IC1301 -WiPE

Non-linear Energy Harvesting in Passive UHF RFID Tag

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WIPE

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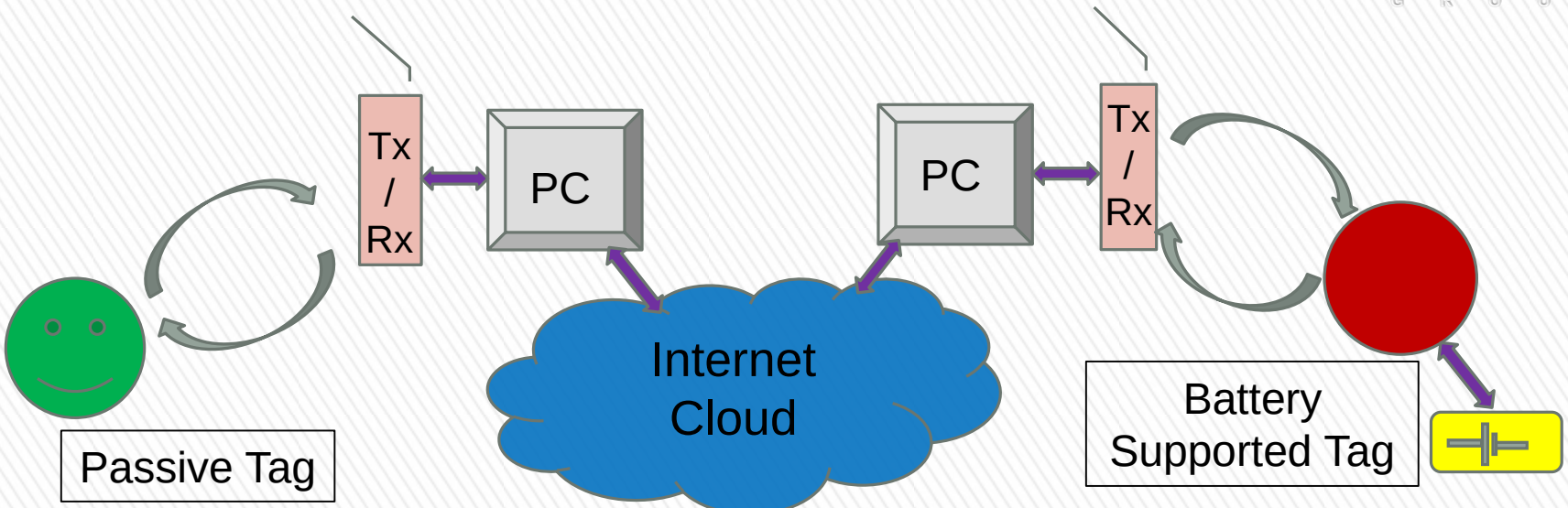
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Agenda

