

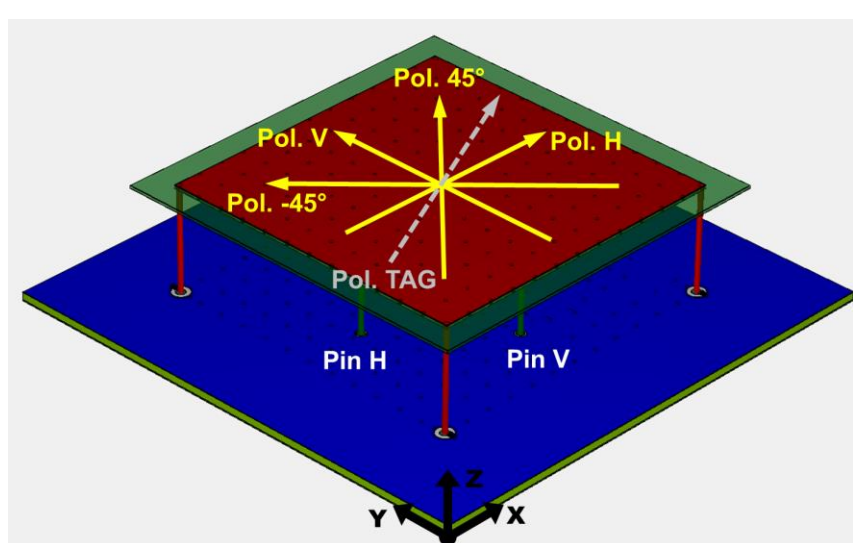
Research context and motivation

Traditionally wireless systems are designed for single predefined operations. To overcome from limitations due to the standard approach **reconfigurable antennas and systems** are employed for **increase performance** and to change the intrinsic characteristic of the antenna to adapt to a pre-determined operative state (**frequency**, **pattern**, **polarization**), achieving **better antenna integration** and **reduce costs**.

Addressed research questions/problems

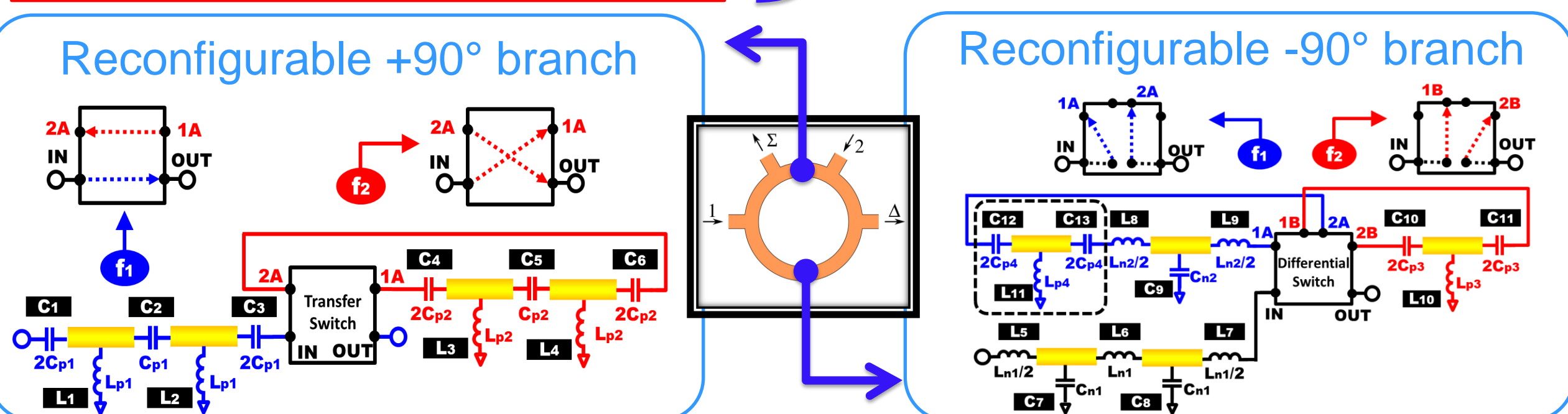
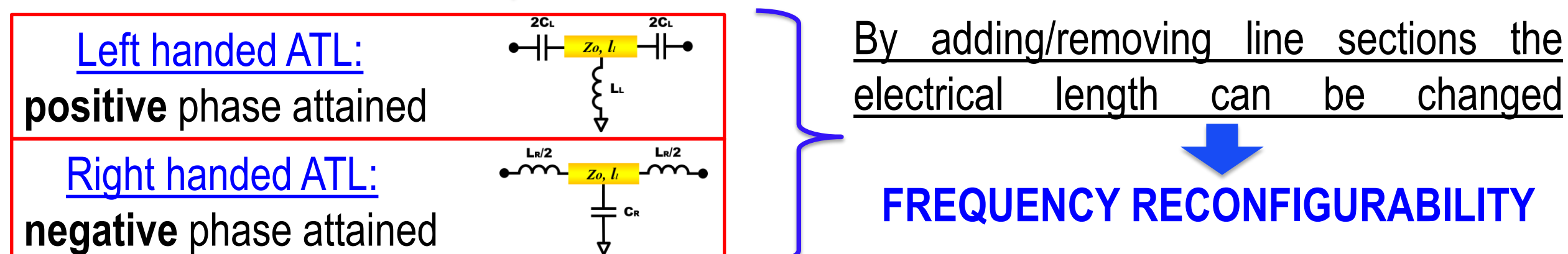
Reduced size and reconfigurable RFID reader patch antenna, based on switchable matching network:

