MULTIBAND REFLECTIVE POLARIZATION CONVERTER USING METASURFACE

Review

GITAM
DEEMED TO BE UNIVERSITY

AY 2021-25

GITAM (Deemed-to-be) University

Major Project
Project ID: C-11

Department of Electrical Electronics and Communication Engineering

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Introduction

- **Communication systems face challenges due to atmospheric impacts, signal reflection, and polarization mismatches, leading to power loss and reduced efficiency. Traditional circularly polarized antennas, while addressing polarization mismatches, often require complex feeding techniques, increasing system complexity. This study aims to develop a metasurface-based polarization converter that efficiently transforms linearly polarized waves into circularly polarized waves, enhancing signal integrity and communication performance, particularly for 5G systems.**

Abstract

Metasurfaces are composed of artificially engineered periodic resonant structures capable of altering the amplitude, frequency, phase, and polarization of incident electromagnetic (EM) waves. Problems including atmospheric mismatches, reflection effects, and polarization mismatches frequently affect communication links. When transmitting and receiving antennas have different polarizations, polarization mismatching occurs. This problem can be solved by circularly polarized antennas, but their design necessitates intricate feeding methods that aren't always feasible. To prevent polarization mismatching, Metasurfaces can be combined with antennas and can change the polarization of electromagnetic waves. Polarization mismatches in communication lines can be successfully addressed by employing a metasurface as a superstrate to transform the linear polarization of an incident electromagnetic wave into circular polarization during the reflection phase. In our previous work, we designed a metasurface that achieved polarization conversion across four distinct frequency bands: three bands for linear-to-linear polarization conversion and one band for linear-to-circular polarization conversion. The performance was observed by plotting the corresponding graphs, demonstrating the metasurface's effectiveness in addressing polarization mismatches. Building on this, we have now designed a metasurface operating as a polarization converter within the 4-8 GHz frequency range. The impact of the metasurface on key characteristics, including polarization conversion efficiency, has been thoroughly evaluated.

Moving forward, we aim to fine-tune the metasurface design further and conduct a detailed analysis of its current distribution. Following this, we plan to fabricate the optimized design and carry out experimental measurements to validate its performance and compare the results with simulations, ensuring its practical application.

Objective and Goals

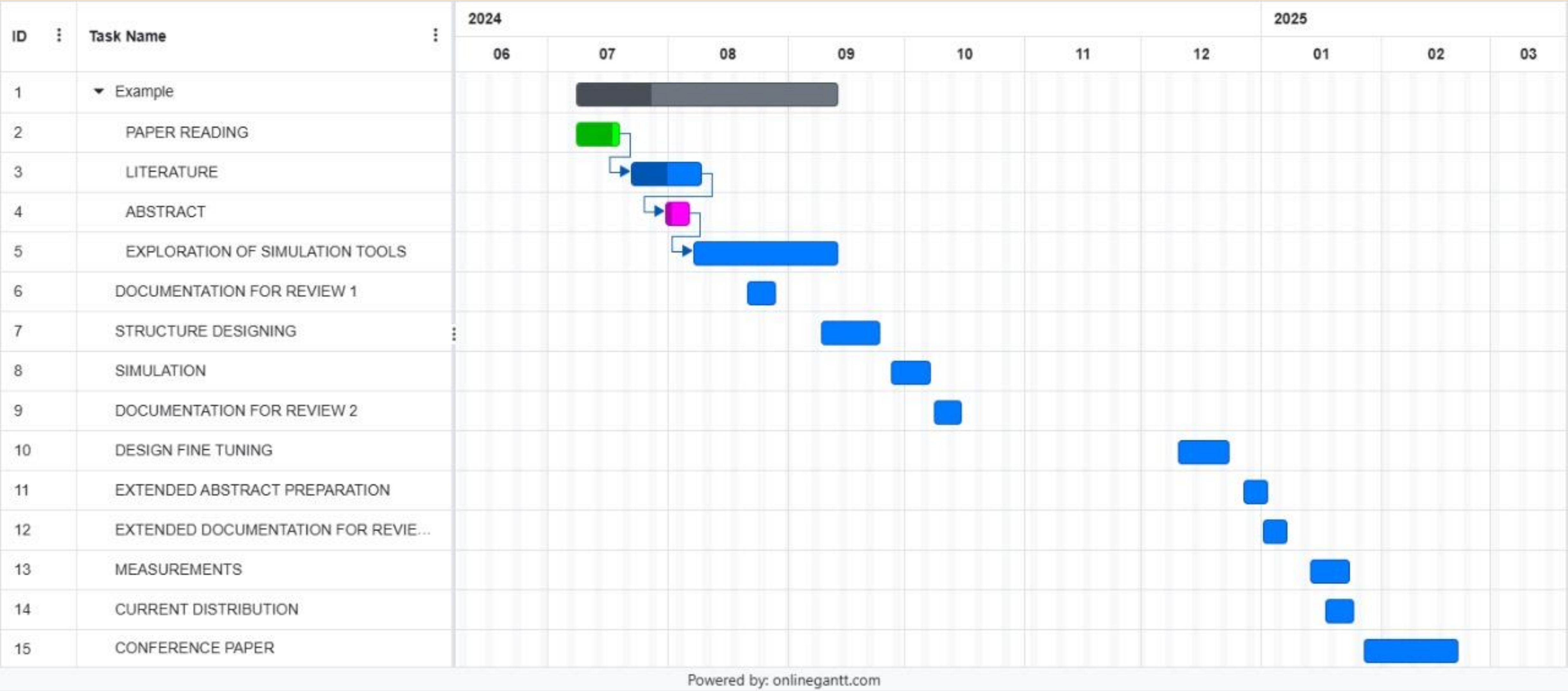
Objective

- ✓ Analyze the designed metasurface by calculating the axial ratio, current distributions, and determining ellipticity to evaluate polarization performance.
- ✓ Compare the simulated results with other papers for best results and finetune if it is not good as expected.

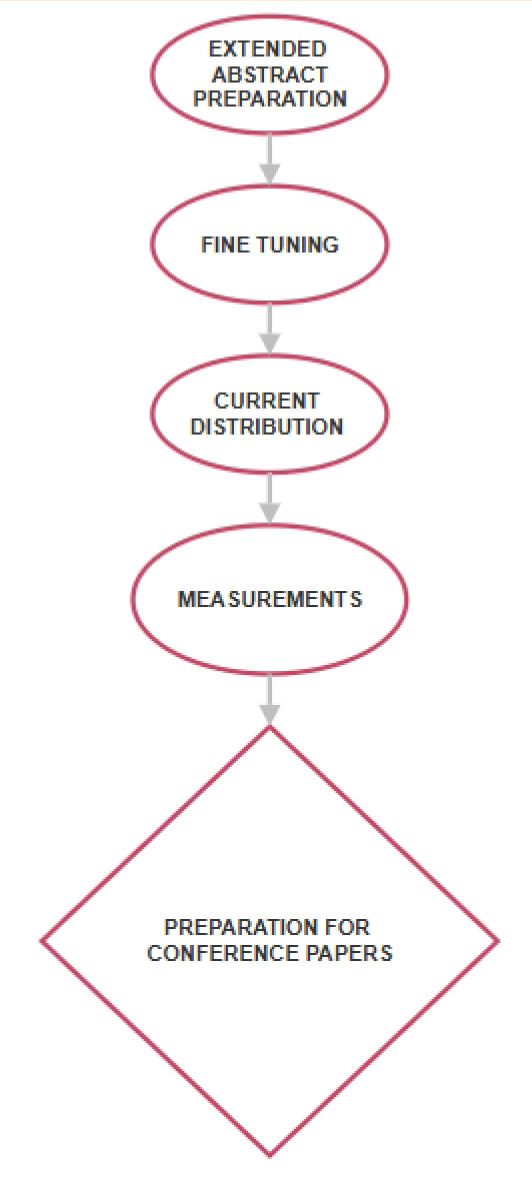
Goals

- ✓ Evaluate Performance
- ✓ Analyze Current Distribution
- ✓ Prepare a Conference Paper

Project Plan



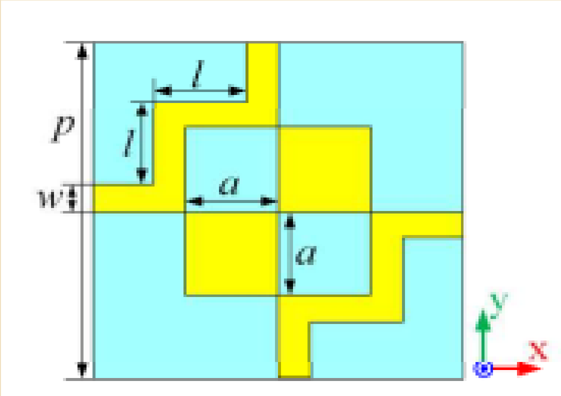
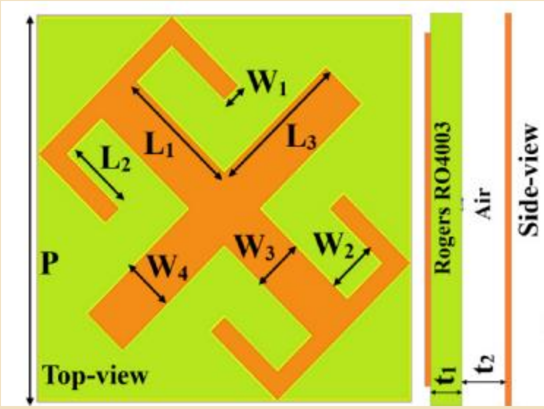
Architecture



Background work

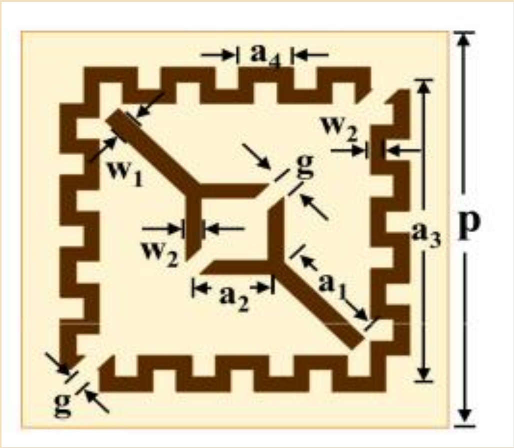
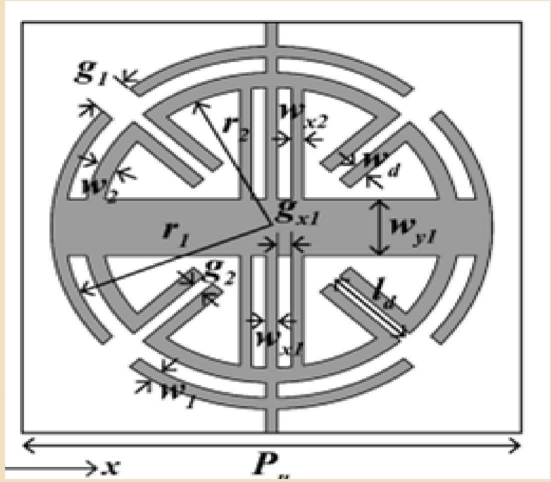
Literature Survey

Key Publications

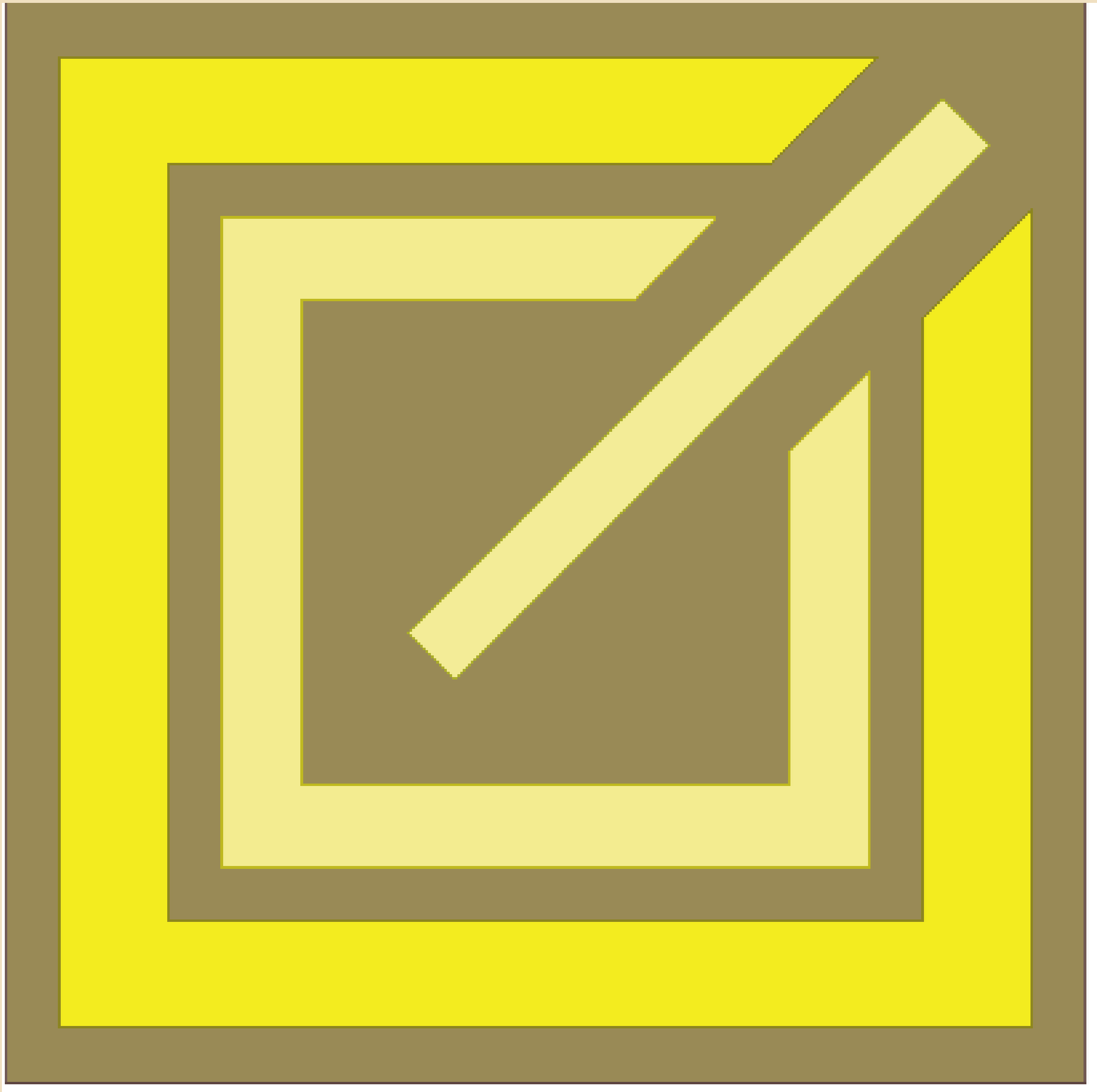
TITLE	AUTHOR and YEAR	STRUCTURE	KEY FINDINGS
• Simultaneous Transmission and Reflection Mode Linear-to-Circular Polarization Conversion Using a Single Metasurface	Debidas Kundu; Dhrubajyoti Bhattacharya; Debashree Pathak 2021		• **Dual-Mode and Linear-to-Circular Polarization Conversion (LCP)**:The metasurface is designed to achieve linear-to-circular polarization (LCP) conversion in both transmission and reflection modes simultaneously.
• A Low-Profile Multifunctional Metasurface Reflector for Multiband Polarization Transformation.	Soumendu Ghosh , Jeet Ghosh , Moirangthem Santosh Kumar Singh and Abhishek Sarkhel 2023		• **Metasurface Design**: multifunctional. • **Broadband Polarization Conversion**: **Tri-Band LP-to-LP Conversion**: **5.47-5.68** GHz, **7.86-8.84** GHz, and **14.68-16.83** GHz. **Quad-Band LP-to-CP Conversion**: 5.30-5.41 GHz, 5.77-7.58 GHz, 9.27-13.91 GHz, and 17.53-19.59 GHz. • **Radar Cross-Section (RCS)** Reduction: **5.85-5.95** GHz, **9.2-10.3** GHz, and **16.6-18.5** GHz.

Literature Survey

Key Publications

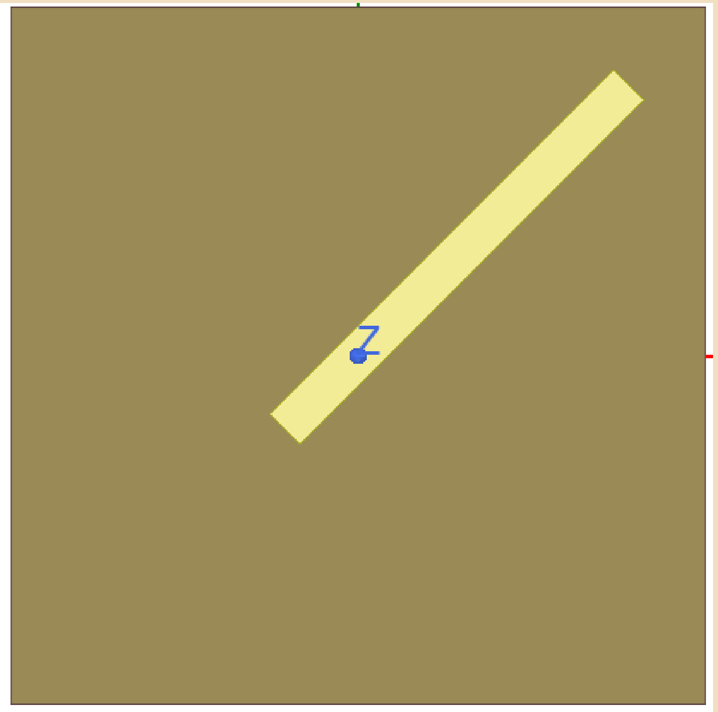
• Multi-Band and Multi-Functional Metasurface-Based on Reflective Polarization Converter for Linear and the Circular Polarizations	RAHUL DUTTA , JEET GHOSH , ZHENGBAO YANG ,AND XINGQI ZHANG, 2021		• **Multiband Polarization Conversion: linear-to-orthogonal** linear 4.3 GHz, 7.2 GHz, 12.3 GHz, and 15.15 GHz • **linear-to-circular and circular-to-linear: 4 GHz, 4.75–5.95 GHz, 8.35–8.8 GHz, and 14.35–14.6 GHz.** • **Design and Resonance Mechanism: The multiband operation is attributed to multiple resonances occurring within the structure, which is based on a meandered square ring and diagonal split strip resonator.**
Ultrathin Single Layer Transmissive Dual-Band Linear to the Circular Converter for Non-Adjacent of Dual Orthogonal Circularly Polarized Antenna	SOUMIK DEY , SUKOMAL DEY. 2024		• **Dual-Band Transmissive Polarizer:** Designed on a single-layer, ultra-thin dielectric substrate (0.51 mm thick Taconic TLY-5). • **Frequency and Angle Stability: The** LTCP achieves polarization conversion at **11.2 GHz and 22.75 GHz** with oblique angle stability up to 35°.

Architecture

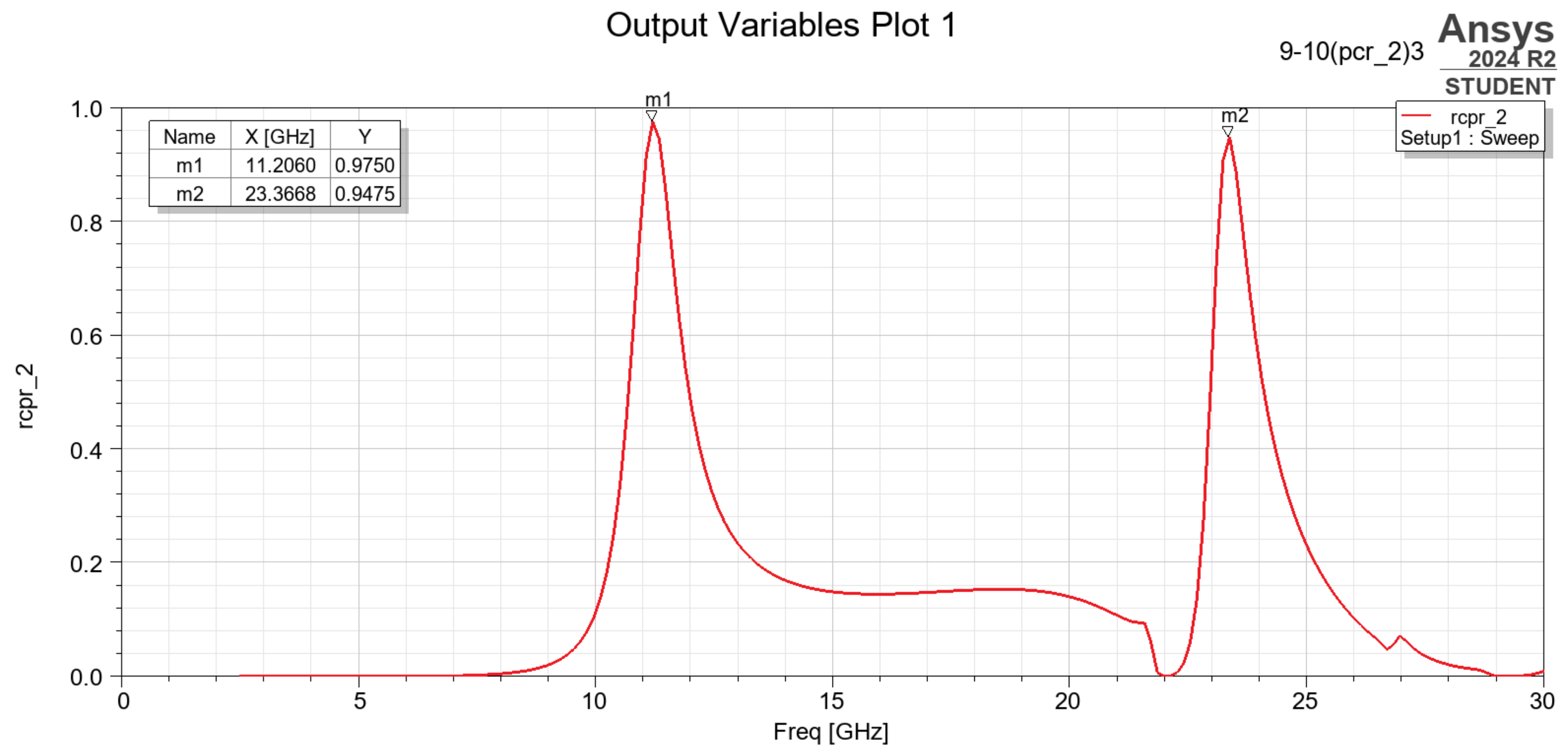


Architecture

Structural Diagram

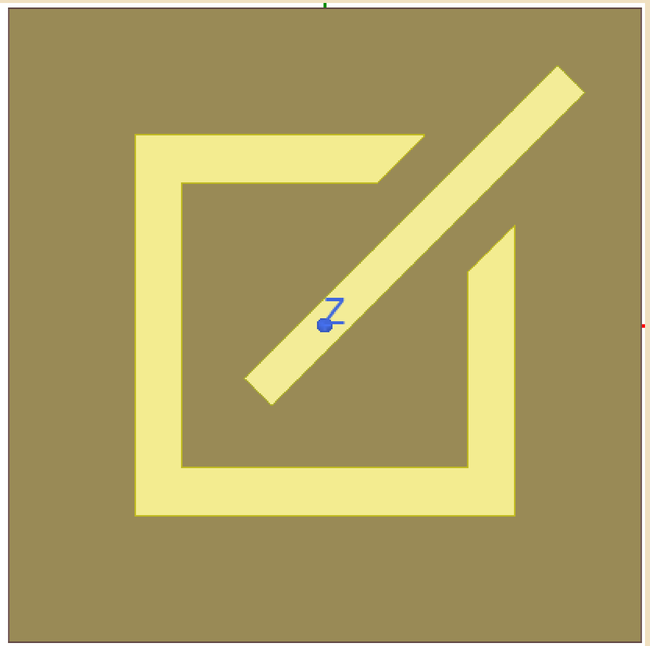


Behaviour Diagram

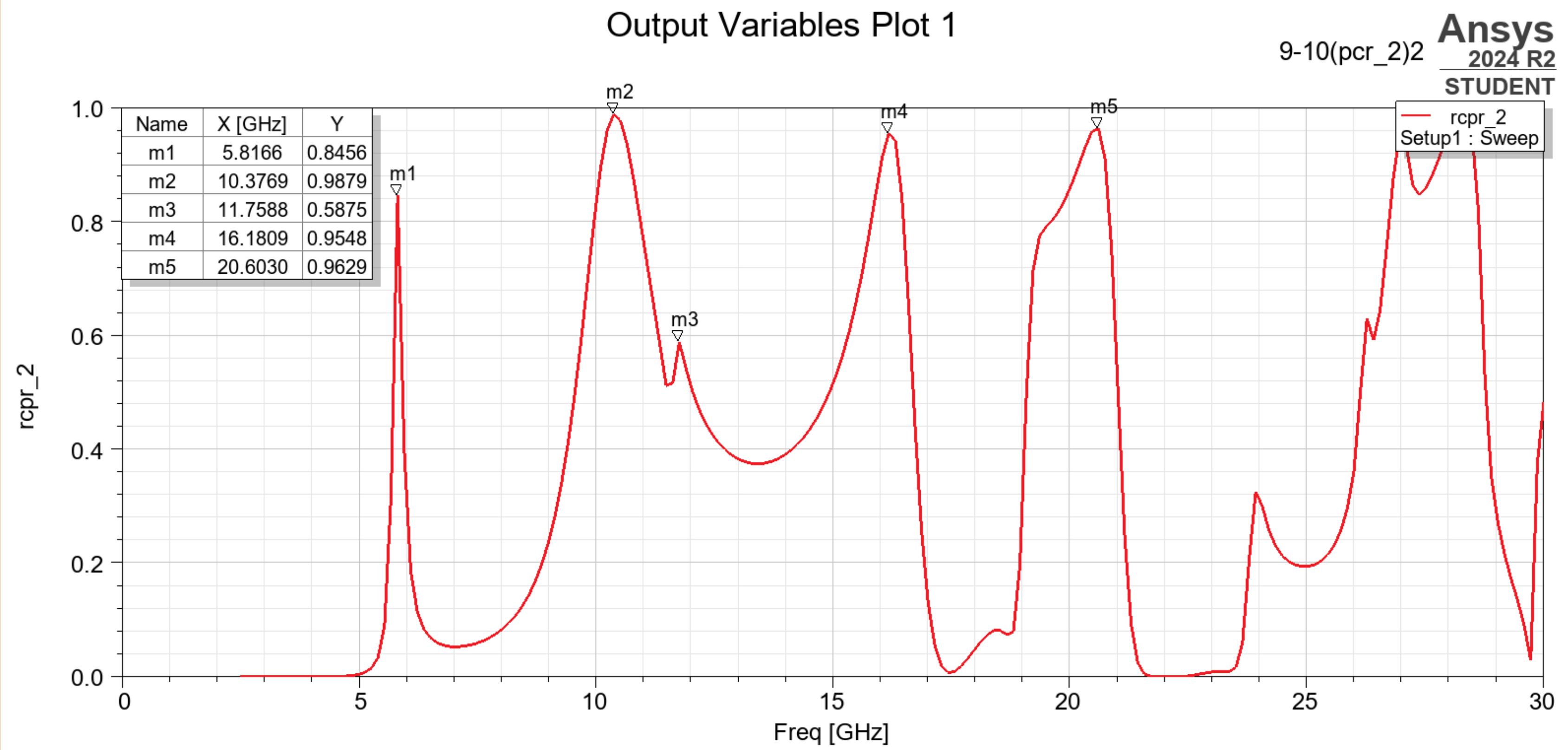


Architecture

Structural Diagram

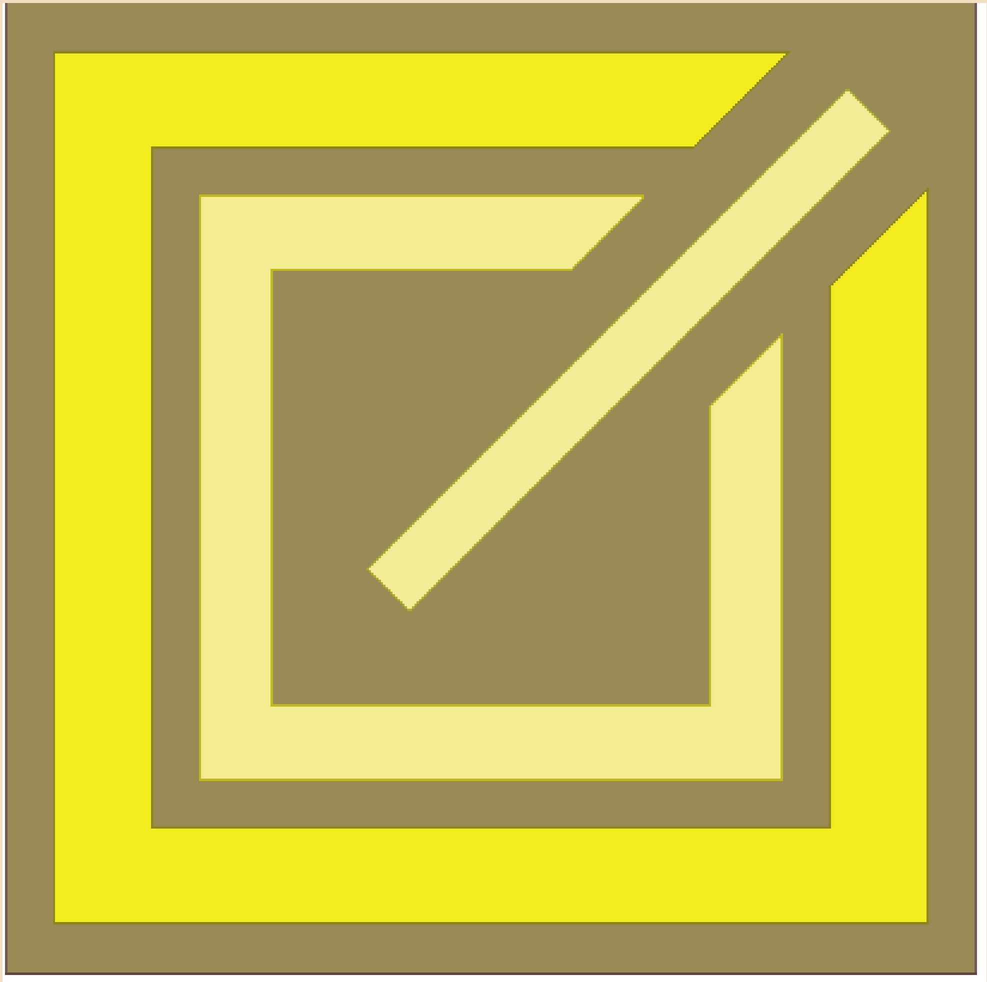


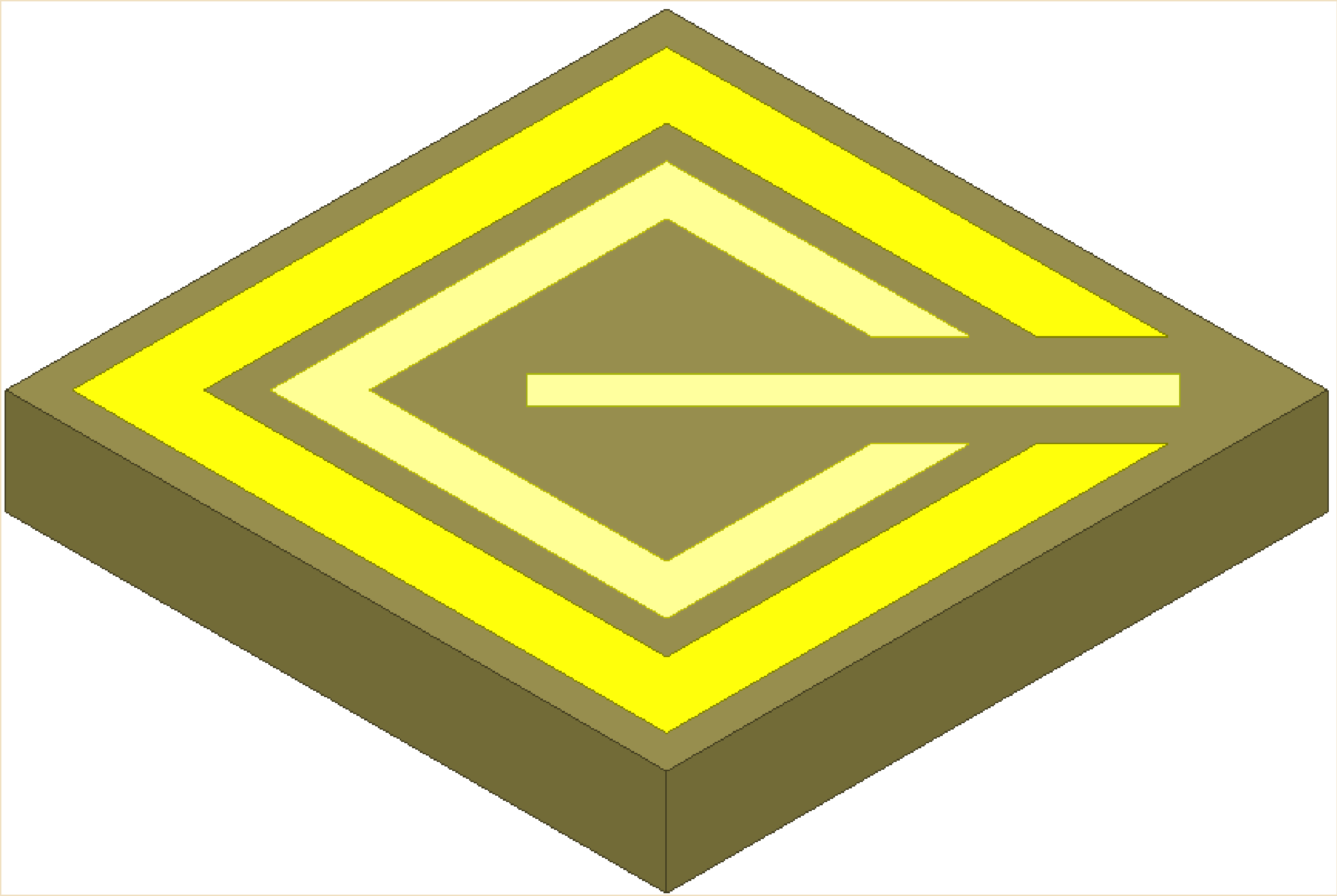
Behaviour Diagram



Implementation – Iteration

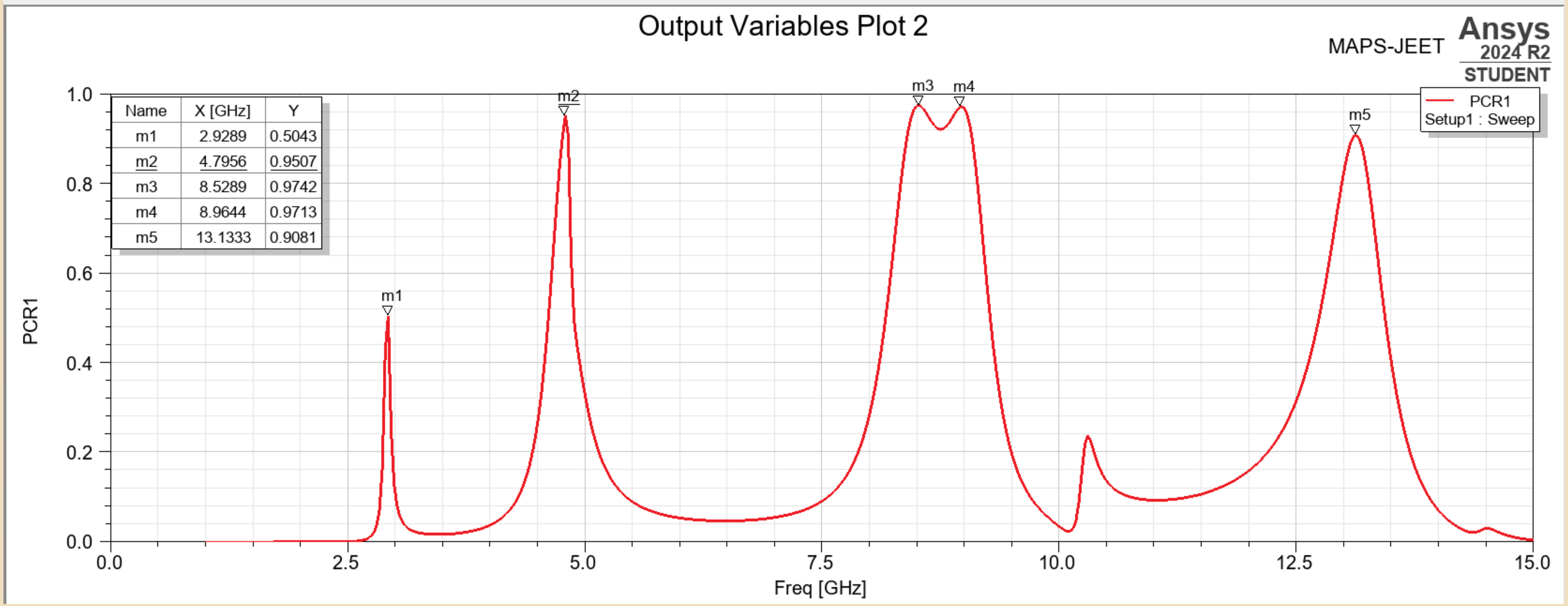
Iteration :





Results – Iteration

Iteration : Results



Conclusion

- In our simulation using Ansys 2024, we created a 10x10 mm metasurface with a thickness of 1.6 mm to effectively convert linearly polarized waves into circular polarization without the need for complicated feeding techniques. The metasurface exhibited three linear polarization (LP) bands and one near-circular polarization (CP) band, which indicated its performance over various frequencies.

- By maximizing the geometrical structure, we obtained high polarization conversion efficiency and potential for multi-band CP performance by fine-tuning. The metasurface provides a low-cost, compact, and versatile platform for 5G, radar, and remote sensing communication systems. Its simplicity, scalability, and wide frequency range compatibility make it a strong candidate for electromagnetic applications of the future.

THANK YOU

Have a Great Day !