- Introduction
- Design / Prototypes
- Experimental Results
- Conclusion

Introduction

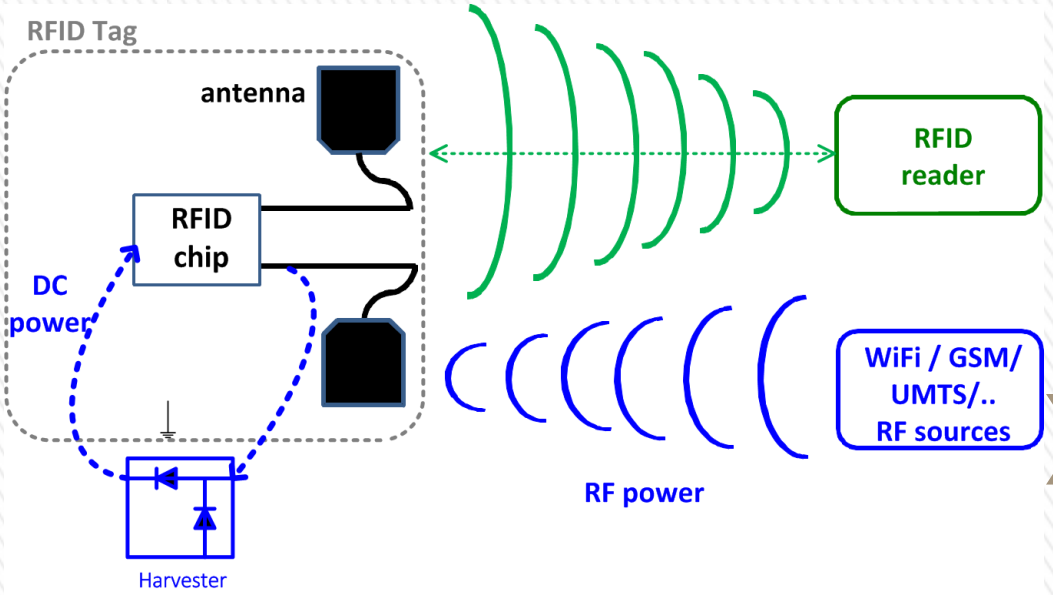


Longer life…shorter read range

Shorter life…longer read range

Energy harvesting solutions

- Solar
- Kinetic/ Mechanical
- Thermal
- **Electromagnetic**



Introduction

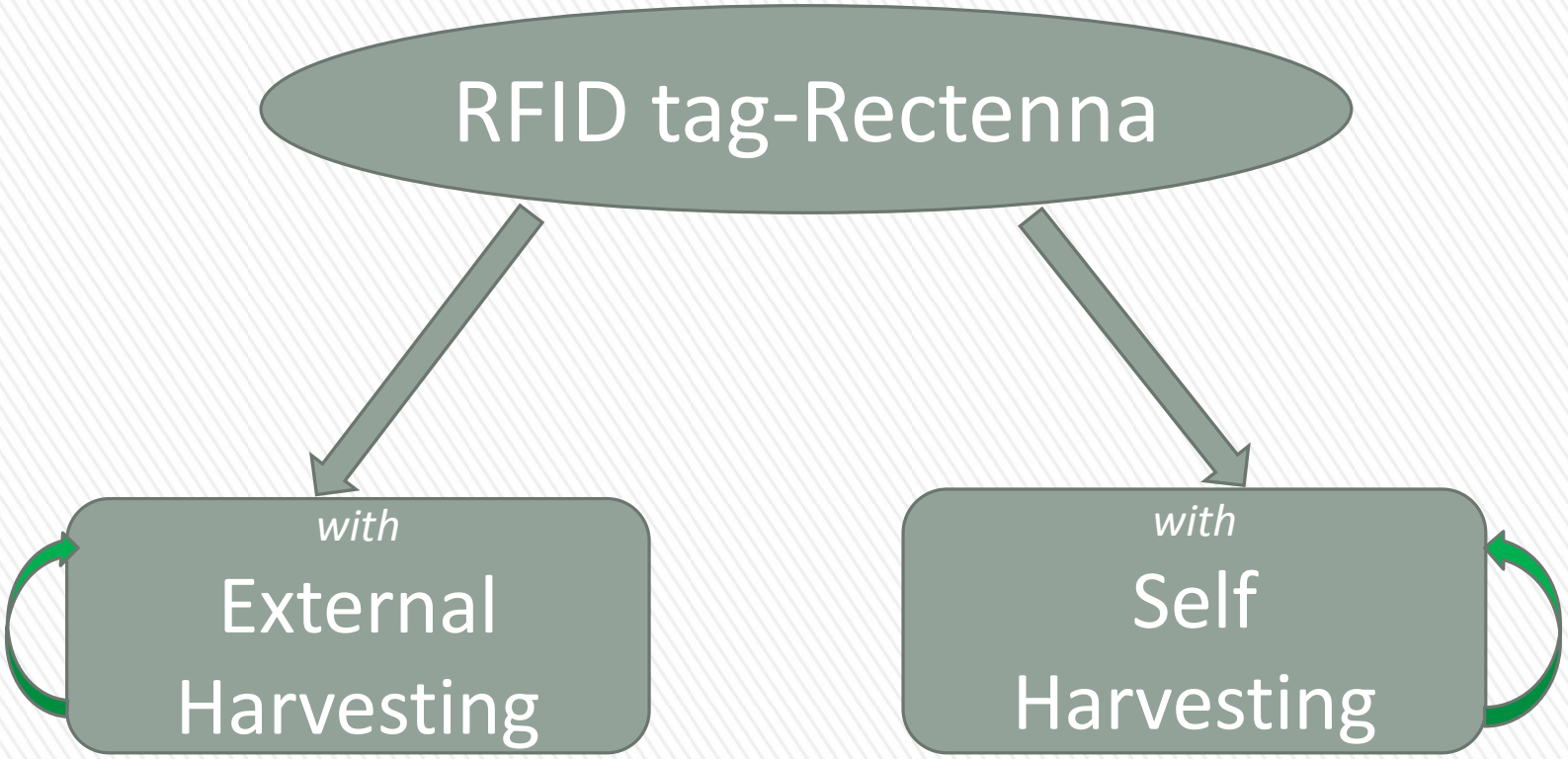
Main objective

- To combine RFID tag and EEH device, both working at different frequencies

- To exploit non-linear behavior of RF devices for mutual benefit

Design Procedure

Approach



Dual Band tag-harvester

RFID communication @ 868 MHz
EEH @ UMTS 2.17 GHz

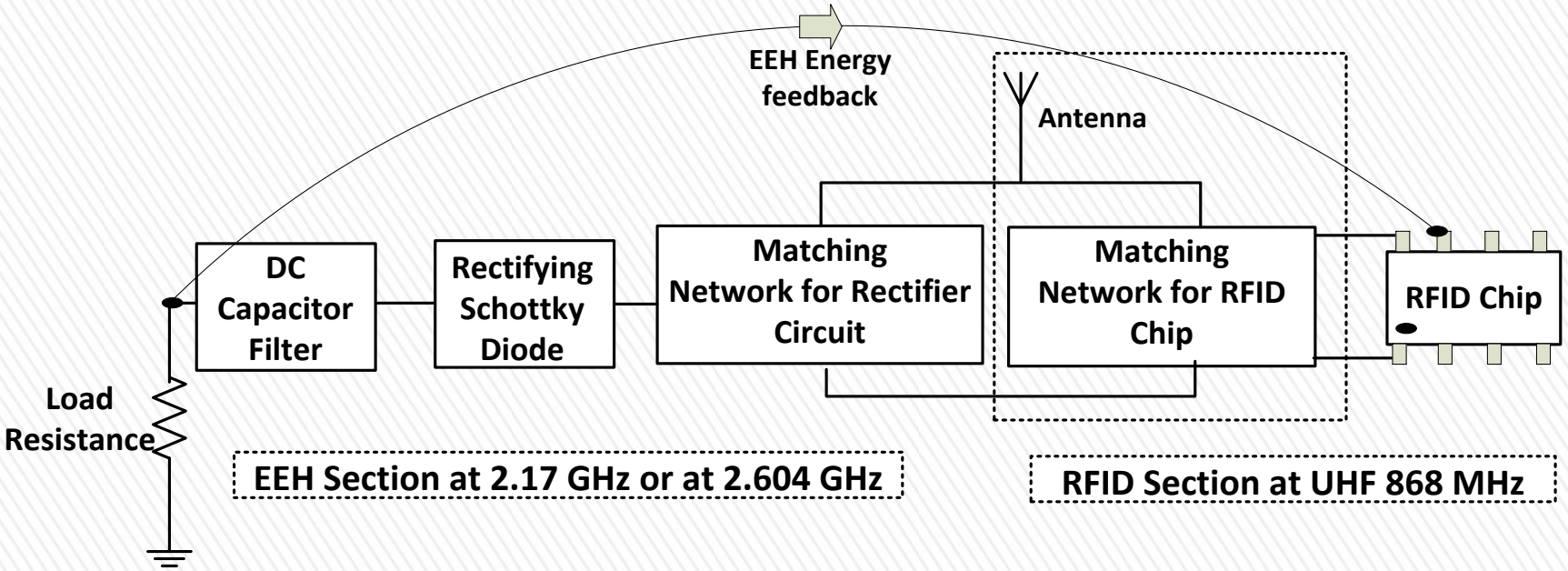
Single Band tag-harvester

