A Double Square Reconfigurable Intelligent Surface for 3.6GHz

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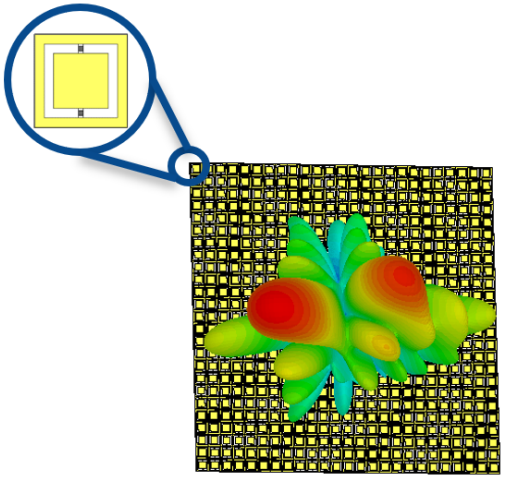
Instituições Associadas

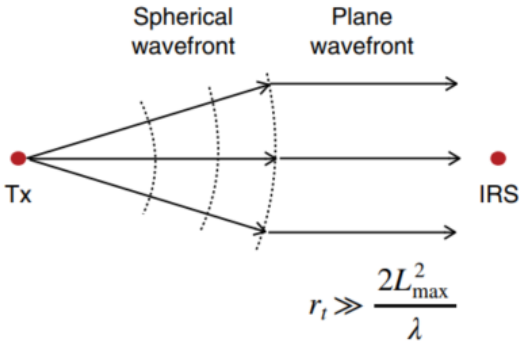
Motivation:

- Moving beyond 5G, researchers are delving into 6G, focusing on the convergence of emerging tech trends. Reconfigurable intelligent surfaces (RIS) play a vital role in shaping smart radio environments for future wireless networks.



RIS- Principals:

Conventional Beamforming [1]:



$$\varphi_{n,m} = \mathrm{k}(r_{t(n,m)} + r_{r(n,m)})$$

- Assuming the RIS is in the Far-field region and using parallel-ray approximations:

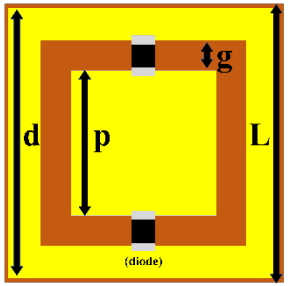
$$r_{t(n,m)} = r_t - \mathrm{n}L_x \cos\phi_t \sin\theta_t - \mathrm{m}L_y \sin\phi_t \sin\theta_t$$

$$r_{r(n,m)} = r_r - \mathrm{n}L_x \cos\phi_r \sin\theta_r - \mathrm{m}L_y \sin\phi_r \sin\theta_r$$

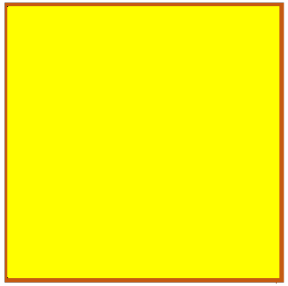
- Therefore, the phase distribution of the RIS can be achieved by:

$$\varphi_{n,m} = -\mathrm{k}(\mathrm{n}L_x \cos\phi_t \sin\theta_t + \mathrm{m}L_y \sin\phi_t \sin\theta_t + \mathrm{n}L_x \cos\phi_r \sin\theta_r + \mathrm{m}L_y \sin\phi_r \sin\theta_r)$$

Proposed Unit cell (UC)



