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Novel Design of Seven Port MIMO Antenna for Wideband Application

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ABSTRACT: In this project a seven port MIMO antenna is designed. First a single antenna is designed with the Roger RT/ Duroid 5880 substrate of thickness of 0.254 mm with a partial ground plane. This ground plane improves the performance of an antenna. A strip patch is introduced with a H- shaped stub on top of the strip. The unit cell size metamaterial consist of two ellipse connected by a strip is placed above the substrate. Further this single antenna is modified to seven port MIMO antenna. The proposed antenna is a good candidate for smart devices and sensors.

KEYWORDS: Multiple Input Multiple Output, Partial Ground Plane, Metamaterial, Seven Port Antenna.

I. INTRODUCTION

MIMO Antenna is a wireless communication technology that uses multiple antennas at both the transmitter and receiver to improve the performance of the system. This technology improves data throughput, reliability, and spectral efficiency by creating multiple communication paths within the same frequency band. In a MIMO system, the antennas' gain can significantly impact the system's performance. A higher gain antenna can provide a stronger, more focused signal, which can lead to improved signal quality and increased data rates. This can be particularly beneficial in a MIMO system where multiple antennas are used to transmit and receive data simultaneously. In this design metamaterial is used to improve performance. Metamaterial is the one in which the electromagnetic property can be altered beyond the material nature. In seven port MIMO antenna metamaterial is used to improve performance of miniaturized antenna. Roger RT 5880 substrate is a high frequency lamination material used for designing PCB. In seven port MIMO antenna circular polarization is used to avoid cross polarization interference in designed antenna which can improve mutual coupling. The context of Multiple-Input Multiple-Output (MIMO) antennas, mutual coupling refers to the electromagnetic interaction between antenna elements, which can negatively impact the performance of the MIMO system.

II. MIMO ANTENNA

In a MIMO antenna array, each antenna at the transmitter and receiver ends issued to transmit and receive multiple data streams simultaneously. The signals transmitted by each antenna combine constructively at the receiver end, which improves the signal strength and reduces the effects of interference and fading.

MIMO Antenna has some techniques eigen-Beam forming can be done at both the transmit side of a link and the receive side. Classical Beam forming is like using a high gain antenna, but one that need not be reoriented to point in different directions, Eigen-Beam forming achieves the same gain but is insensitive to antenna orientation or scattering elements in the vicinity of the antenna. Many people think of systems like phased-array radar when the idea of beam forming is introduced, and indeed, phased-array is a method of using multiple antenna elements to steer the directivity of the antenna cluster in different directions, forming a transmit or receive antenna "beam". Spatial Multiplexing is often the technique that people find difficult to believe, let alone grasp. This MIMO technique actually transmits multiple unique information "streams" from different antennas, each operating at an identical centre frequency. A receiver using at least as many antennas as the number of streams transmitted can decode these individually and thus increase the amount of data flowing through a fixed channel bandwidth. A 4×4 MIMO system can achieve four streams under optimal conditions and thus transmit four times as much data as a SISO system over the same channel bandwidth. Space-time coding is a mechanism that can be utilized to transmit over multiple antennas and achieve

similar gains as can be achieved using multiple antenna diversity reception. Space-time coding means taking the data that would ordinarily be transmitted from a single antenna and applying a signal processing coding technique in order to transmit a mathematically altered version of the same information content on additional antennas in a way that enhances the ability of the receiver to separate the data from the background noise. Space-time coding can be a natural match to receive beam forming or diversity reception.

MIMO antenna arrays are typically used in modern wireless communication systems, such as 4G LTE, 5G, and Wi-Fi. These systems use advanced signal processing algorithms to improve the capacity and reliability of the communication link by exploiting the spatial diversity provided by the multiple antennas. MIMO antenna arrays come in different configurations, such as SIMO (Single- Input Multiple-Output), MISO (Multiple-Input Single-Output), and spatial multiplexing MIMO. The choice of the MIMO configuration depends on the specific application and the available resources.

III. PROPOSED SEVEN PORT MIMO ANTENNA

In this project a seven port MIMO antenna is designed. First a single antenna is designed with the Roger RT/ Duroid 5880 substrate of thickness of 0.254 mm with a partial ground plane. This ground plane improves the performance of an antenna. A strip patch is introduced with a H- shaped stub on top of the strip. The unit cell size metamaterial consist of two ellipse connected by a strip is placed above the substrate. Further this single antenna is modified to seven port MIMO antenna. The proposed antenna is a good candidate for smart devices and sensors.

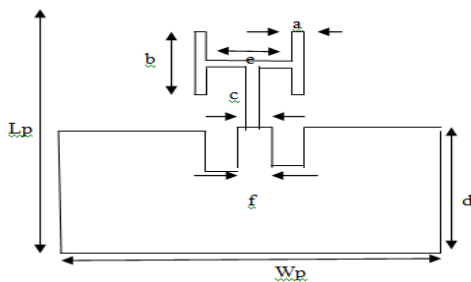


Fig 1: Single Antenna Design

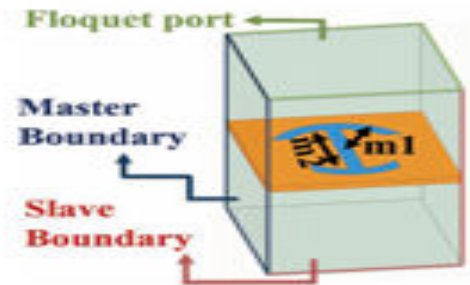


Fig 2: Unit cell of Metamaterial decoupler

MIMO parameters are also discussed in terms of Envelope correlation coefficient (ECC), diversity gain (DG), and mean effective gain (MEG) to further investigate the performance of the MIMO antenna. To understand the characteristics of the MIMO Antenna, it is essential to assess its diversity characteristics in terms of ECC, DG, and MEG. In general, the value of the diversity gain for MIMO antenna lies between 0 and 1 and can be expressed by

$$DG = \frac{mt(R^2)}{\|R\|_{Fr}}$$

The MEG analyzes the gain between antenna elements while taking into account real propagation conditions. MEG for port I is given by

$$MEG_{port i} = 0.5\eta_{i,rad} = 0.5 \left[1 - \sum_{j=1}^K |S_{ij}|^2 \right]$$

Where K and η_i indicate the number of antennas and radiation efficiency, respectively.

The Antenna Design have specific dimension which is tabulated below.

UNITS	DIMENSION
Lp	12mm
Wp	10mm
a	1mm
b	3mm
c	0.7mm
d	6.75mm
e	6mm
f	1.5mm
m1	2.3mm
m2	3.5mm

IV. SIMULATION RESULTS

The low-profile, single-layer wide band metamaterial-inspired circularly polarized (CP) multiple input multiple-output (MIMO) antenna array. An 7*7 antenna array is manufactured on the Rogers RT/Duroid 5880 substrate with a partial ground plane. The dimensions of the proposed MIMO antenna array at 20 GHz. The isolation and gain are significantly improved by the introduction of a metamaterial-inspired element. Fig 3 shows the simulated proposed antenna.

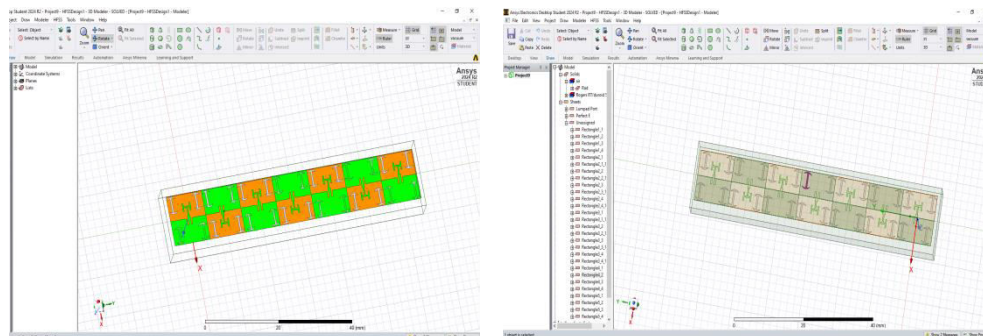


Fig 3: Front and back view of proposed antenna design

Antenna gain is the power transmitted by an antenna in a specific direction as compared to an isotropic antenna. This specification describes how strong a signal an antenna can send out or receive in a specified direction. Gain or 'absolute gain' is defined as "The ratio of the radiation intensity in a given direction to the radiation intensity that would be produced if the power accepted by the antenna were isotropically radiated". Usually this ratio is expressed in decibels with respect to an isotropic radiator (dB).

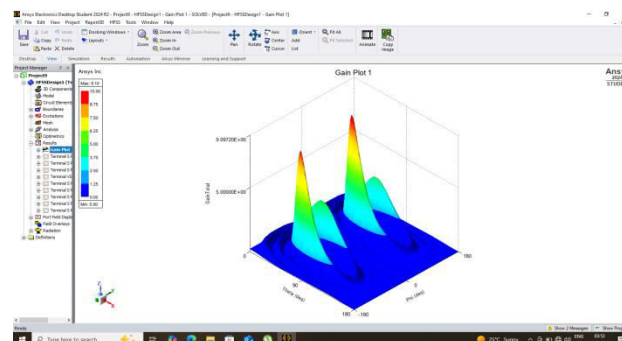


Fig 4: Shows antenna gain of proposed antenna

VSWR is a measure of the impedance matching between the radio or transmission line and antenna. It indicates the amount of power that can be safely delivered to an antenna without damaging it. A good VSWR value should be below 2. The amount of power that is reflected increases with VSWR, so a high VSWR can significantly reduce the effective power output of the antenna

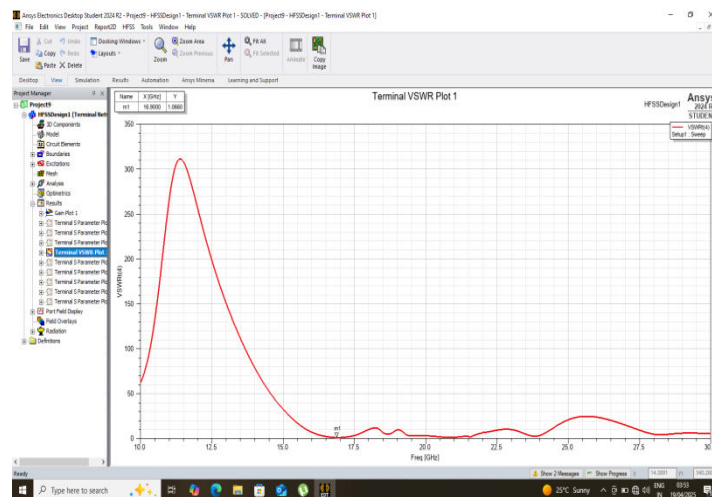


Fig 5: Shows the VSWR of proposed antenna

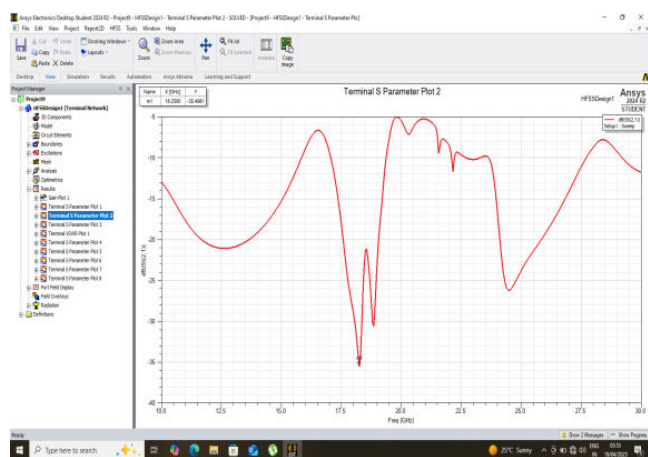
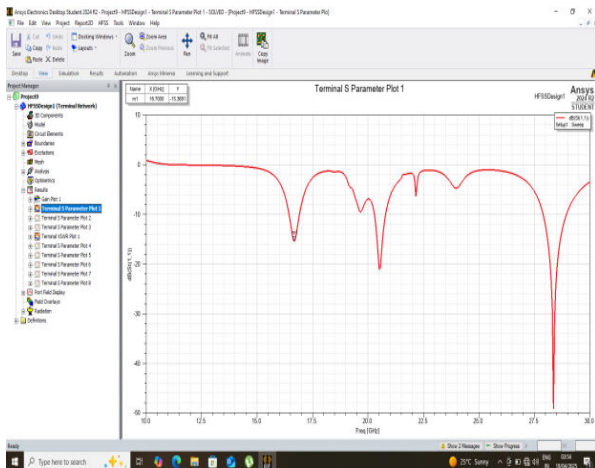


Fig 6: Shows the S11 and S12 parameter of proposed antenna

Isolation refers to the ability of the antenna to separate the desired signal from other unwanted signals in the environment. Here S_{14} is a parameter that describes the isolation loss.

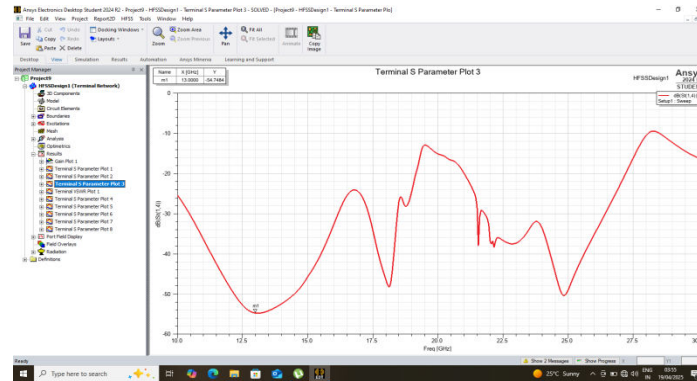


Fig 7: Shows the isolation loss of proposed antenna

Antenna proposed operates at 20 GHz having an antenna parameters such as isolation loss (-54.74dB), reflection coefficient (-15.36dB), transmission coefficient (-35.49dB), gain (9.01dB), and VSWR (1.06). The simulated results shown that the isolated MIMO antenna can reduce mutual coupling, improve impedance matching, high efficiency, enhance isolation between the elements also overcome the cross polarization which leads to improper performance of antenna.

V. CONCLUSION

In this project, a very compact CP hepta-element MIMO antenna with multiple unique metamaterial-inspired unit cells is presented. The enhanced mutual coupling reduction and circular polarization are achieved by employing the meta surface to tickle the current fields and generate the current distribution on the MIMO antenna's elements. Antenna proposed in this design operates at 20 GHz. Measured antenna parameters including isolation loss (-54.74dB), reflection coefficient (-15.36dB), transmission coefficient (-35.49dB), gain(9.01dB), and VSWR(1.06) matched the simulation results rather well. A low cost and simple fabrication characterize the proposed antenna. This confirms that the antenna functions in the 5G NR smart devices and sensors.

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