RFID communication @ 868 MHz
EEH @ its 3rd harmonic 2.604 GHz

Harvested energy is re-injected into the RFID chip

Design Procedure

Block diagram

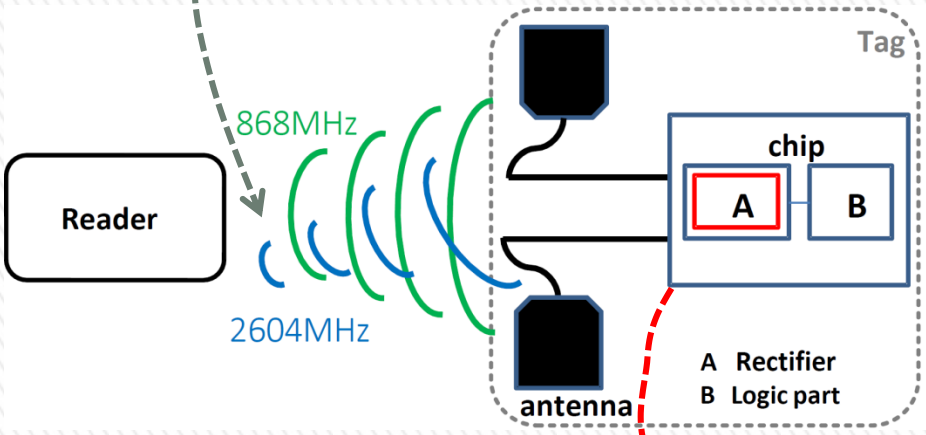


- RFID Tag and EEH section are integrated in a common antenna

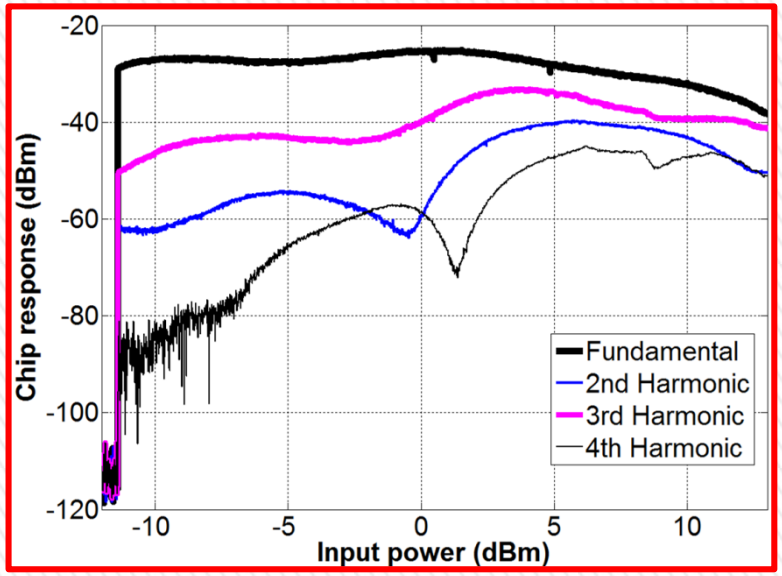
Design Procedure

Waveform design

Passive RFID chip generates modulated harmonic signals



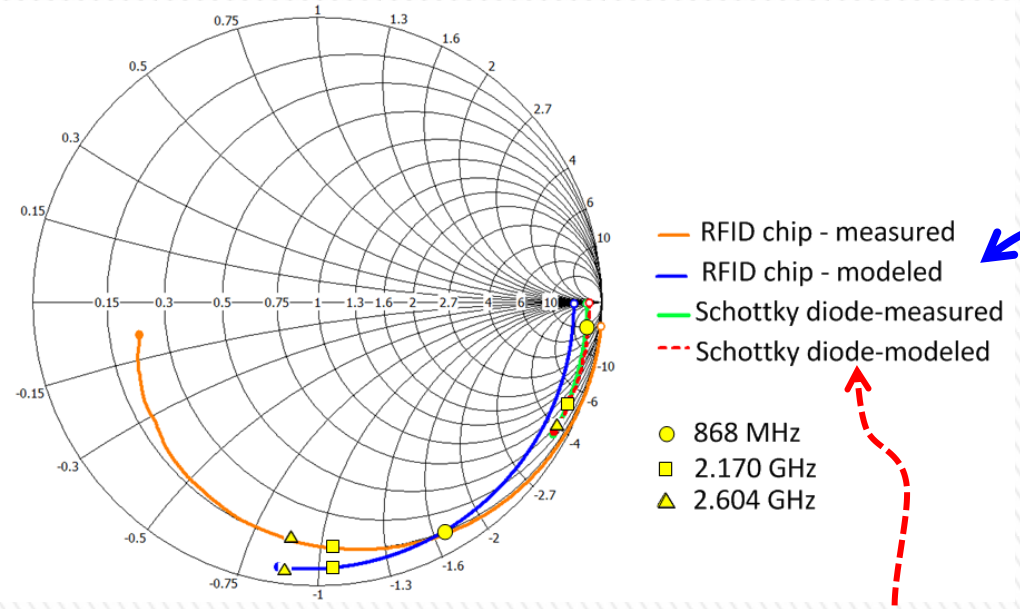
Harmonic signals measured at the RFID chip input



Andia Vera, G.; Duroc, Y.; Tedjini, S., "RFID Test Platform: Nonlinear Characterization," Instrumentation and Measurement, IEEE Transactions on , vol.63, no.9, pp.2299,2305, Sept. 2014

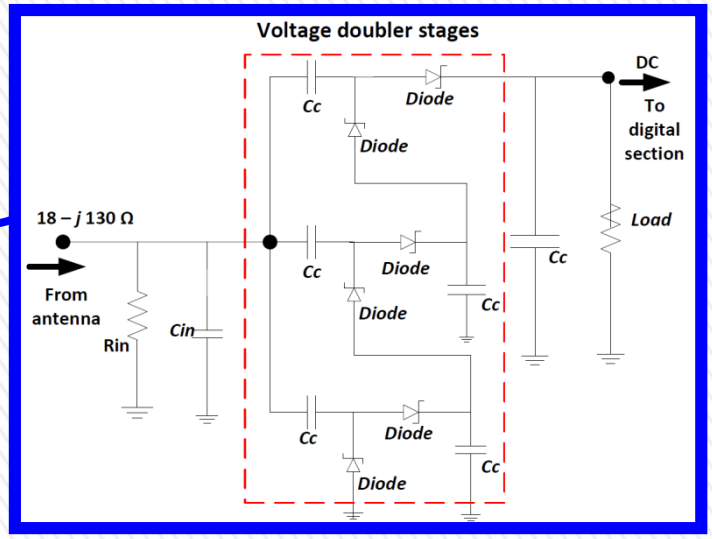
Design Procedure

Device Characterization

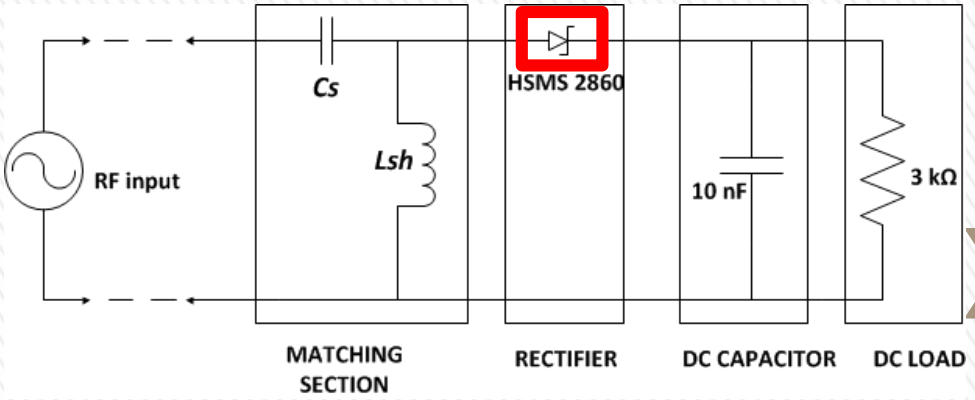


*impedances measured at -10 dBm input power

Passive RFID chip



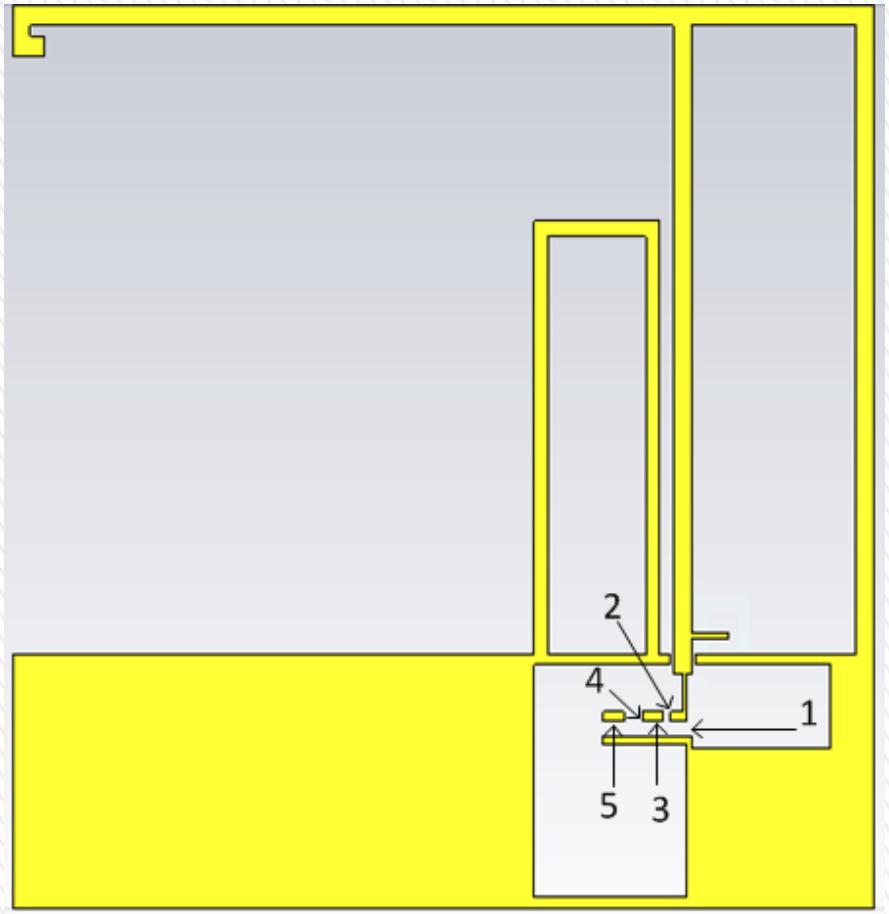
Schottky diode - rectifier



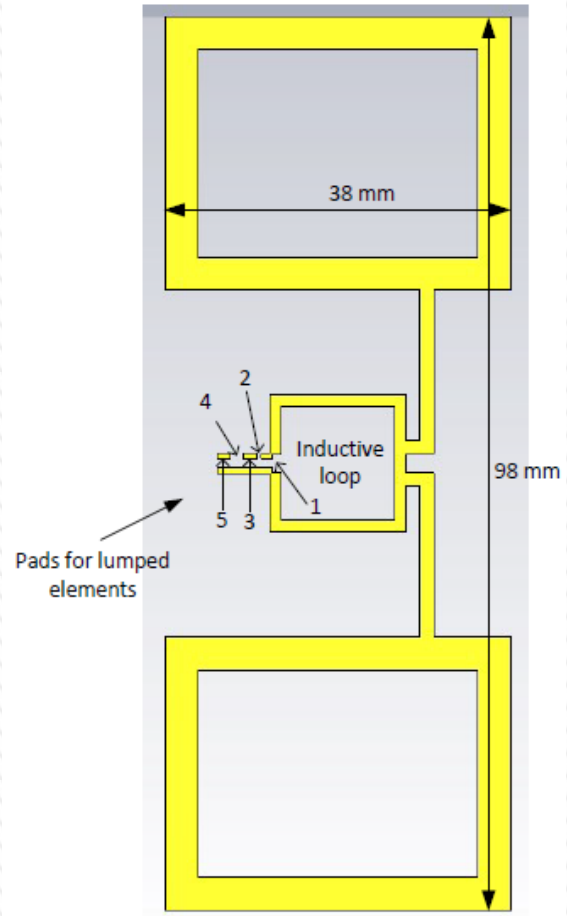
- **RFID chip** EM-4325 with optional Battery Assisted Power (*BAP*) mode
- **Schottky diode** HSMS 2860

Design Procedure

Antenna structures



Single Feed Dual Band Antenna
@ 868 MHz and 2.17 GHz

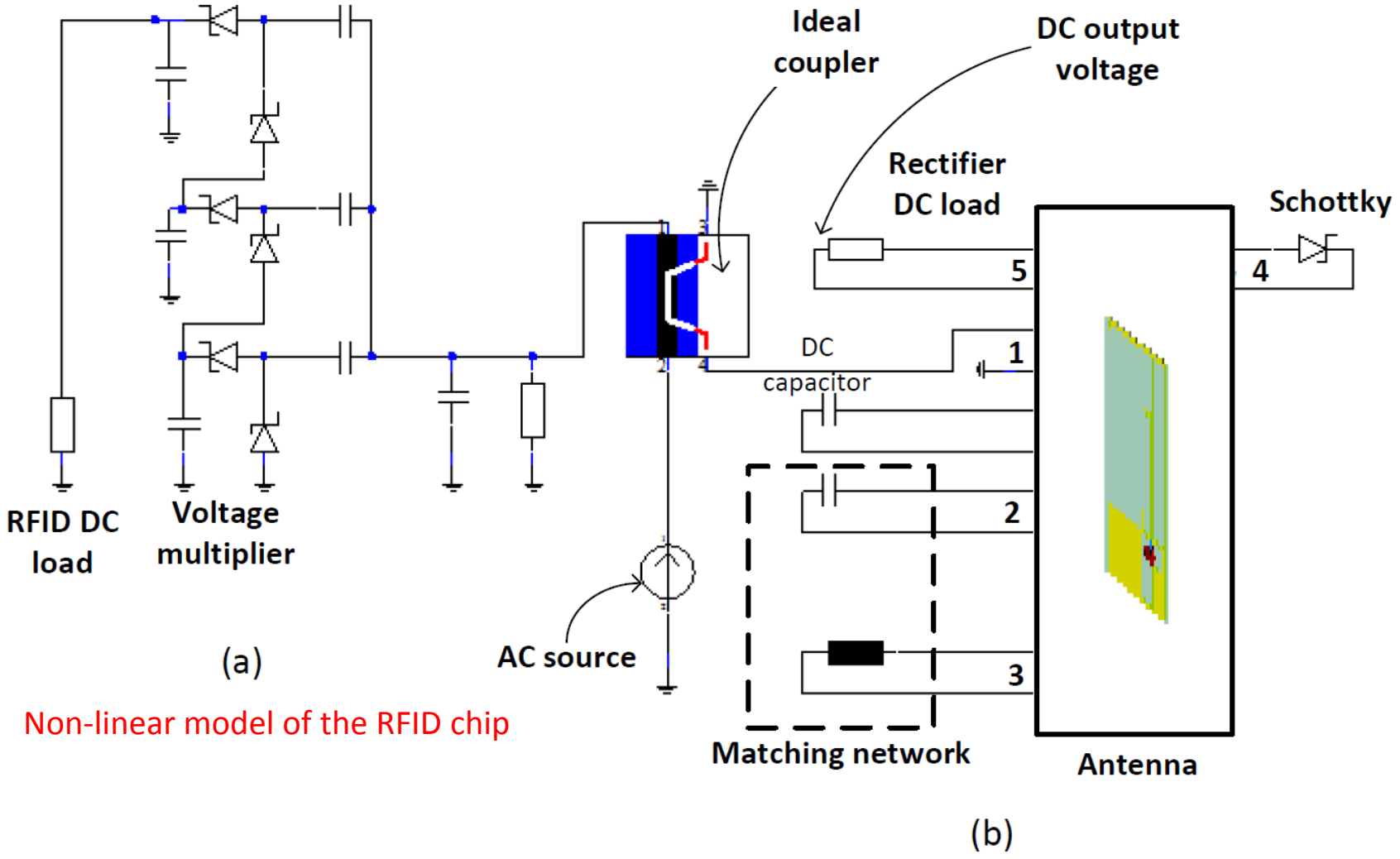


Single Band Antenna
@ 868 MHz

- *The arrows indicates the ports where RFID chip or lumped elements of EEH section are connected*