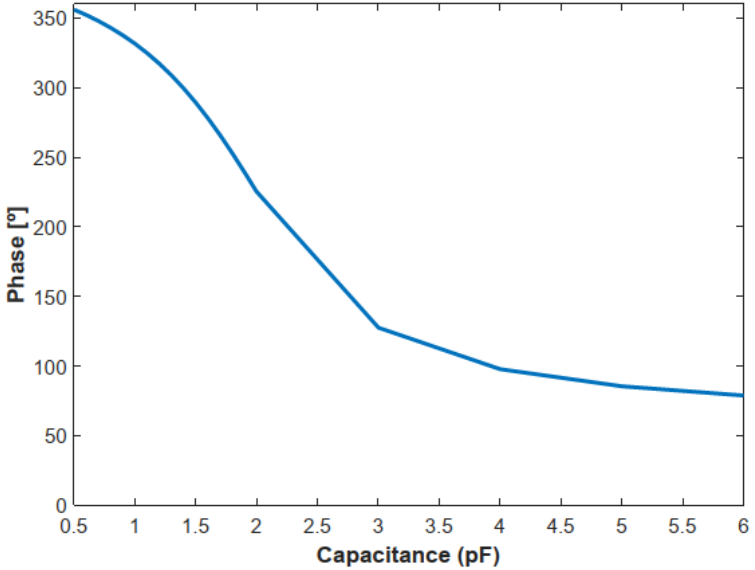
Top view



Bottom view

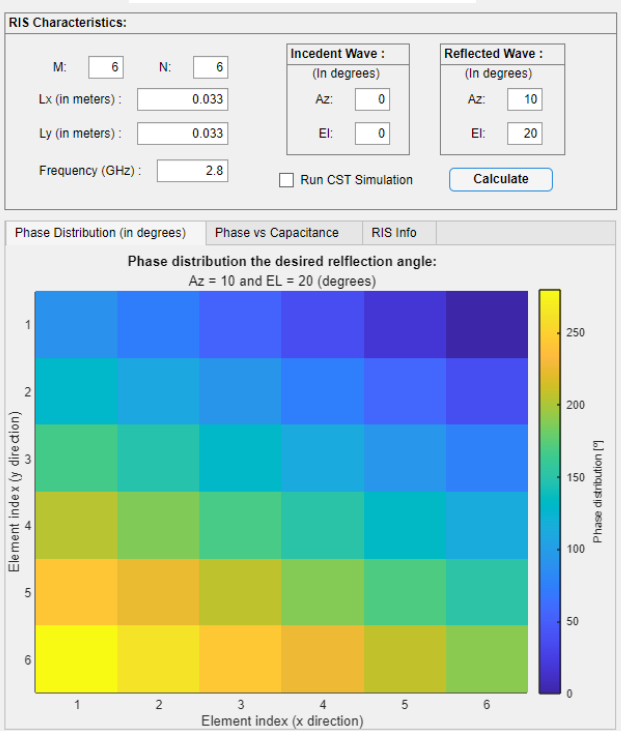
(Overall dimension of 35x35mm)

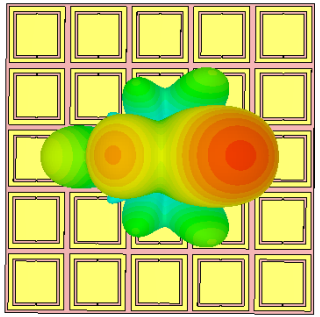
Simulation results of the UC response for diferente capacitances



Phase range: 285º a 3.6GHz

RIS - Design and optimisation:





Characteristics:

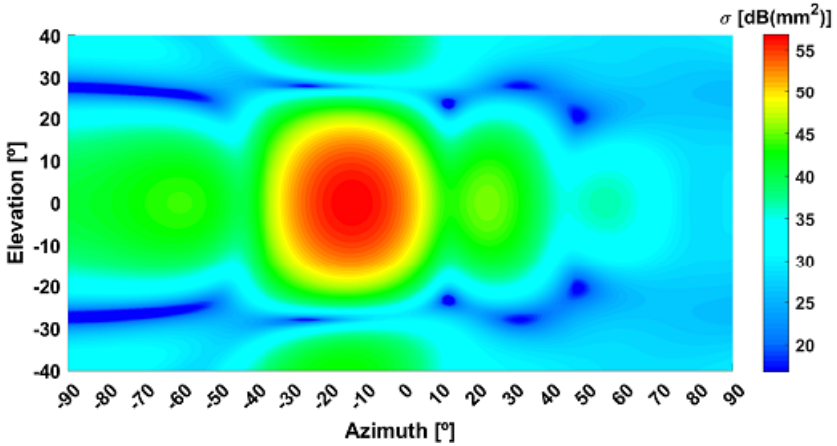
- M=5 and N=5;
- Overall dimensions: 17.5x17.5 cm;
- Technology: Varactor Diode;
- Central Frequency: 3.6 GHz;

Simulation Characteristics:

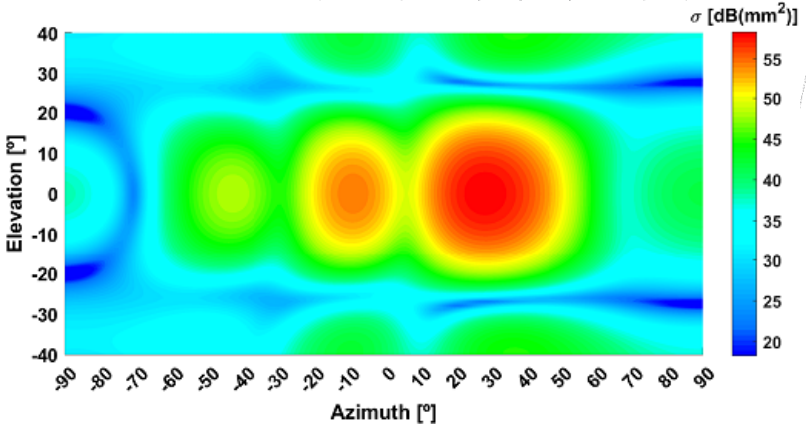
- Tested: Normal incidence;
- Port: Waveguide;
- Boundaries: X: Open add space, Y: Open add space, Z: Open add space

5x5 - RIS Design and optimisation:

Desired reflection angles : Az=-10, EL=0

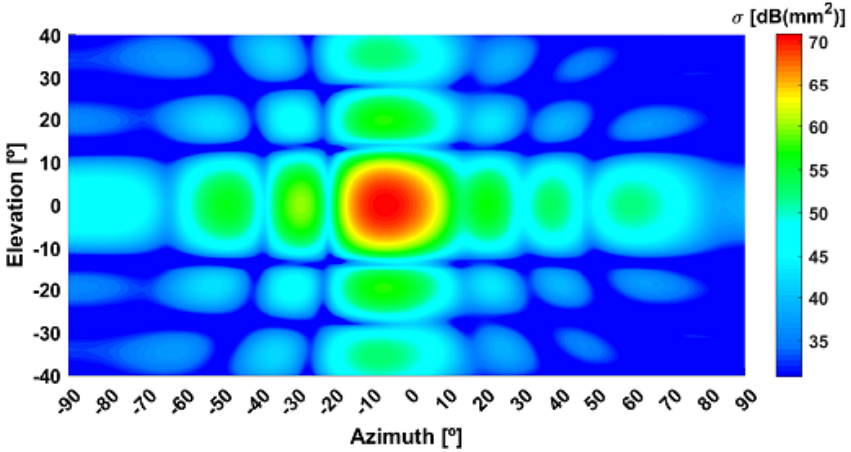


Desired reflection angles : Az=25, EL=0

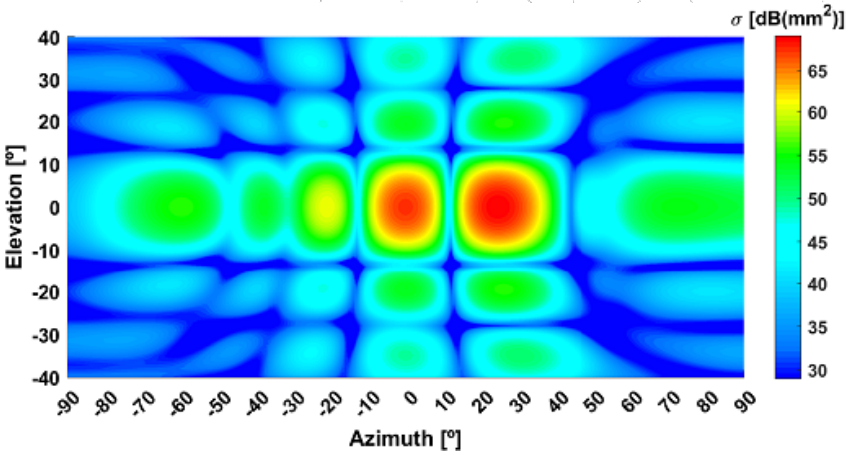


10x10 - RIS Design and optimisation:

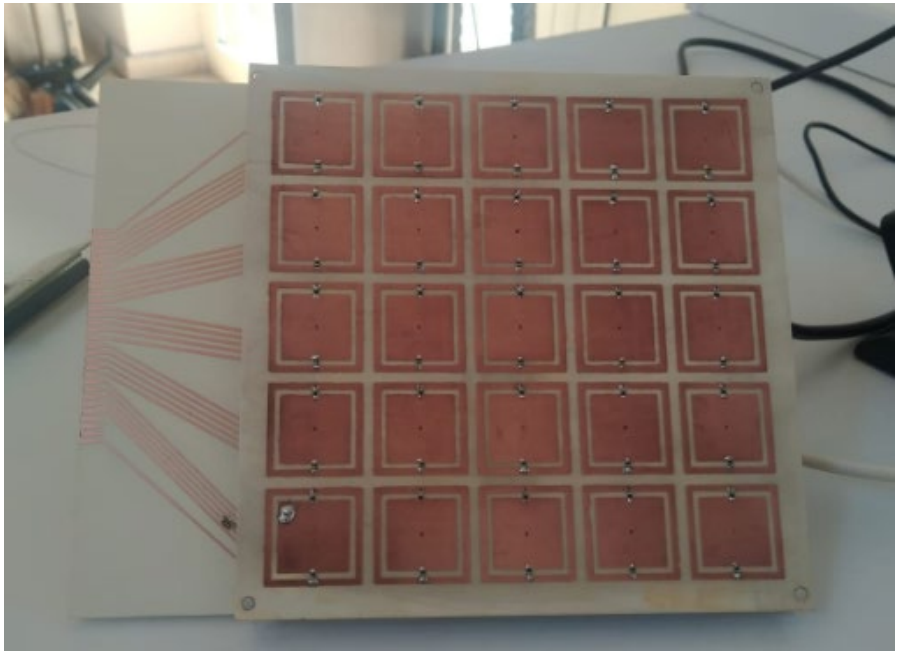
Desired reflection angles: Az=-10, EL=0



Desired reflection angles : Az=25, EL=0

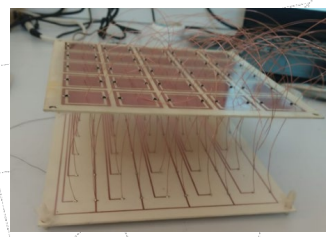


RIS - Prototype:



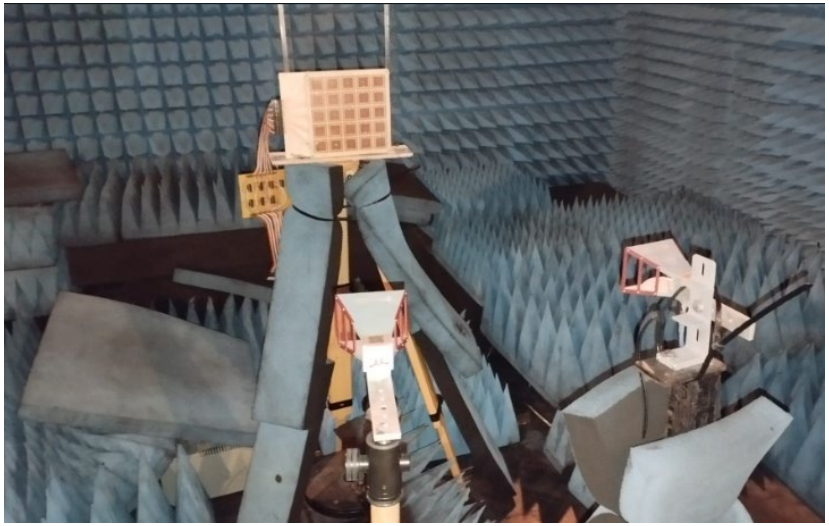
Photography of the Prototype

Photography of the UC feeding lines



Photography of assembly

RIS – Measurement Setup:



Photography of the measurement Setup

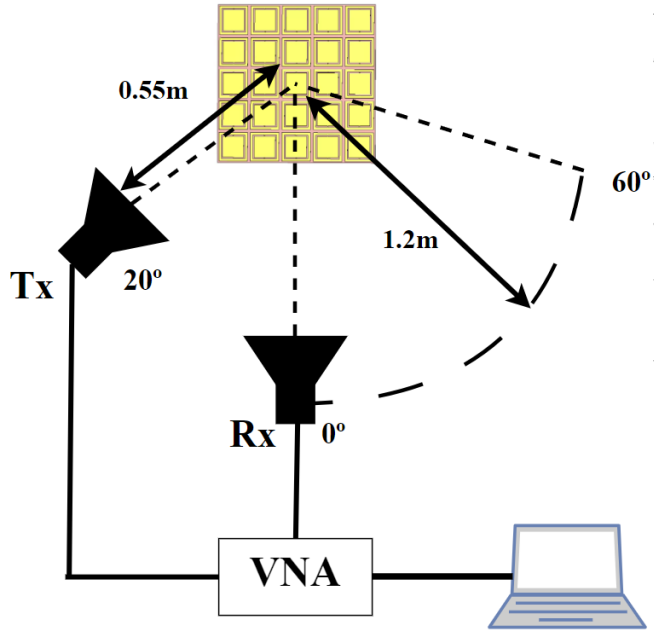
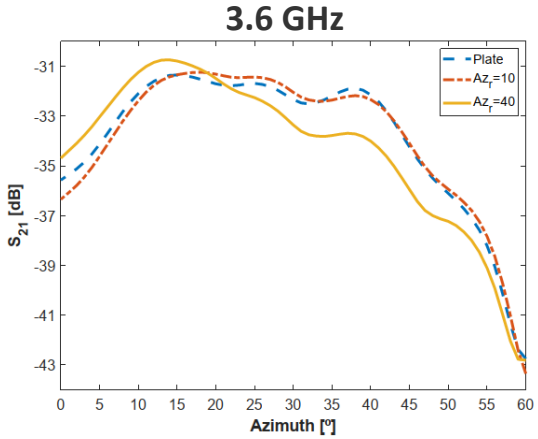
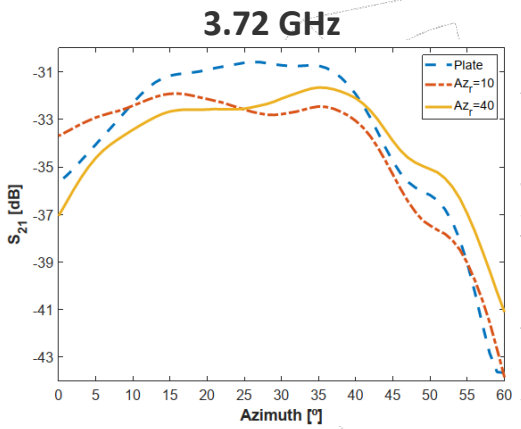
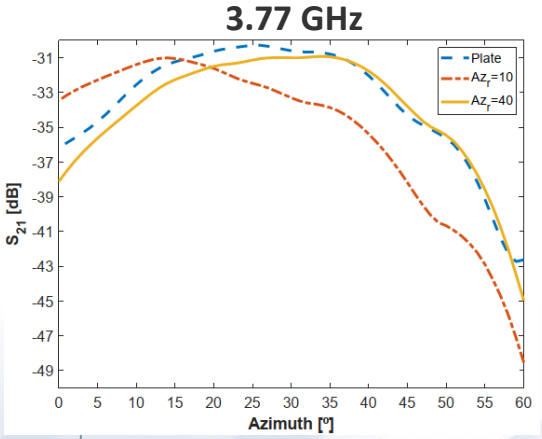


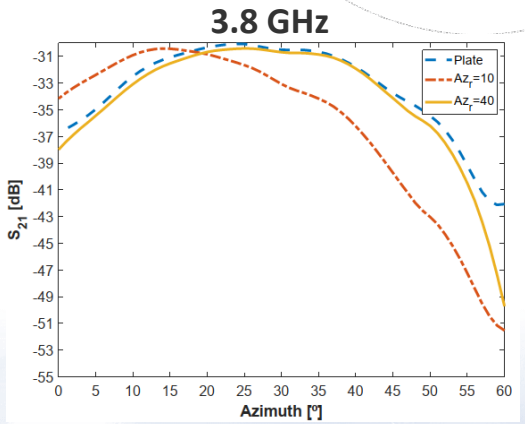
Diagram of the measurement Setup

RIS - Measurements:









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Conclusion:

- In this paper, a double squared reconfigurable intelligent surface designed for operation at 3.6 GHz is proposed.
- Firstly, a unit cell design, based on a double squared layout was studied and optimised to operate at 3.6 GHz.
- Subsequently, two distinct sizes of reconfigurable intelligent surfaces, both built upon the optimized unit cell, are designed and simulated. The simulation results ensured the reconfigurability capabilities of the 5×5 RIS, achieving an aperture efficiency (η = 42.7%, when targeted at 25◦, in the Azimuth plane.
- To further investigate the structure, a prototype of the smaller RIS was produced. The measurement results, of the later, ensured a scanning angle of ±20◦, with a bandwidth of operation from 3.72 to 3.8 GHz.
- Future work will focus on the development of a larger RIS for the purpose of studying and assess its performance in real-world scenarios.

ACKNOWLEDGEMENT

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Appendix A - Pos-processing technique: