UHF Printed Sensor for Force Detection

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Almudena Rivadeneyra

ALMUDENA RIVADENEYRA received the master's degrees in telecommunication engineering, environmental sciences, and electronics engineering from the University of Granada, Spain, in 2009, 2009, and 2012, respectively, and the Ph.D. degree in design and development of environmental sensors from the University of Granada in 2014. She was with the Institute for Nanoelectronics, Technical University of Munich from 2015 until 2018, where her work was centered in printed and flexible electronics with a special focus on sensors and RFID technology. She is currently Marie Curie fellow at the University of Granada developing printed autonomous gas sensors.

Motivation

- **RFID:** Radio Frequency Identification is a standard term to describe technologies that utilize radio waves to capture and identify data
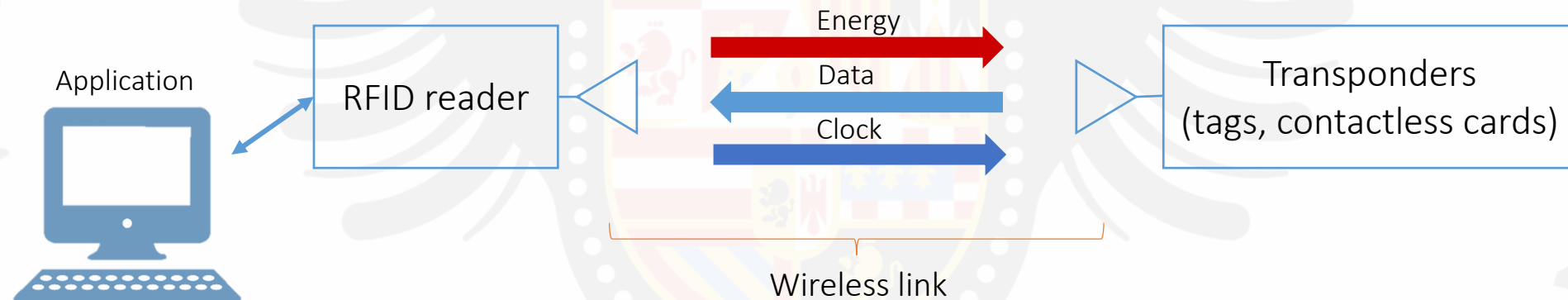
- New applications: supply chain, food safety, secure access, sensor information
- Real time monitoring of tracked objects: WSNs and IoT

RFID bands classification

Frequency classification and characteristics

Classification	Frequency	Characteristic
Low Frequency (LF)	<135 kHz	Inductive. Read range <0.5 m
High Frequency (HF)	13.56 MHz	Inductive. Read Range ~1 m
Ultra High Frequency (UHF)	860-960 MHz	Capacitive. Read Range ~3 m
Microwave	2.4 GHz	Capacitive. Read Range ~3m