- Frequency agility:** one antenna design covers Europe (865-868MHz) and US (902-926 MHz) frequency bands.
- Polarization agility:** the patch radiates in 4 linear polarizations: H, V, +45° and -45° for improving Polarization Loss Factor respect to standard circular polarization approach.

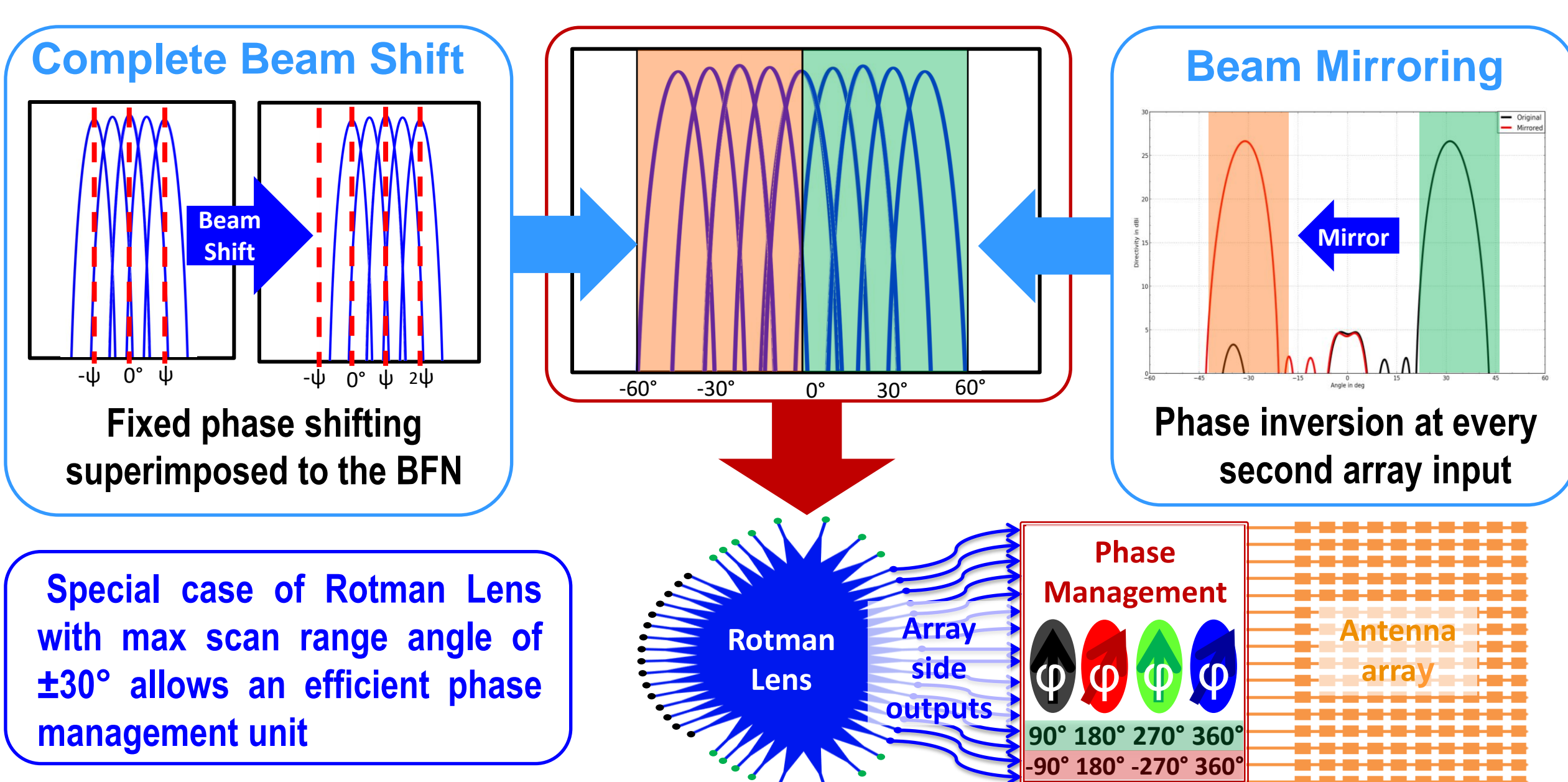


Miniaturized and frequency reconfigurable rat-race coupler:

Artificial Transmission Line (ATL) can synthesize lines of any electrical length independently from physical dimensions → **MINIATURIZATION**

