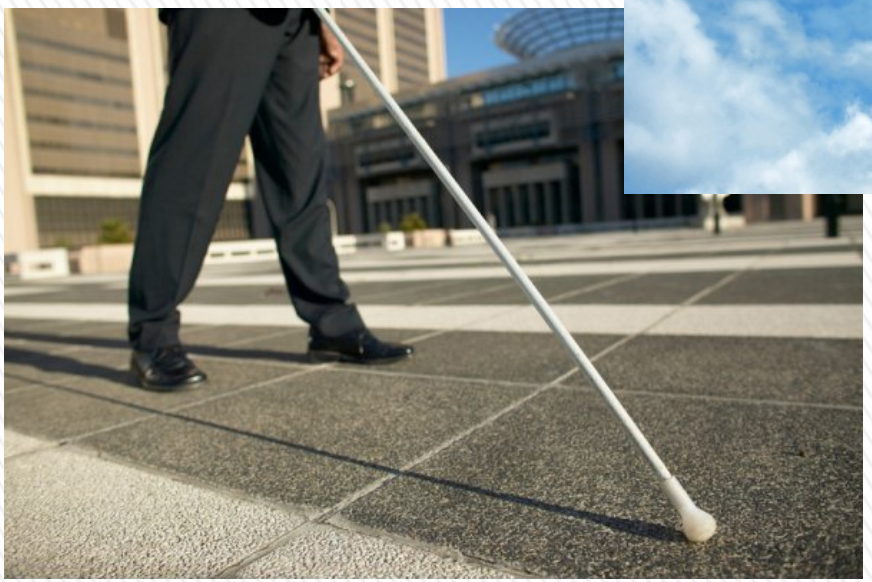
Front side



C. Mariotti, F. Alimenti, M. Virili, G. Orecchini, P. Mezzanotte, L. Roselli, "**Harmonic Chipless Sensor Exploiting Wireless Autonomous Communication and Energy Transfer**", accepted at WPTC 2014 (Korea)

Smart Path Concept

Where am I?



instituto de telecomunicações

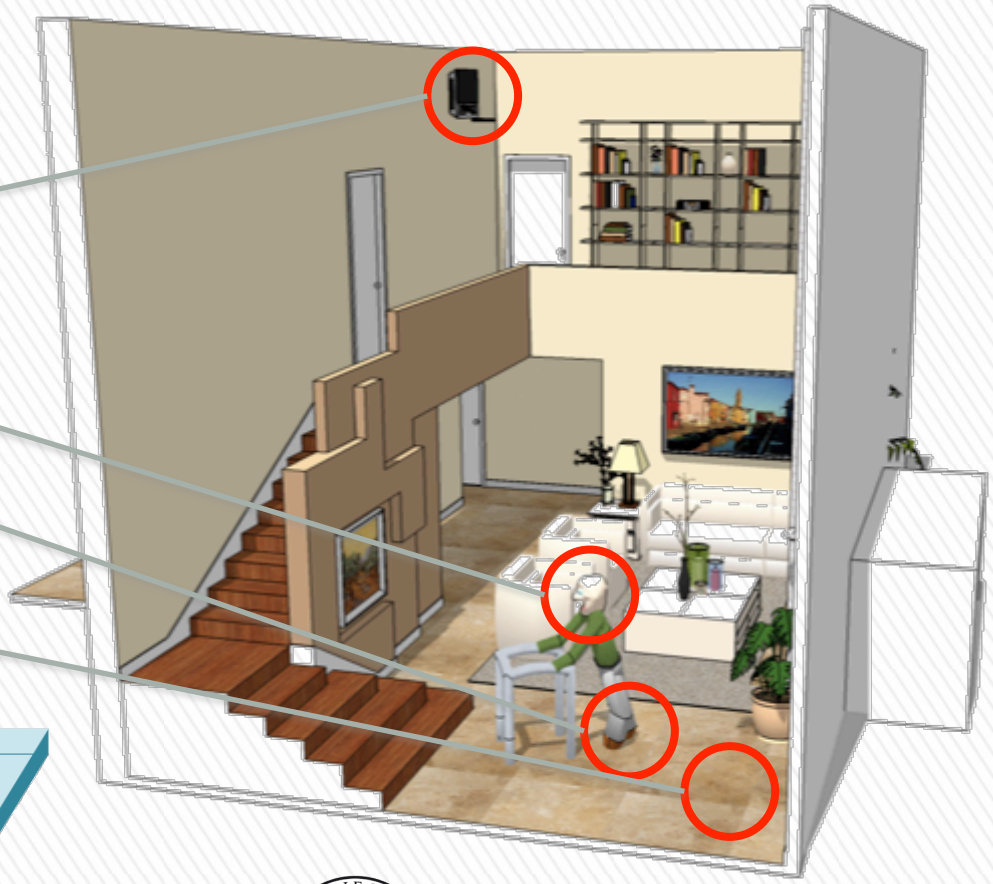
Technological layers:

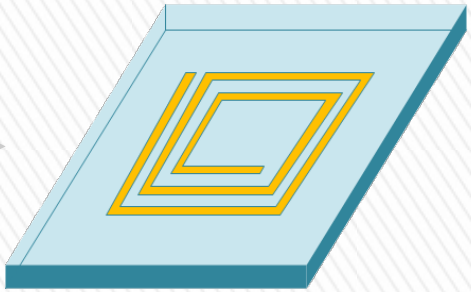
- Wireless comm. to the web (optional)
- Personal information Sys
- Nomadic Reader
- Tag embedded in the floor

cost

Smart Floor Concept

- Access point
- Person
- RFID Reader
- Smart Tile (Tag)



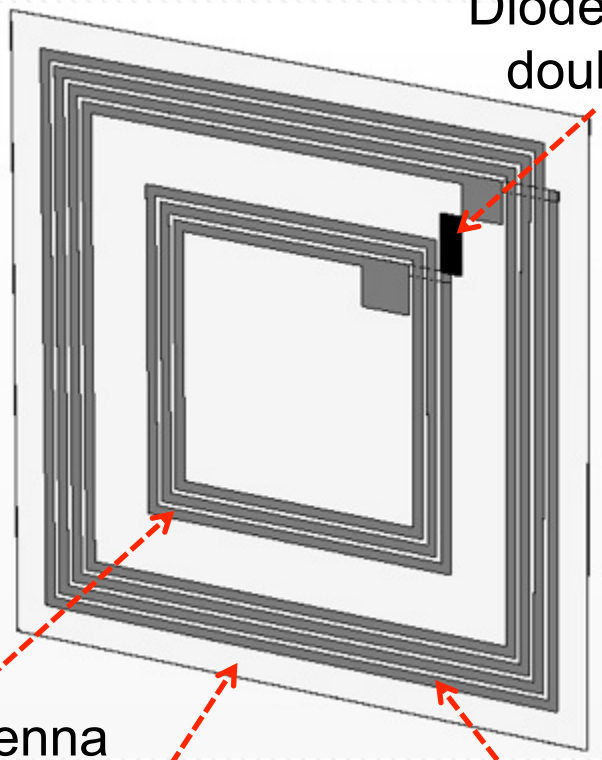


instituto de telecomunicações

Chip-less Tag Evolution for Smart Path/Tile

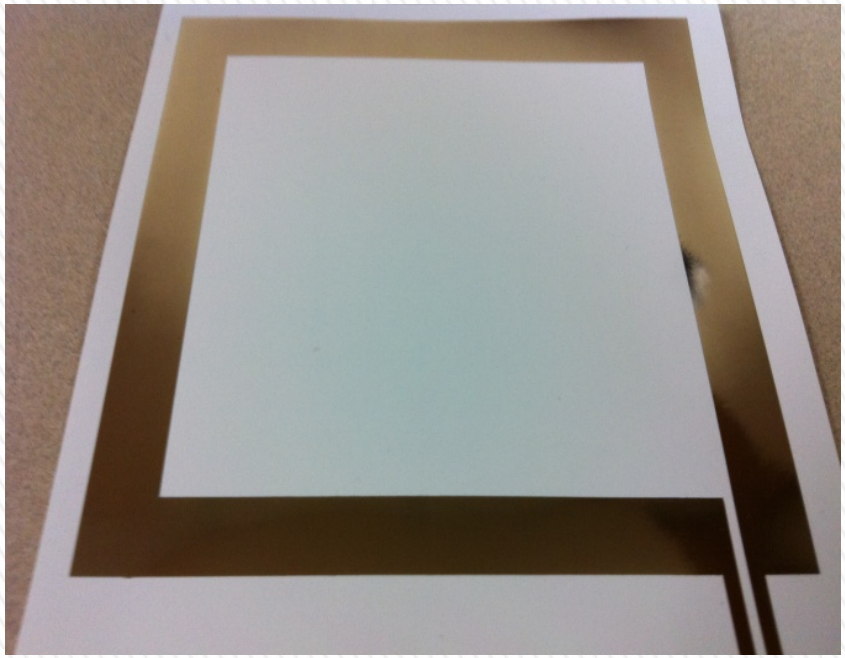
RFID harmonic tag
Chipless - one bit

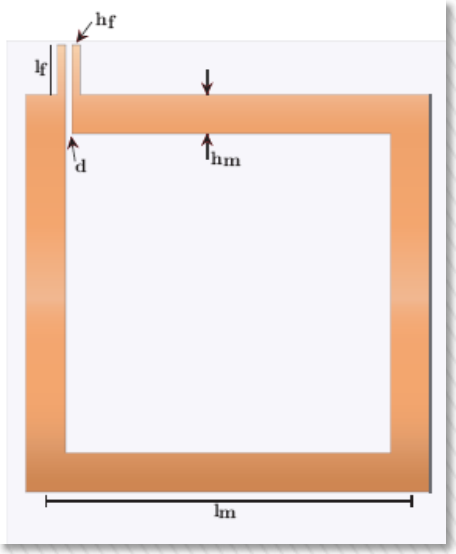
RFID reader



Tile Tag Antenna on Paper

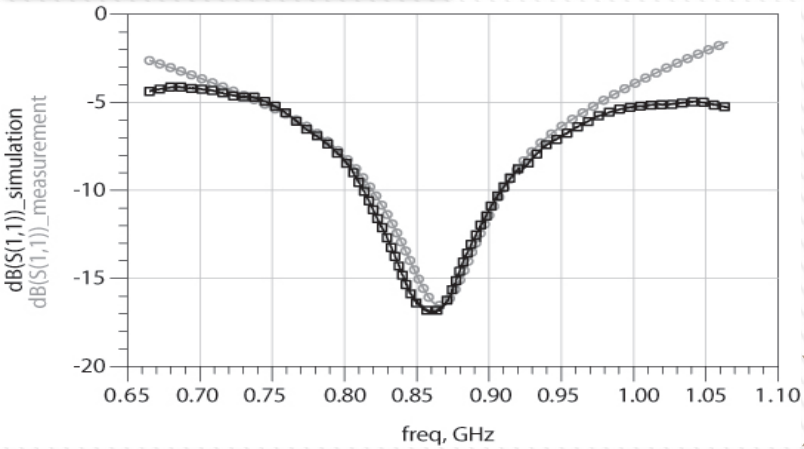
- Ink-jet printed on paper
- Adhesive copper ribbon technology was also used





Dimensions:

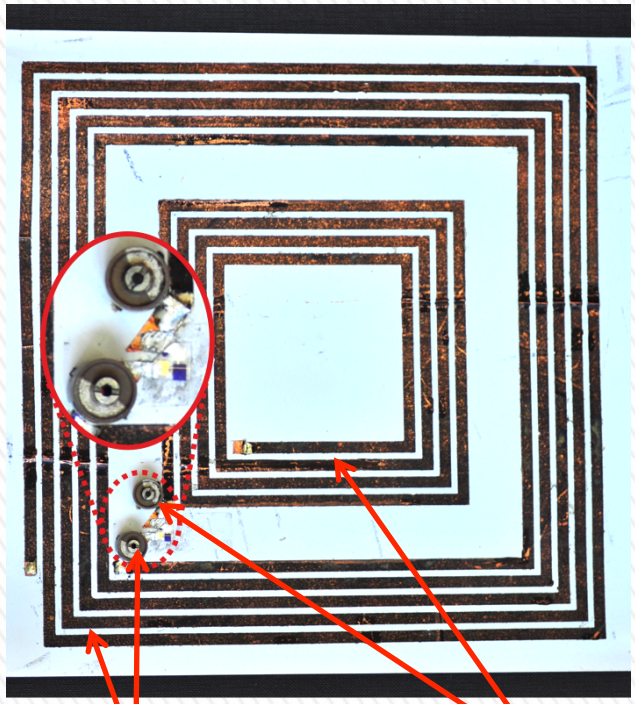
- $l_m = \lambda/2 = 17.34$ cm
- $l_f = 2.4$ cm
- $h_f = 0.4$ cm
- $d = 0.3$ cm



C. Mariotti, G. Orecchini, M. Virili, F. Alimenti, and L. Roselli, "**RFID Tag Antenna Embedded in Concrete Structures for Construction Industry**," in Proceedings of the 6th European Conference on Antennas and Propagation (EUCAP), 2012, pp. 3469–3472.

Organic Chip-less Tile Tag: Preliminary Prototype

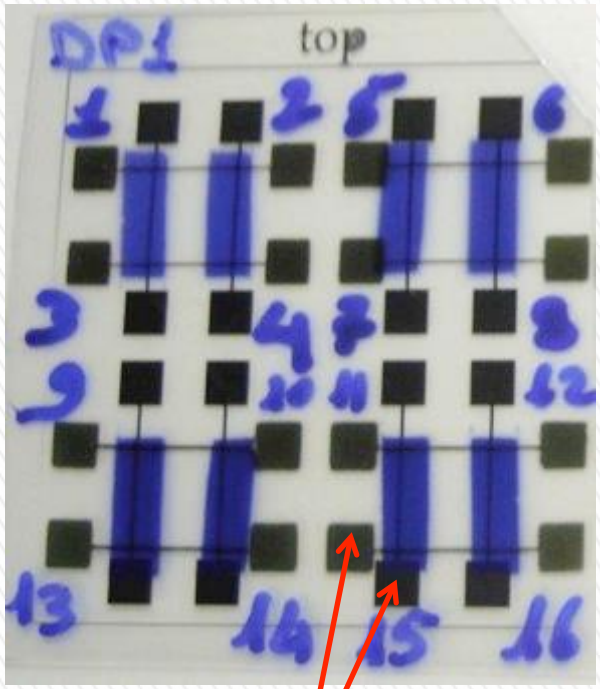
Frequency doubler



Inductor and capacitor of the resonator @ f_0

Inductor and capacitor of the resonator @ $2f_0$

Organic diodes



Metallic contacts of a single diode

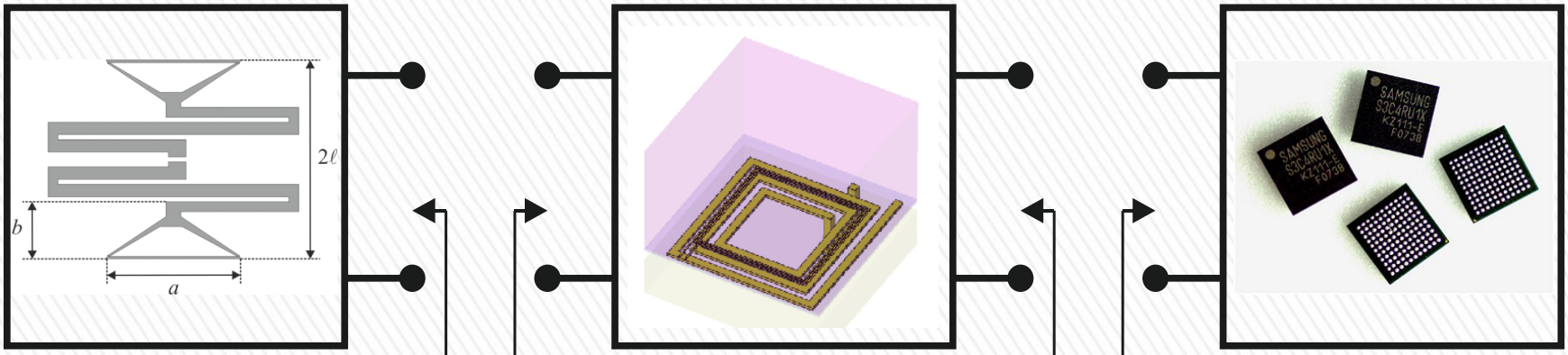
Marco Virili, Giulia Casula, Chiara Mariotti, Giulia Orecchini, Federico Alimenti, Piero Cosseddu, Paolo Mezzanotte, Annalisa Bonfiglio, Luca Roselli, "**7.5-15 MHz Organic Frequency Doubler Made with Pentacene-Based Diode and Paper Substrate"**, accepted at IMS 2014 (Korea)

WPT-Based Assembly Technology:

Antenna

Heterogeneous Transformer

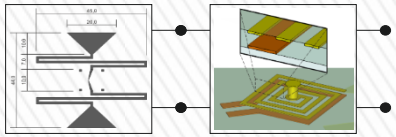
Si-chip/ Active circuitry



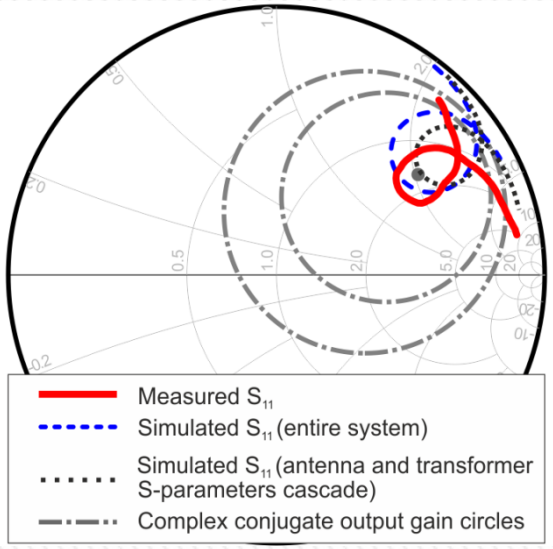
Z_S Z_{IN} Z_{OUT} Z_L

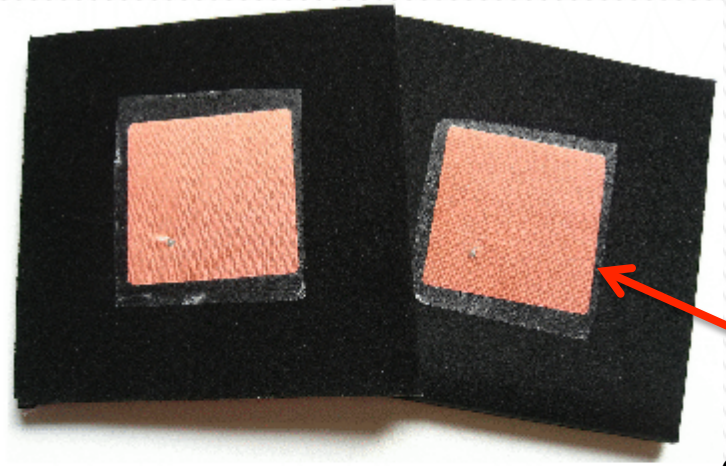
WPT-Based Assembly Technology: Wearable Textile Antenna for BAN

2.45 GHz patch antenna magnetically coupled to active circuitry on flexible substrate

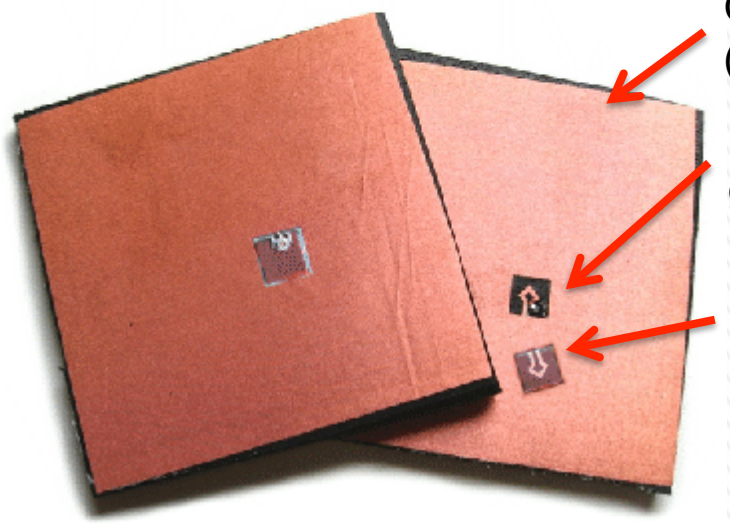


S_{11}





Patch antenna (front view)



Ground plane (back view)

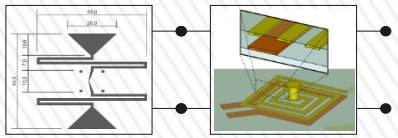
Primary winding on ground plane

Secondary winding on flexible substrate

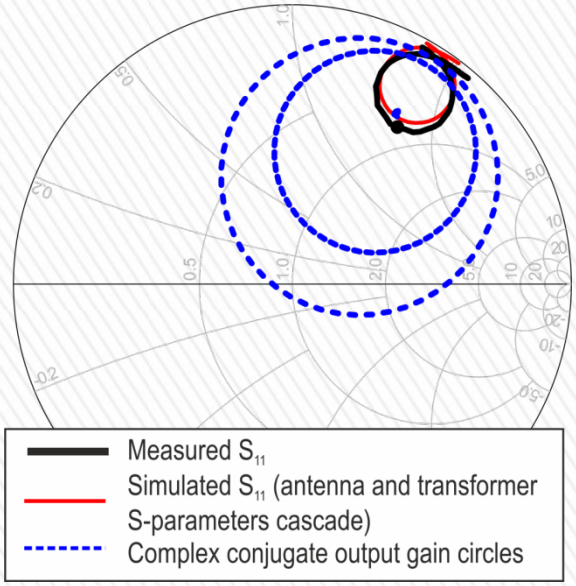
Virili, M.; Rogier, H.; Alimenti, F.; Mezzanotte, P.; Roselli, L., **"Wearable Textile Antenna Magnetically Coupled to Flexible Active Electronic Circuits,"** *Antennas and Wireless Propagation Letters, IEEE* , vol.13, no., pp.209,212, 2014.

WPT-Based Assembly Technology: Flexible Substrate Antenna

868 MHz bow-tie antenna magnetically coupled to active circuitry

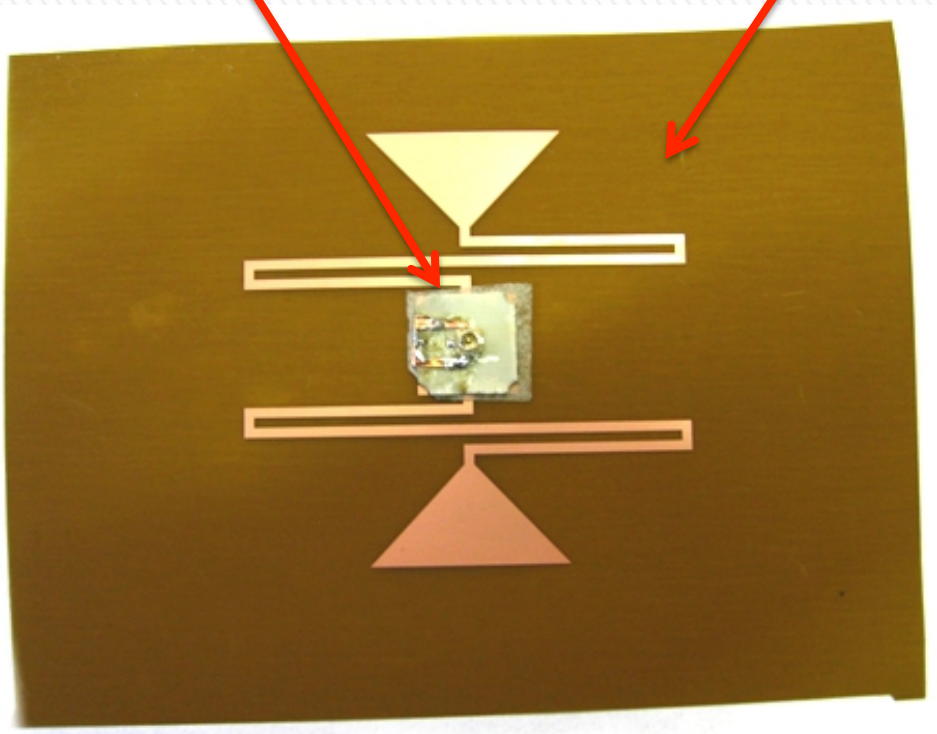


S_{11}



PCB (Rogers RO4003) with secondary winding and UFL connector

Flexible substrate (Pyralux) with antenna and primary winding



M. Virili, P. Mezzanotte, H. Rogier, F. Alimenti, and L. Roselli, "**Design of an UHF RFID antenna on flexible substrate magnetically coupled to the tag**", *International Review of Progress in Applied Computational Electromagnetics, ACES 2013*, 24-28 Mar. 2013, Monterey, CA, USA.

Agriculture WSNs

T leaf sensor prototype

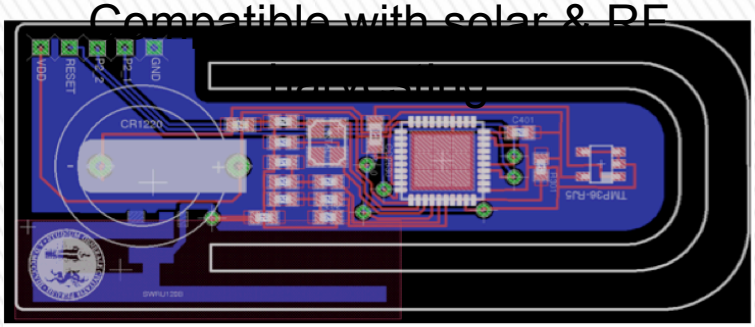
leaf sensor evolution

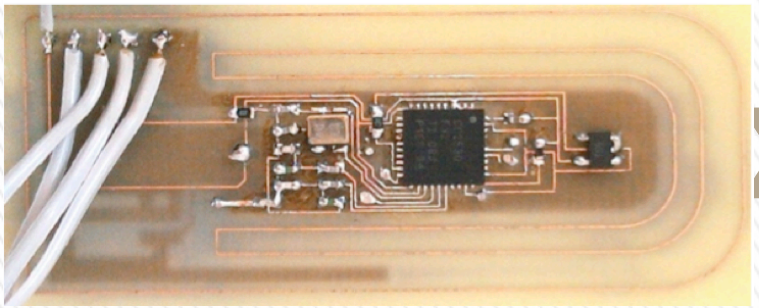
ULP TICC2530 transceiver

Zigbee protocol

Compatible with realization on paper

Compatible with solar & RF





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Thank you

cost