Design Procedure

Electric-electromagnetic co-simulation

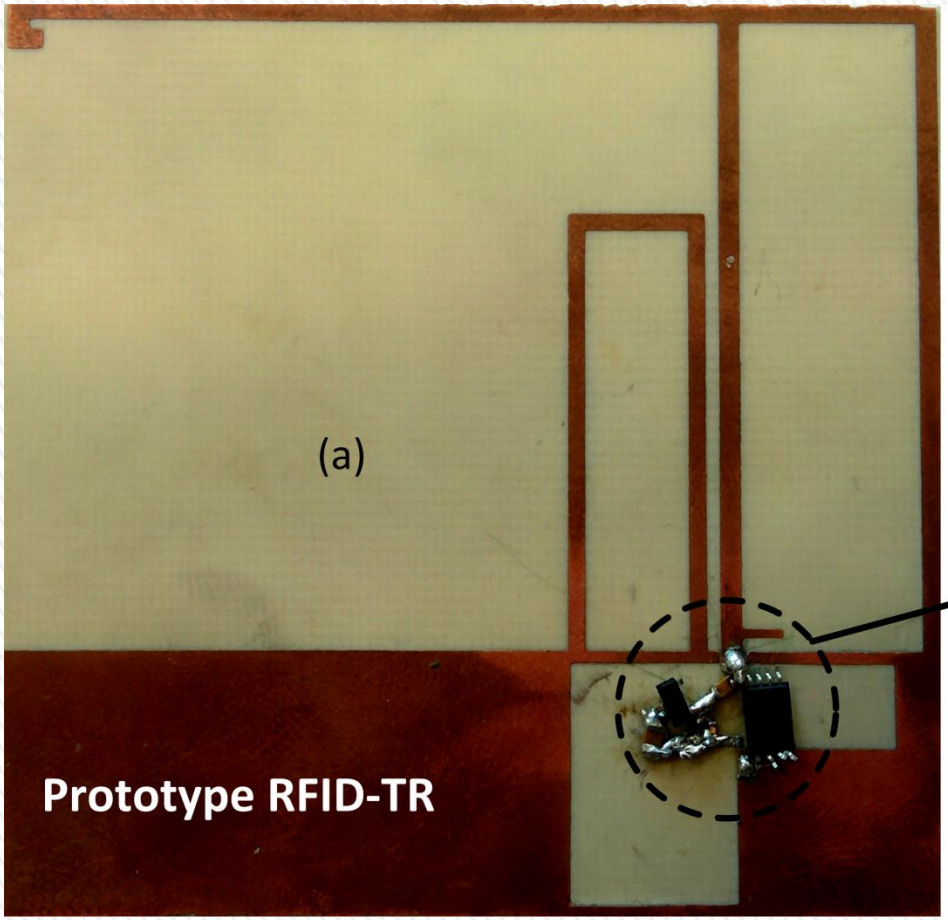


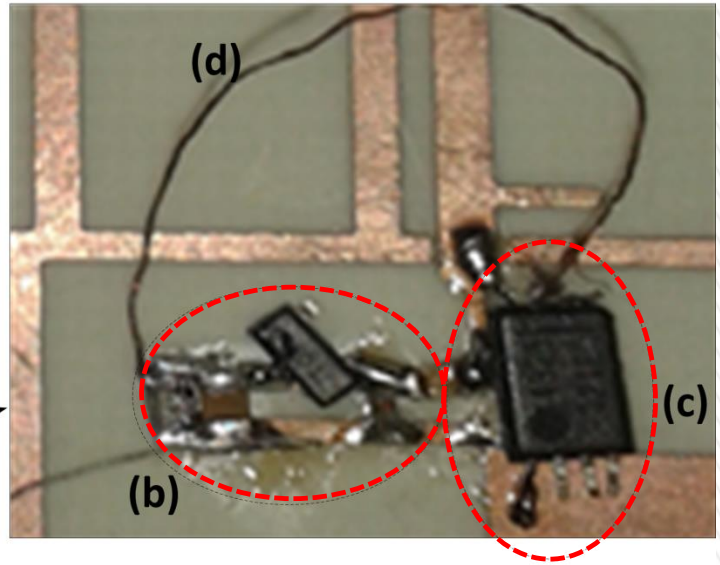
Non-linear model of the RFID chip

Co-simulation integration of RFID-TR

Prototypes

RFID-TR with *External - Harvesting*

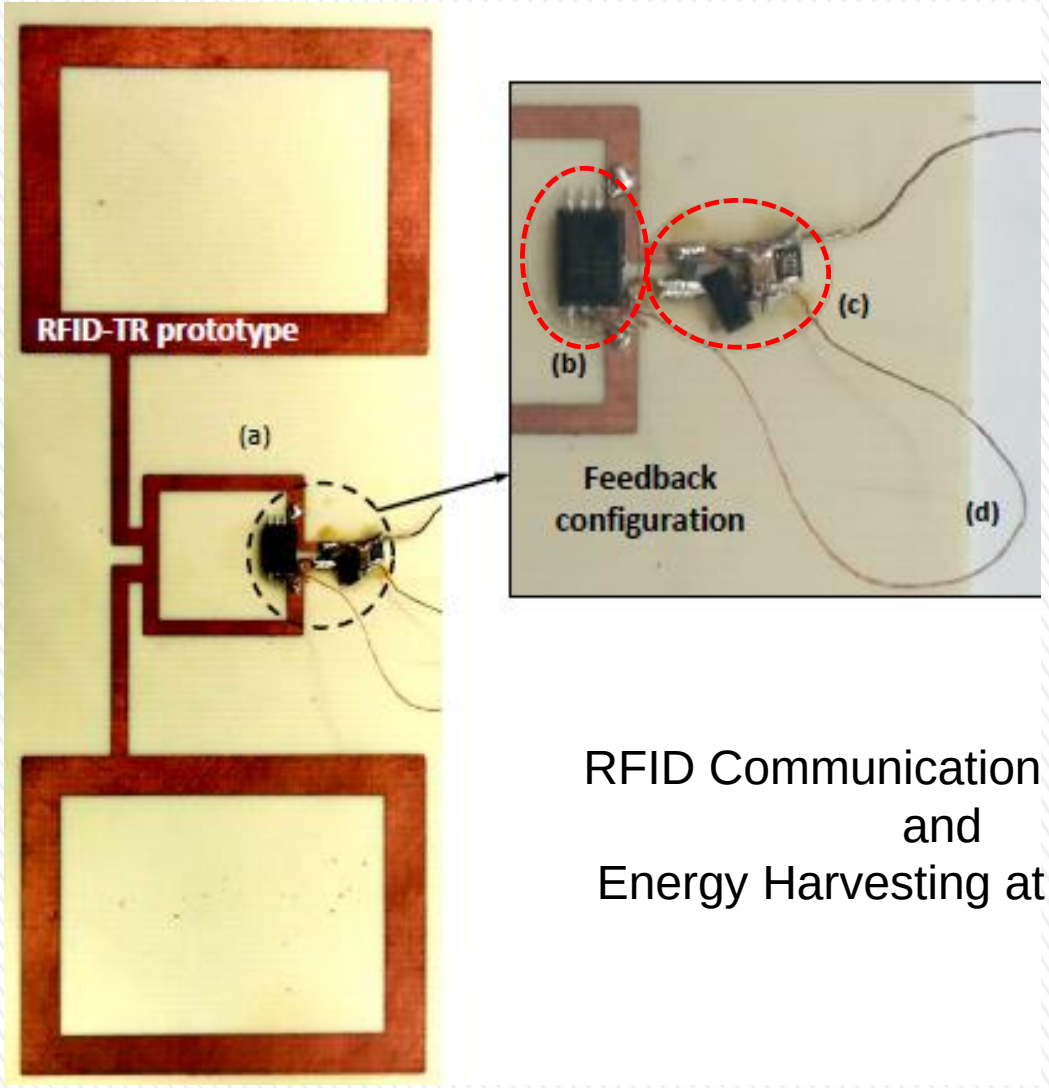




Substrate: Rogers RO4003
Permittivity: 3.55
Thickness: 0.8 mm

(a) Dual Band Antenna,(b) EEH section,(c) RFID chip EM4325,(d) Feedback wire

RFID Tag with *Self-Harvesting*

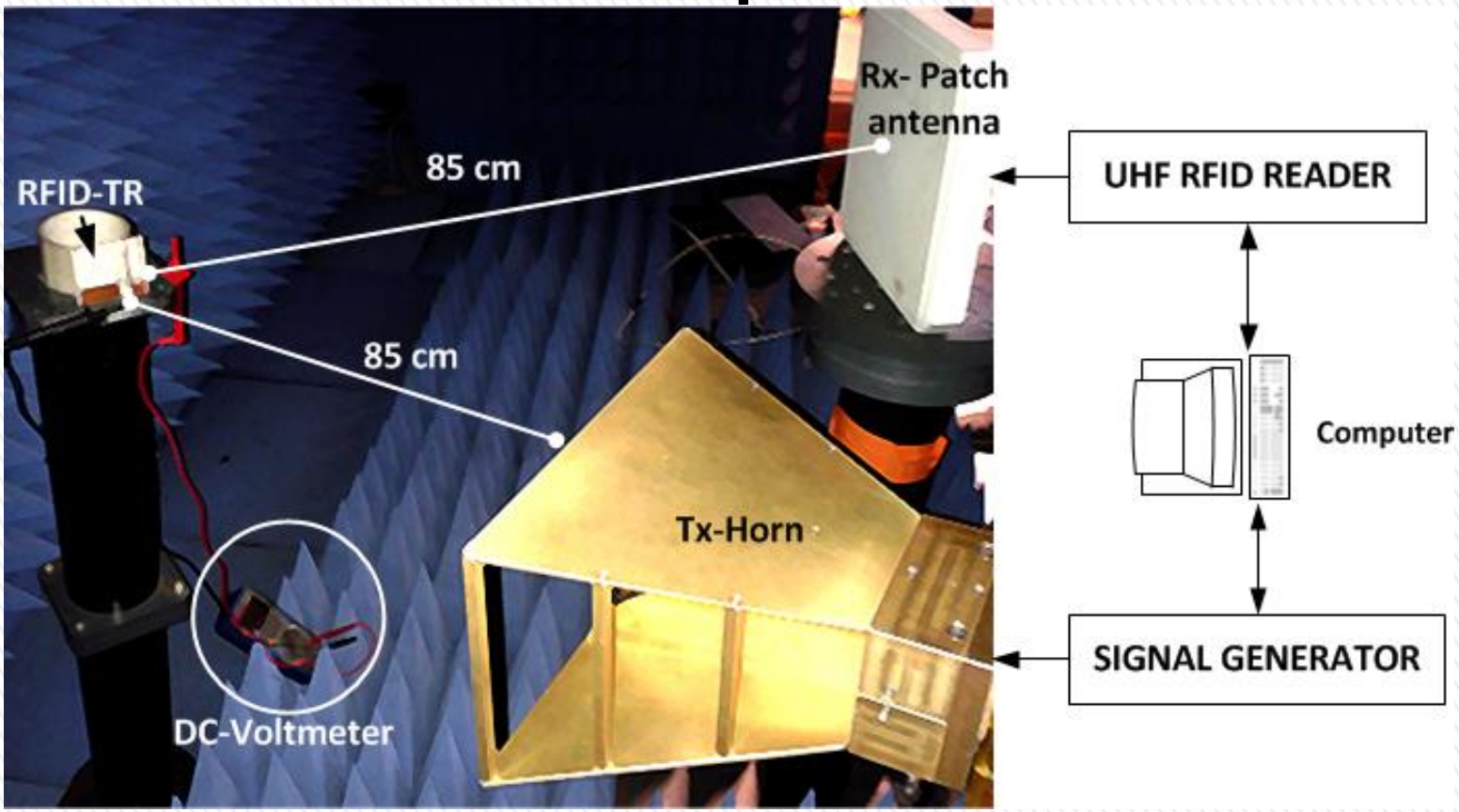


RFID Communication at 868 MHz
and
Energy Harvesting at 2.604 GHz

(a) Single Band Antenna, (b) EEH section, (c) RFID chip EM4325, (d) Feedback wire

Experimental Results

Setup



Equipments Used:

- Signal Generator (Agilent N5182A) for UMTS 2.17 GHz
- UHF RFID Reader (Impinj Speedway R420) for 868 MHz
- Horn Antenna (Gain = 10 dB)
- Reader Antenna (Gain = 6 dB)
- DC voltmeter

Experimental Results

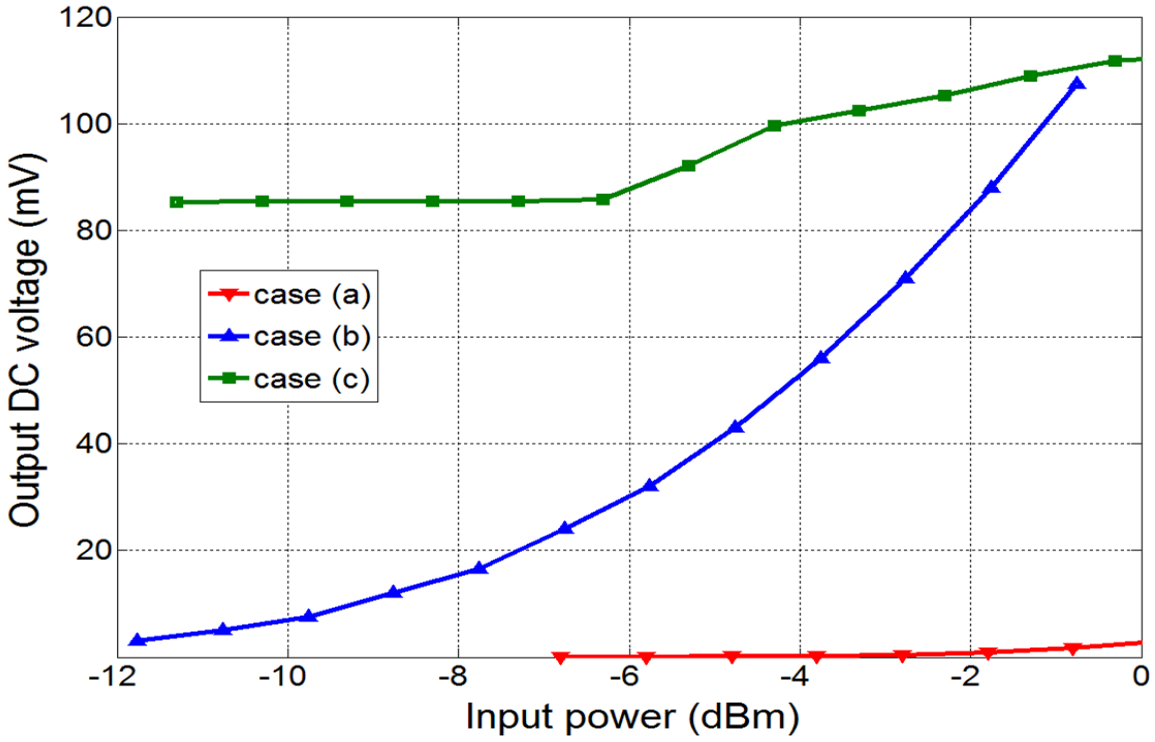
Goals:

1. To measure DC output in EEH section (*harvesting evaluation*)
2. To measure tag sensitivity (*read range evaluation*)

Case	Configuration
(a)	RFID reader at 868 MHz sweeping in power
(b)	RF source at 2.17 GHz sweeping in power
(c)	Reader at 868 MHz (30 dBm) + RF source at 2.17 GHz sweeping in power

Experimental Results

Harvesting evaluation



Output voltage with feedback condition

Measured DC output voltages without and with Feedback

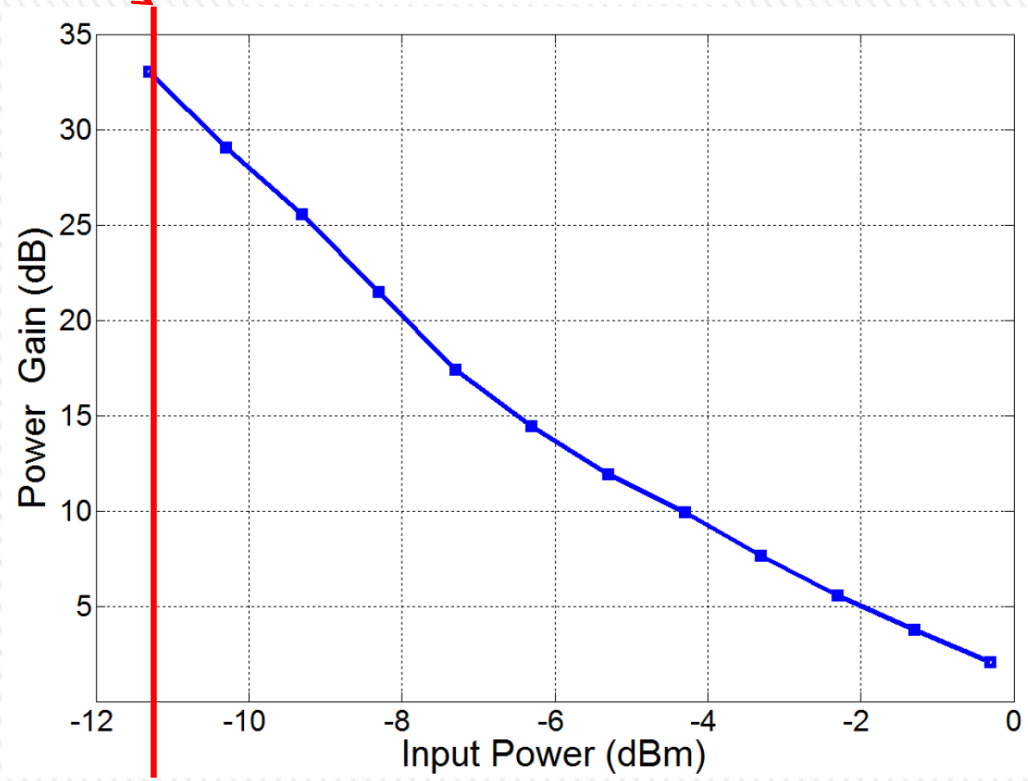
Case	without feedback [mV]	with feedback [mV]
(a)	1.8	7.1
(b)	26.4	107.4
(c)	48.4	111.9

Experimental Results

Case	Configuration	DC voltage with feedback [mV]
(b)	RF source at 2.17 GHz sweeping in power	*Vb*
(c)	Reader at 868 MHz (30 dBm) + RF source at 2.17 GHz sweeping in power	*Vc*

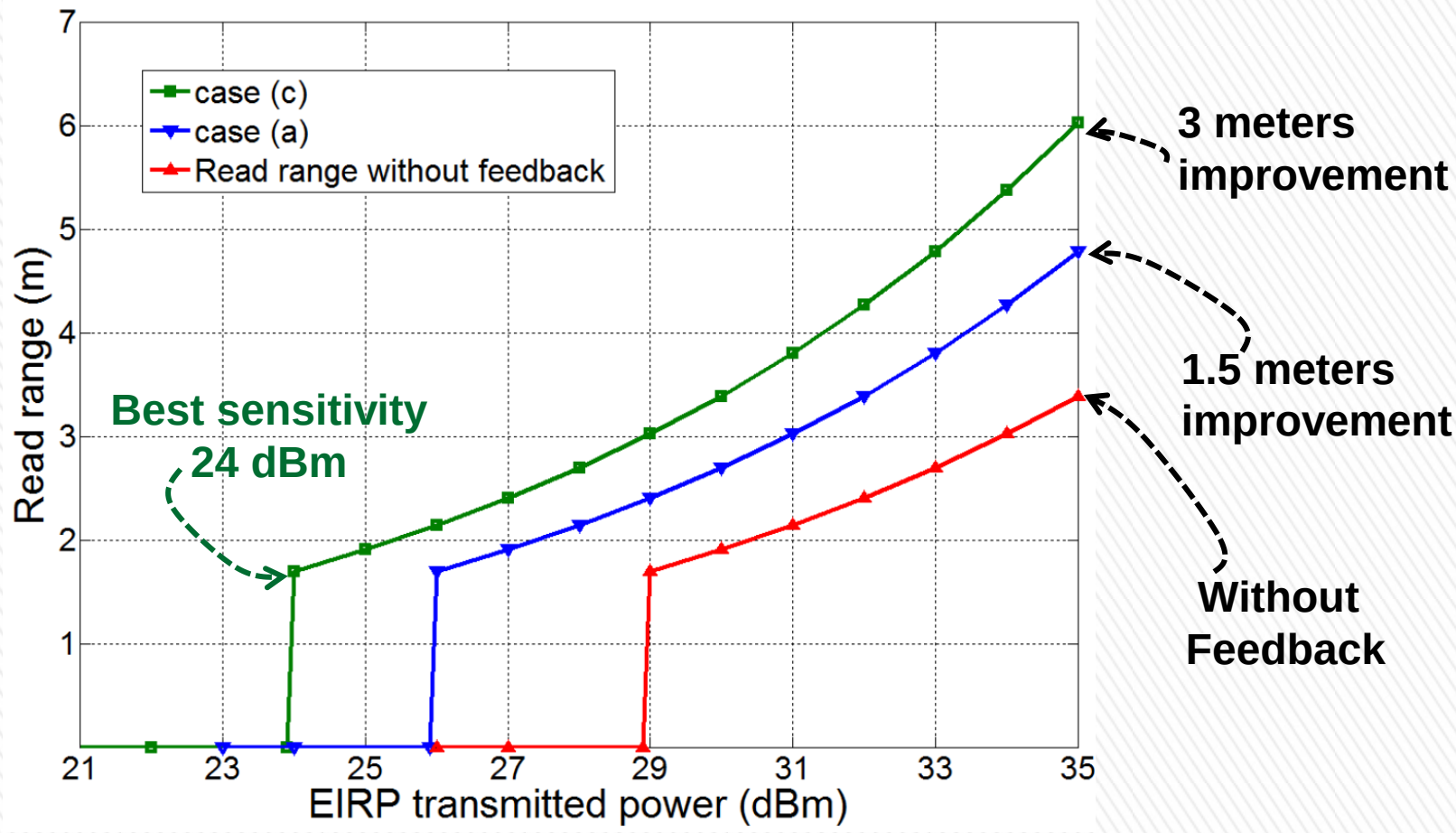
$$G_P = 10\log_{10}\left(\frac{V_c^2}{V_b^2}\right)$$

Gain of 33 dB at -11 dBm input power



Experimental Results

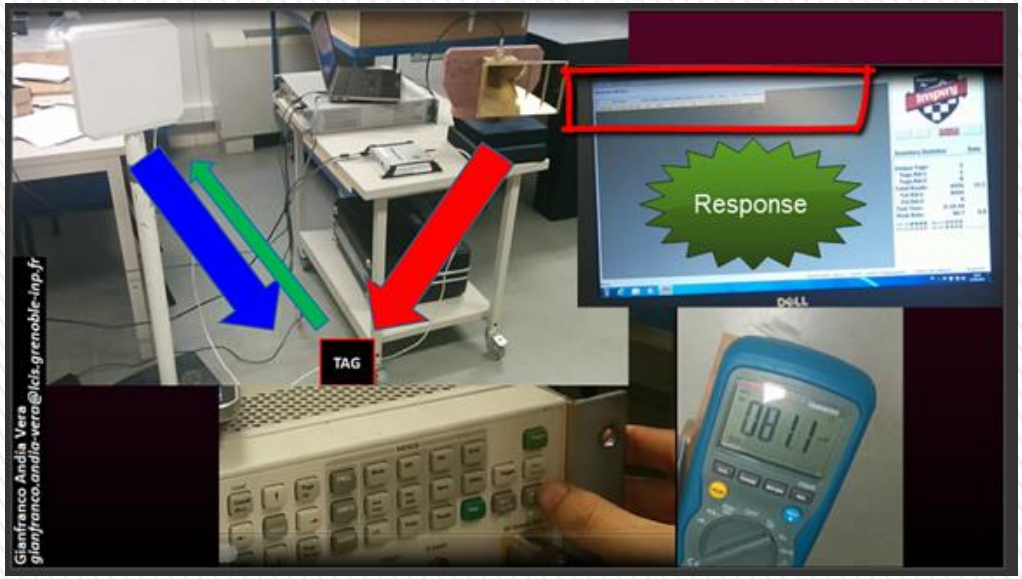
Read-Range Evaluation



Experimental Results

Demo Videos

harvestingRFID.mp4
harvestingRFID-Test-Short.mp4



Conclusion

- RFID tag - Energy harvester approaches are presented here
- 33 dB of harvested power gain is achieved when both sources are combined compared to a single source
- The RFID-TR read range increases in 3 meters when the combined harvested power is re-injected
- Non-linear behavior is exploited as:
  - Impedance power dependency, and
  - Harmonic production

Thank you!

Any Questions?

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