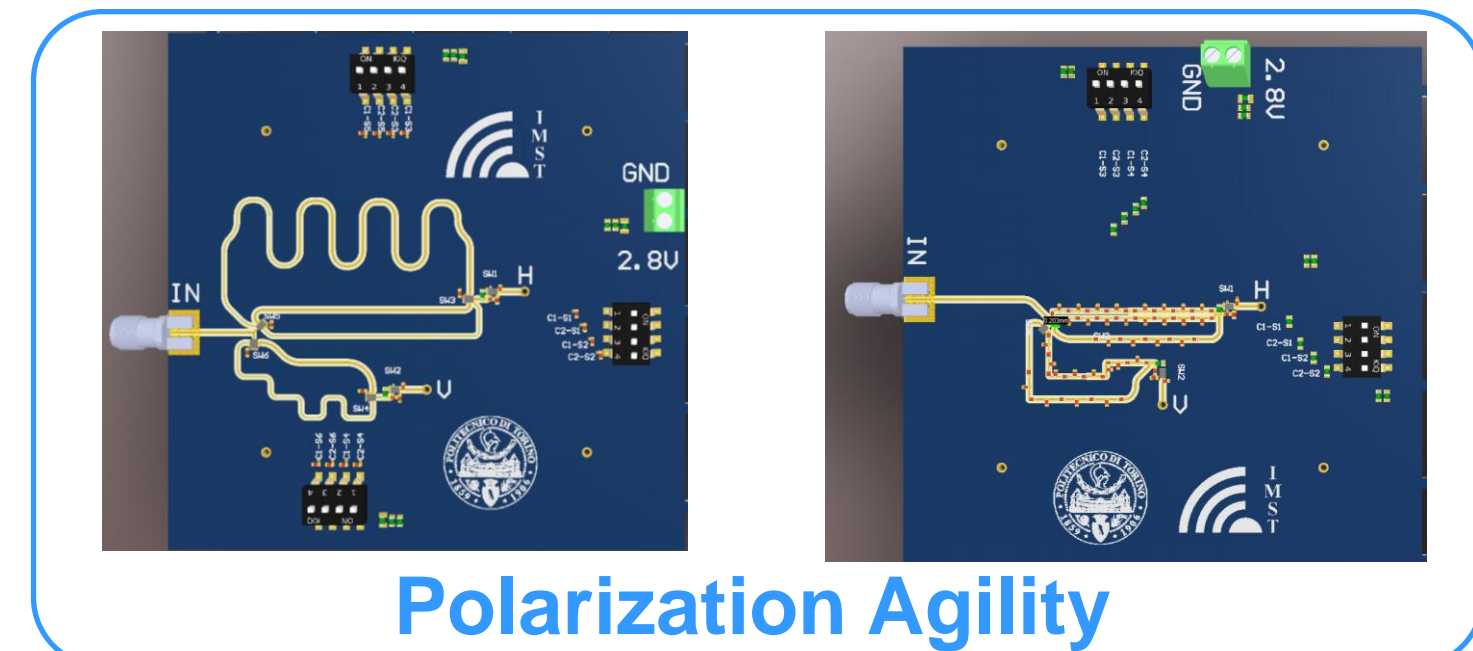
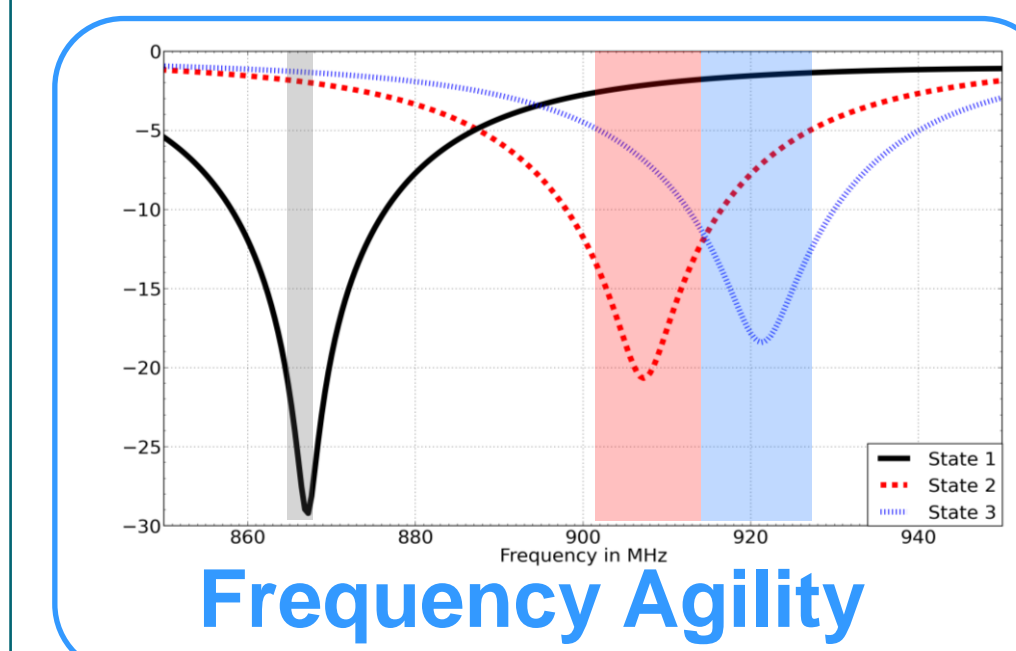


Innovative phase management for scan range extension based on Rotman Lens: a reconfigurable phase distribution applied to the Rotman lens **double the scan range** of an antenna array. It combines two effects involving phase shifters called **Complete Beam Shifting** and **Beam Mirroring**.



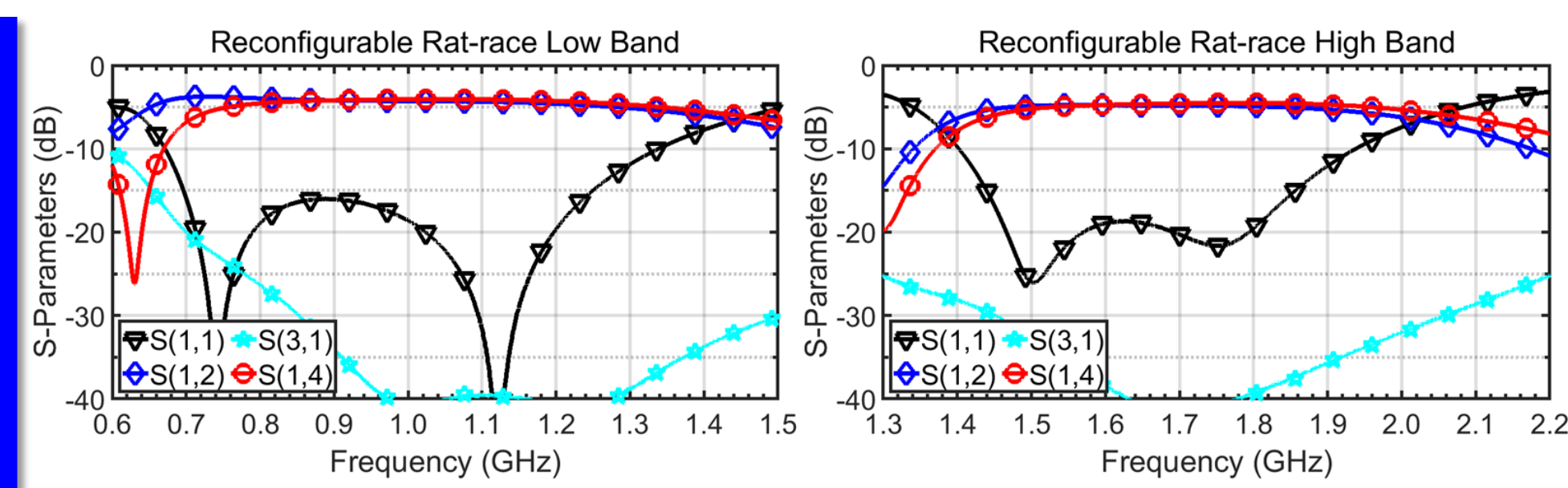
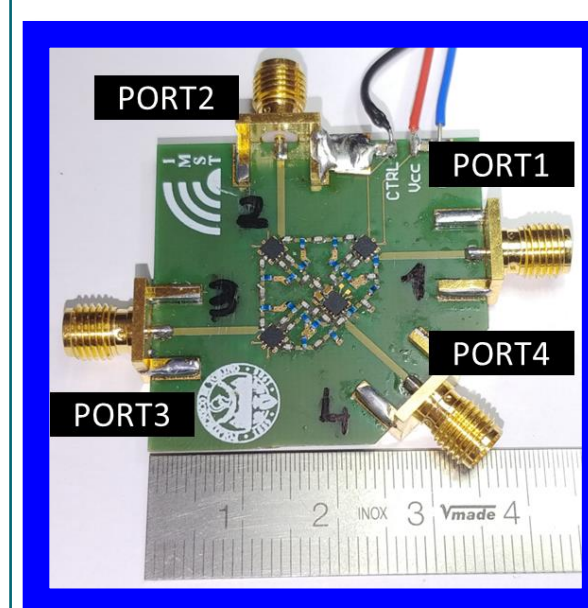
Novel contributions

The **reduced size and reconfigurable RFID reader patch antenna**, presents a new method to apply the reconfigurability at the matching network to an electrically small patch ($0.175 \lambda \times 0.175 \lambda$). For changing the linear polarizations (V, H and $\pm 45^\circ$), 2 different concepts of reconfigurable feeding network has been designed, employing switchable delay and metamaterials lines. In this way the **maximum Polarization Loss Factor is 0.7dB**, with respect to 3 dB given by Circular Polarization approach.

