School of Advanced Technology

Modified Dipole and Patch Antennas with Metamaterial

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Abstract

In the field of communications, antennas play a vital role in transmitting and receiving electromagnetic waves. As technology advances and communication systems become more sophisticated, the demand for high-performance antennas increases.

This project explores the design of modified dipole and patch antennas with the integration of metamaterials. By utilizing the CST Microwave Studio software, simulations of two types of antennas were done, and they are modifed to operate at higher frequency with wider bandwidth. The metamaterial structure was also simulated, and will be attached to the antennas in the future.

Introduction

In today's ever-connected world, wireless communication plays a pivotal role in various domains. With the growing demand for high-speed data transfer, extended coverage, and improved signal quality, researchers are constantly exploring innovative techniques to enhance the performance of antennas, such as their operation bandwidth and radiation properties. In this project, we focus on two types of antennas: modified dipole antennas and patch antennas, both augmented with metamaterials. Dipole antennas are widely used due to their simplicity and broadband characteristics, while patch antennas are popular for their compact size and ease of integration into various devices. By applying metamaterial elements to these antenna designs, we aim to further enhance their performance in terms of bandwidth, gain, radiation pattern control, and impedance matching.

Methodology

1.Antennas Choice

In this project, the two types of antennas chosen for modification and optimization are the dipole and the patch antenna. The dipole antenna, consisting of two conductive elements, is a fundamental and widely used antenna configuration. As for the patch antenna, it consists of a metallic patch on a grounded substrate and is known for its compact size and compatibility with integrated circuits.

2. Metamaterials

Metamaterials possess extraordinary EM properties, such as negative refractive index, electromagnetic cloaking, and subwavelength focusing, which can enable unprecedented control over electromagnetic waves and enable antennas to exhibit new and desirable characteristics. By incorporating metamaterials into antenna designs, we aim to enhance their performance in terms of bandwidth, efficiency, directivity, and miniaturization.

3. Simulation Models

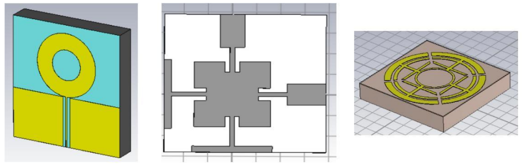

Figure 1. (a) Modified Dipole (Coplanar waveguide fed ring dipole);
(b) Modified Patch (Dual Microstrip fed top-loaded patch);
(c) Metamaterial (Modified SRR structure)

Results and Discussion

1. Results for Modified Dipole Antenna

Two designs, one at 24GHz, the other at 26-29 GHz.

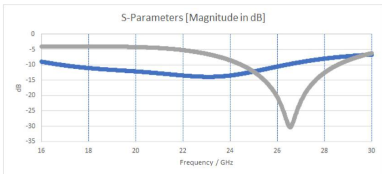

Figure 2.
S11 vs freq.
blue - original
grey - 5G band

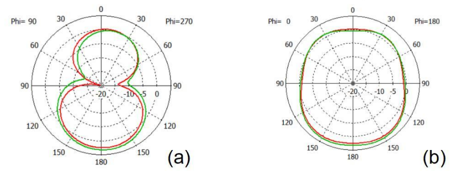

Figure 3. Radiation pattern on E-plane (a) and H-plane (b) at 22GHz (g) and 22.5GHz (r).

2. Results for dual-polarised microstrip antenna

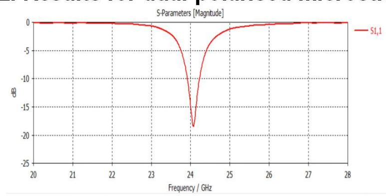

Figure 4.
S11 vs freq.

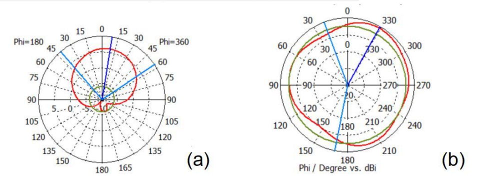

Figure 5. Radiation patterns on E-plane (a) and H-plane (b).

3. Metamaterial structure

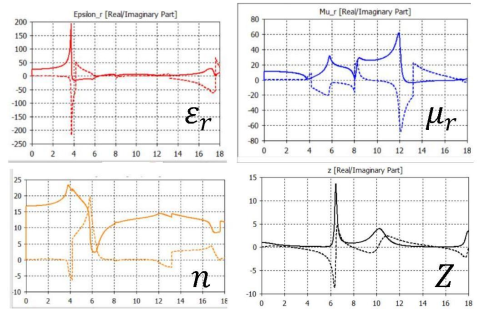

Figure 6.
EM properties of the metamaterial

Conclusion and Future Work

The two traditional antenna designs are operating around 24GHz. The dipole type is featured with a wider bandwidth, but its gain is lower. The modified patch has a very thin bandwidth, but provides a much higher gain. The metamerial structure provides negative permitivity or permeability at the designed frequency.

The next step is to modify the metamaterial's operating frequency and attach it to the designed antennas, to see the possible improvement in the radiation patterns.

SURF
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References

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