Lower Bit-Rate
Higher Size

Higher Bit-Rate
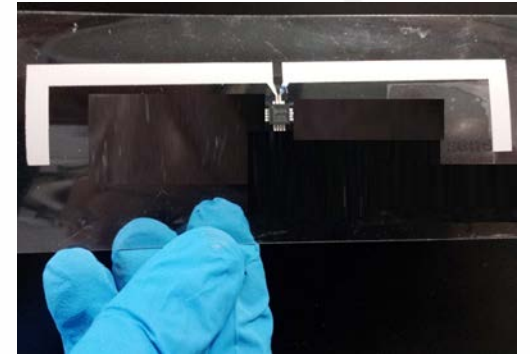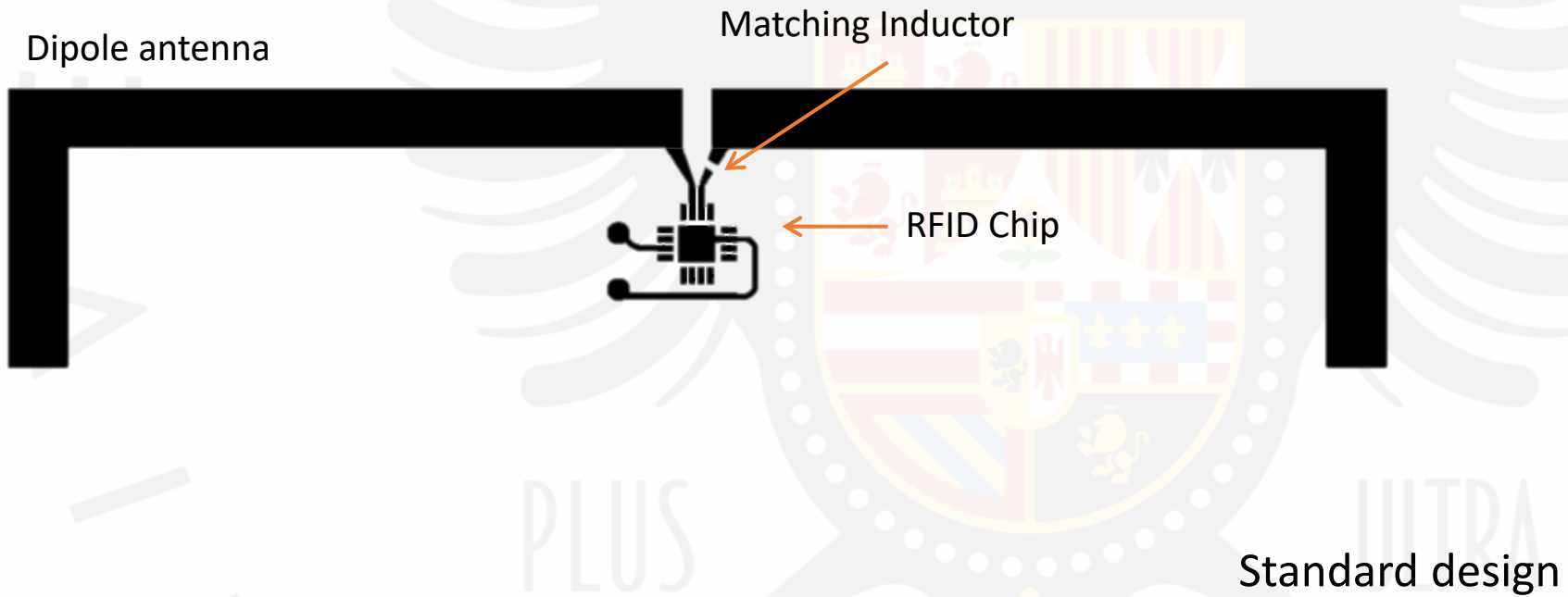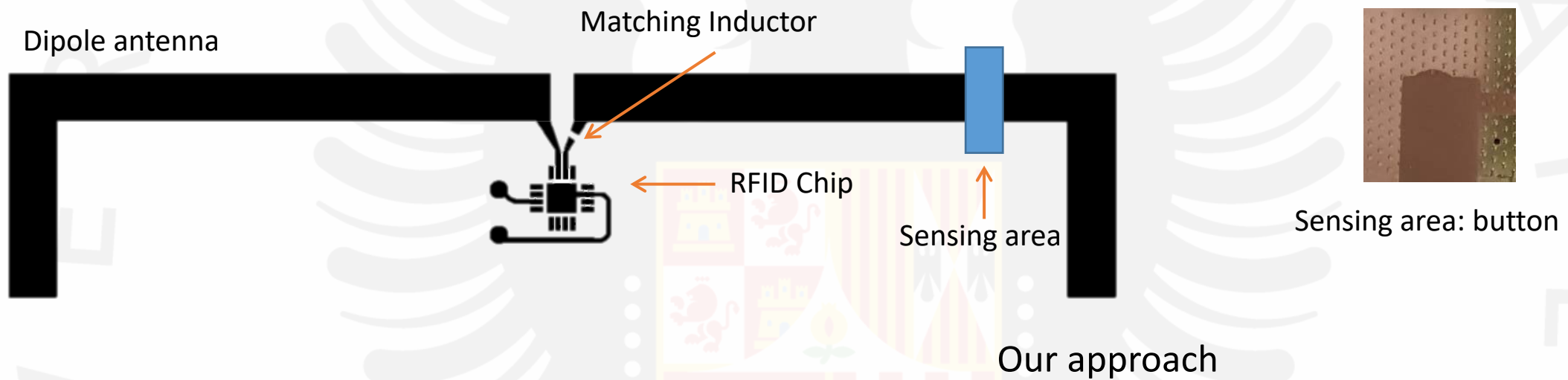Smaller Size
Affected by liquids
and metals

Alien Technology ®

Tag-it. Texas Instruments ®

Sensor Design

Dipole antenna

Matching Inductor

RFID Chip

Standard design

Working principle

Dipole antenna

Matching Inductor

RFID Chip

Sensing area

Sensing area: button

Our approach

Operation mode:

a) **Direct Wireless Link (standard use)**

RFID chip

Reader

b) **Communication and Force value**

Button Unpressed

RFID chip

Reader

c) **Communication and different force**

Button Pressed

RFID chip

Reader
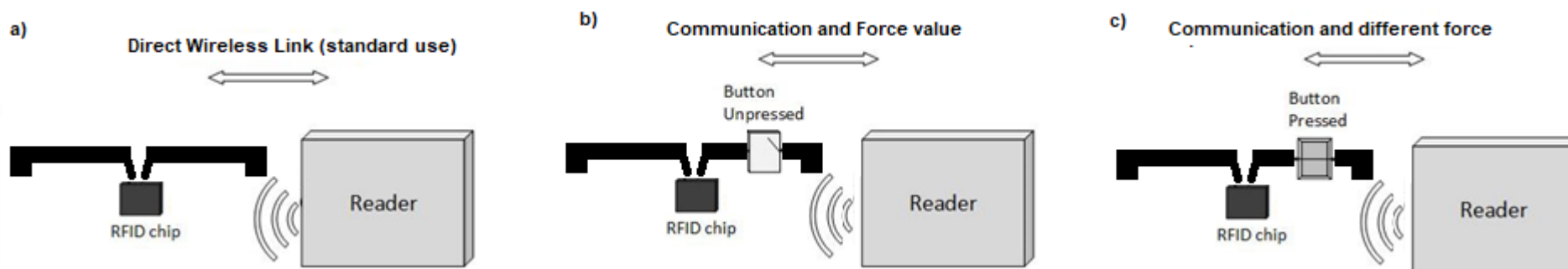
Materials

- Dipole antenna → Silver (Ag) paste (LOCTITE ECI 1010)

- An array of pillars → polydimethylsiloxane (PDMS)

- Substrate → polyethylene terephthalate (PET) (Melinex 506) 100 µm-thick

Fabrication

- A manual screen printer (Nino from Coruna, Switzerland) with a screen with 120 Threads/cm of mesh density

- After printing, the pastes were dried at 100°C for 30 min in an Memmert oven before printing the next type of paste

- **Fabrication steps:**
  1. Print UHF antenna
  2. Dry Ag paste
  3. Print PDMS array
 4. Cure PDMS array
  5. Glue Ag clamp

Characterization

- The E5061B ENA Vector Network Analyzer of Keyight for the S_{11} parameter measurements

- Similar capacitive pressure sensors were already studied in [1]

[1] S. C. Mannsfeld et al. "Highly sensitive flexible pressure sensors with microstructured rubber dielectric layers", Nature materials, 2010, vol. 9, no. 10, pp. 859-864.

Results
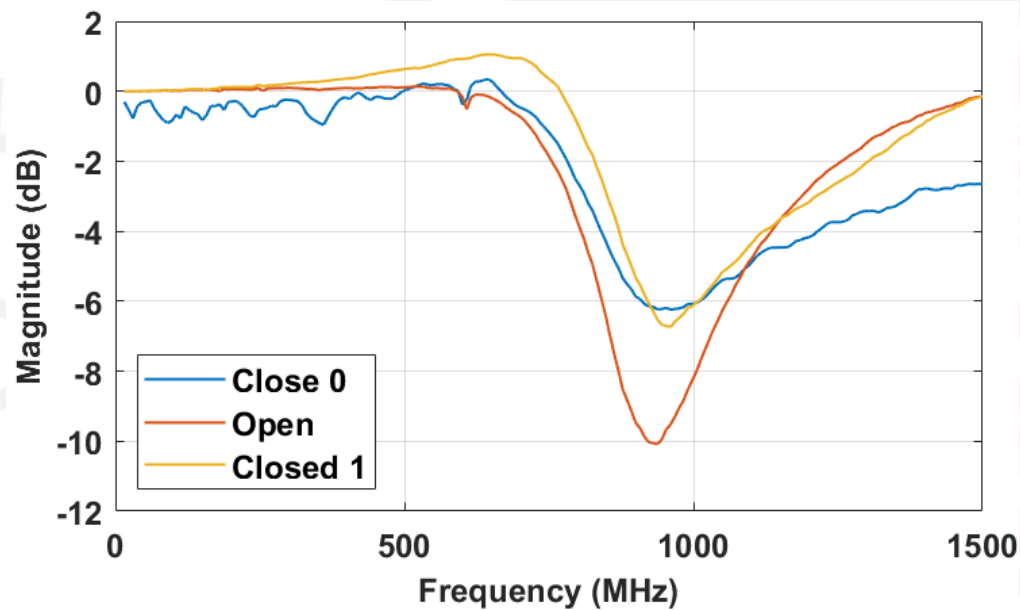
- The dipole antenna that can be modelled as RLC series designed to resonate at 868 MHz when the sensor is pressed
- When the sensor is released, a small series capacitance is added to the dipole series capacitance causing a shift of the resonance frequency upwards
- This detuning of the resonance frequency is enough to be discriminated by an RFID reader, but it is not enough to inhibit the wireless link between the reader and the sensor tag

Conclusions

- We demonstrate the possibility of designing a printed UHF sensor for force detection based on PDMS and silver on a flexible substrate
- There is a shift in the resonance frequency as well as a change in its magnitude when the force is applied in the area with structured PDMS
- When pressing the mentioned area, the resonance frequency is increased and its magnitude decreases
- This solution paves the way for including sensor information in printed RFID antennas

Future work

- Study in depth the influence of the force applied on the resonance frequency

- Analysis of the area where the structured PDMS is located and the response of the antenna

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Thank you!   Questions?

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