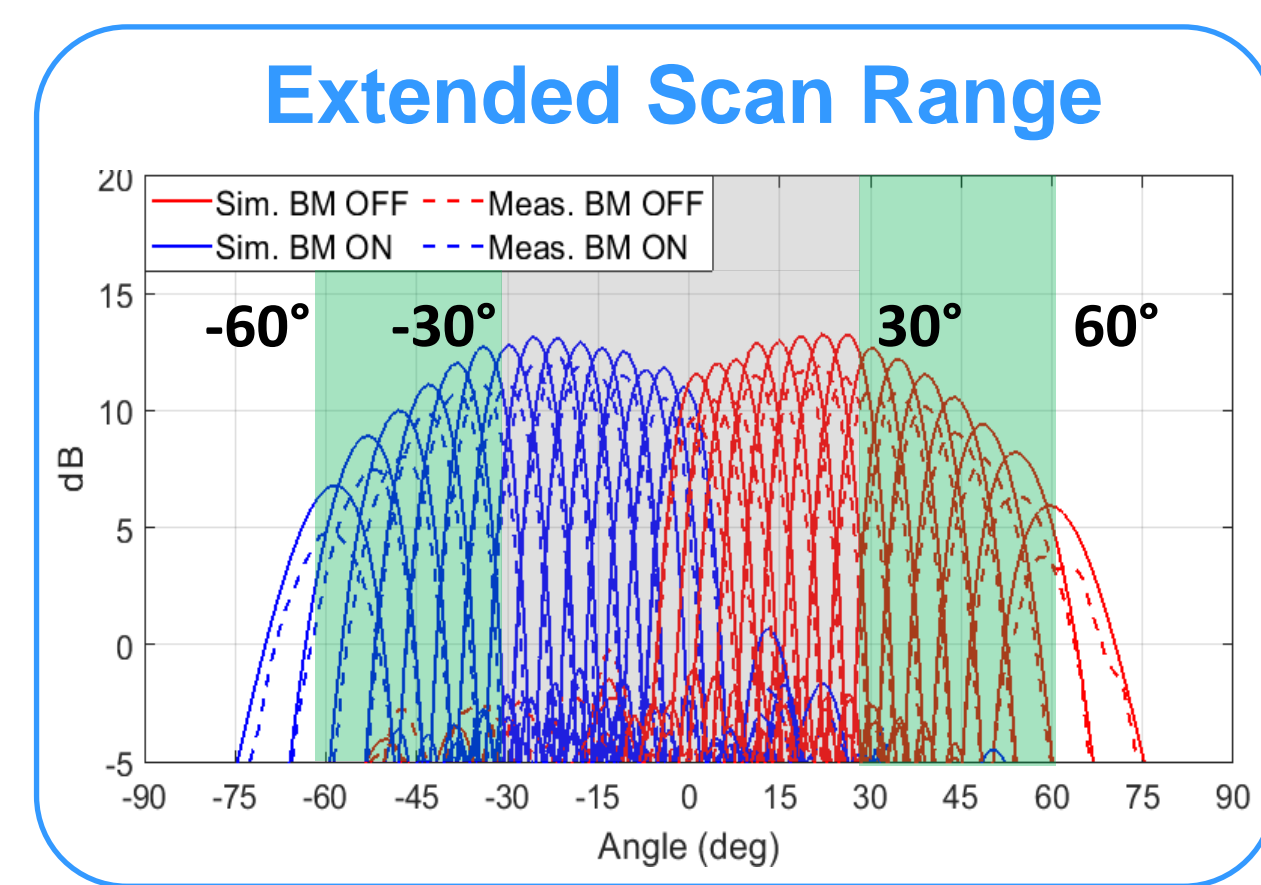
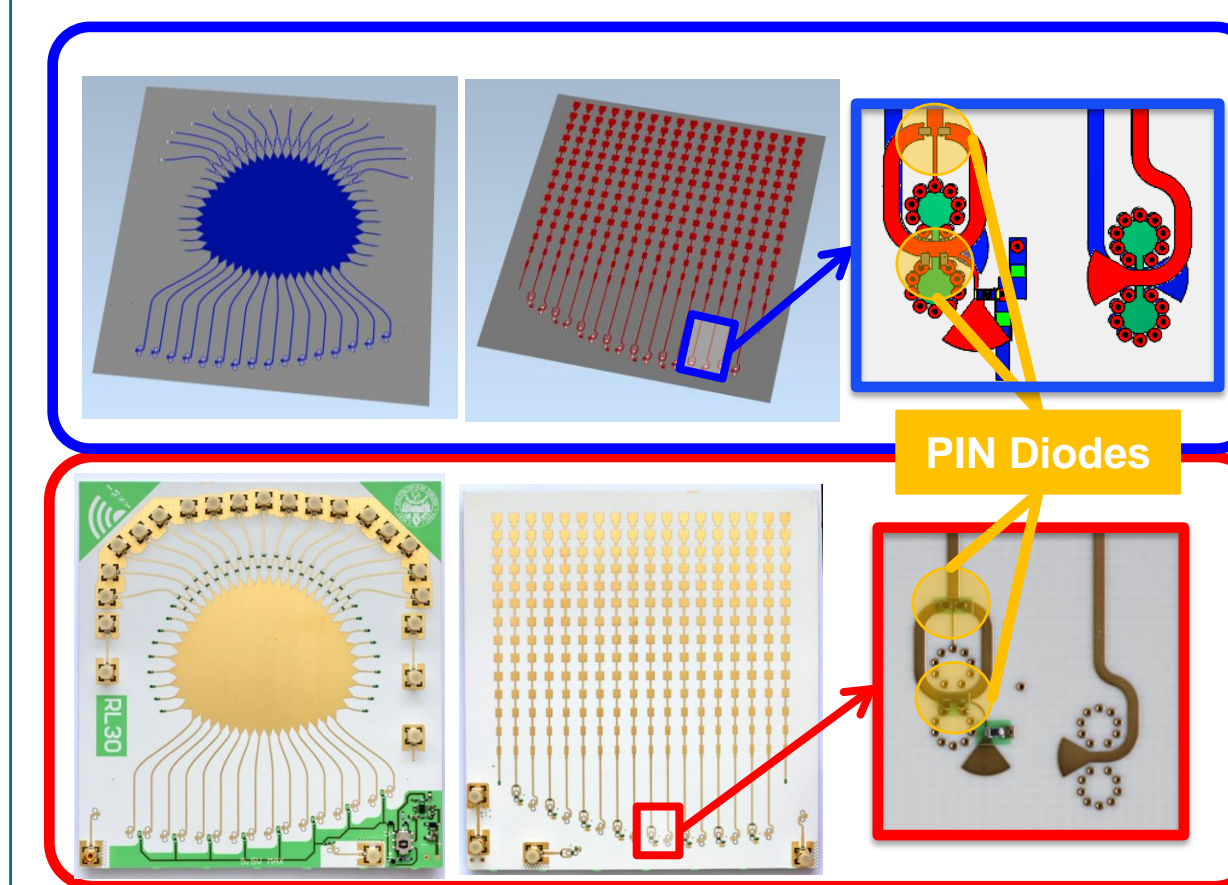


Miniaturized and frequency reconfigurable rat-race coupler

Center Frequency	Operative Band	Insertion Loss	Return Loss	Isolation	Relative Area
900 MHz	64%	3.9 dB	10 dB	26 dB	3.03%
1.7 GHz	24%	4.3 dB	15 dB	30dB	10.42%



Innovative phase management for scan range extension based on Rotman Lens allows to **double the scan range** of the Rotman Lens. For the investigated case of a $\pm 30^\circ$ Rotman Lens design a dedicated phase management unit has been designed employing a novel switchable microstrip-to-slot coupled phase inverter, for a compact and efficient design.



Adopted methodologies

Due to the heterogeneous nature of this topic, different methodologies were exploited for designing the reconfigurable antenna systems. In particular the combination of **circuit simulation** and **EM modeling** was the key elements for the design.

Future work

New tunable materials are currently developed (Metal-Insulator-Metal, phase change materials, optically responsive materials), and their reconfigurable property will be applied to bands V (40-75 GHz) and W (75-110 GHz).

List of attended classes

- 01MMRRV – Tecniche numeriche avanzate per l'analisi ed il progetto di antenne (26/5/2017, 4 credits)
- 01QFRRV – Tecniche innovative per l'ottimizzazione (11/9/2017, 4 credits)
- 01QFDRV – Photonics: a key enabling technology for engineering applications (11/9/2017, 5 credits)
- 01RZTRV – Il criterio di responsabilità nella ricerca e nell'innovazione - l'impatto sulle sfide sociali (24/5/2017, 4 credits)
- 01RZURV – Il criterio di responsabilità nella ricerca e nell'innovazione - Il ruolo dell'ICT nell'era di internet (30/5/2017, 4 credits)
- 01QTXRV – BIO/CMOS interfaces and co-design (18/10/2017, 3 credits)
- 01QRNRV – Electromagnetic dosimetry in MRI: computational and experimental methods (9/11/2017, 4 credits)
- 08IXTRV – Project management (26/8/2019, 1 credit)
- 01RISRV – Public speaking (14/7/2019, 1 credit)
- 02LWHRV – Communication (12/7/2019, 1 credit)
- 02RHORV – The new Internet Society: entering the black-box of digital innovations (7/7/2019, 1 credit)
- ESoA Course – RADAR 2020, FUTURE RADAR SYSTEMS (7/5/2018, 3 ECTS credits)
- ESoA Course – Antenna Systems for 5G Communication (20/5/2019, 3 ECTS credits)

Submitted and published works

- E. Tolin, O. Litschke, S. Bruni and F. Vipiana, "Compact Extended Scan Range Antenna Array based on Rotman Lens," in *IEEE Transactions on Antennas and Propagation*. (Early Access Article)
- E. Tolin, A. Bahr, F. Vipiana, "Miniaturized and Reconfigurable Rat-Race Coupler Based on Artificial Transmission Lines," in *IEEE Microwave and Wireless Components Letters* (Submitted)
- E. Tolin, A. Bahr, S. Bruni, F. Vipiana, "Frequency and Polarization Agile RFID Patch Antenna With Reduced Dimensions", 2019 IEEE International Symposium on Antennas and Prop. & USNC/URSI National Radio Science Meeting, Atlanta, USA
- E. Tolin, A. Bahr, S. Bruni, F. Vipiana, "Polarization Reconfigurable Patch Antenna for Compact and Low Cost UHF RFID Reader", 10th IEEE International Conference on RFID Technology and Applications (RFID-TA 2019), Pisa, 2019
- E. Tolin, F. Vipiana, O. Litschke, S. Bruni, "Compact design of a 24 GHz extended scan range Rotman lens antenna", 13th European Conference on Antennas and Propagation (EuCAP 2019), Krakow, 2019
- E. Tolin, F. Vipiana, O. Litschke, S. Bruni, "Phase Shifters Design for Scan Range Extension of Rotman Lens Beamforming Based Antenna Arrays", 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, Boston, USA
- E. Tolin, O. Litschke and F. Vipiana, "Phase Management for extended scan range antenna arrays based on Rotman lens," 12th European Conference on Antennas and Propagation (EuCAP 2018), London, 2018, pp. 1-5.
- E. Tolin, O. Litschke, S. Bruni, F. Vipiana, "Innovative Rotman lens setup for extended scan range array antennas", 2017 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), Verona, Italy
- E. Tolin, A. Bahr, M. Geissler and F. Vipiana, "Flexible and cost effective reconfigurable UHF RFID antenna system," 2017 11th European Conference on Antennas and Propagation (EuCAP), Paris, 2017, pp. 2037-2040