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UWB-MIMO 4-Port Fractal Antenna with Reduced Mutual Coupling

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Abstract: UWB MIMO antenna loaded structure Mutual coupling between the four radiating elements is obtained to be less than - 25 db. The patterns of radiation are stable over the operating range and a peak gain of 4.5 dB is obtained at 7.5GHz and Return loss is obtained less than 10dB. Simulation is conducted using HFSS simulation tool and printed on a 30 X 30 X 1.6 mm^3 FR4 material. 4 linear SRR structures are used between adjacent elements to ensure good isolation. MIMO antenna with grounded stubs and fractal geometry are used to improve isolation and to achieve wide band phenomena. UWB-MIMO antenna using to achieve better isolation. The UWB MIMO 4-port fractal antenna combines the characteristics of ultra-wideband operation, multiple input multiple output capability, four-port configuration for simultaneous data streams, and a fractal antenna design for wide bandwidth and compact size. This makes it suitable for high-speed, reliable communication in applications requiring UWB technology, such as high-speed data transfer, localization, and radar systems. By integrating a copper rectangular plane between ports, interference and crosstalk are minimized, enhancing the antenna's capability to handle multiple input and output signals efficiently. This innovative design approach not only improves isolation but also contributes to the antenna's overall effectiveness in various communication applications.
Keywords: MIMO Antenna, Ultrawide Band Applications, Mutual coupling.

I. INTRODUCTION

MIMO technology, driven by the rapid advancement of wireless communication, utilizes multiple antenna elements for signal transmission and reception. By leveraging these antennas, MIMO achieves increased communication capacity and spectrum utilization without raising transmitting power. This technology is crucial for meeting the demands of stable transmission quality and high data rates.In the realm of wireless communication, UWB technology has emerged as a key player due to its wide bandwidth. However, conventional UWB suffers from multipath fading, primarily caused by dense medium reflections and refractions. To address this issue, MIMO technology has been introduced. Fractal geometries offer an efficient solution for shrinking antenna size while maintaining pattern stability and bandwidth. Their self-similar properties enable compact antenna designs, making them valuable candidates for modern wireless devices. They are particularly useful in designing electrically small antennas and mitigating mutual coupling between elements in MIMO setups.

UWB MIMO 4-port fractal antenna is an antenna designed to operate across a wide range of frequencies, support multiple input/output channels simultaneously, and have a compact size thanks to its fractal geometry-inspired design. This type of antenna would be well-suited for wireless communication systems that require high data rates, reliability, and flexibility in challenging environments.

MIMO antenna have good isolation and MIMO antenna isolation contribute to higher data rates, increased capacity, better signal quality, and enhanced system reliability, making it a crucial aspect of modern wireless communication systems. MIMO antenna isolation helps mitigate interference between different antennas in the system. By keeping the signals from interfering with each other, the system can maintain better signal quality and reliability, leading to improved data throughput and overall performance. With better isolation between antennas, MIMO systems can support a higher number of spatial streams, thereby increasing the overall capacity of the system. This means that more data can be transmitted simultaneously, allowing for higher data rates and more efficient use of the available spectrum. Improved isolation helps minimize co-channel interference and multipath effects, resulting in cleaner received signals. This leads to better signal-to-noise ratio (SNR) and lower error rates, which are crucial for maintaining high-quality communication links, especially in challenging environments.

MIMO systems rely on accurate channel state information (CSI) to optimize signal transmission and reception. Higher isolation between antennas reduces the coupling between them, making it easier to estimate the individual channel characteristics accurately. This enables more effective beamforming and spatial multiplexing techniques, further improving system performance. With sufficient isolation between antennas, MIMO systems can be deployed in closer proximity without causing interference.

This flexibility allows for more compact and cost-effective antenna configurations, making MIMO technology suitable for a wide range of applications, including indoor wireless networks, cellular communication systems, and wireless backhaul links. MIMO systems exploit spatial diversity to enhance signal reliability and robustness against fading and other channel impairments. Higher antenna isolation ensures that each antenna receives a distinct signal path, maximizing the diversity gain and improving system resilience in challenging propagation environments.

II. ANTENNA GEOMETRY

The proposed antenna design features a hexagonal radiator with iterative fractal geometry, complemented by a transmission line feed to allow for flexible fractal pattern cutting on the patch surface. The dimensions of the feedline are meticulously calculated to ensure optimal performance. Utilizing a substrate Fr4 epoxy material that is 1.6 mm thick, the antenna is Simulated for efficiency and durability.

Incorporating fractal geometry, a hexagonal patch is selected as the foundation, with a hexagonal slot introduced onto the patch to initiate the first iteration of the structure. To further enhance performance, a copper rectangular plane is strategically placed between the antenna ports, effectively reducing isolation and improving overall signal integrity.

The iterative process involves scaling down the first iteration to achieve the desired third iteration structure, ensuring optimal size and performance. This third iterative structure is then inserted within the hexagonal slot of the preceding iteration, maintaining a minimal gap between radiating elements to prevent unnecessary enlargement of the antenna size.

By integrating a copper rectangular plane between ports, interference and crosstalk are minimized, enhancing the antenna's capability to handle multiple input and output signals efficiently. This innovative design approach not only improves isolation but also contributes to the antenna's overall effectiveness in various communication applications.

The copper rectangular plane between the ports helps improve isolation by reducing electromagnetic coupling between adjacent ports. This can lead to better performance in terms of minimizing interference and crosstalk.

Table: Parameters of antenna

Parameters	Value(mm)
Substrate length (SL)	30
Substrate width (SW)	30
feed length (FL)	14
feed width (FW)	2
Height(H)	1.6
SL1	26
SL2	22
SL3	18
SW1	26
SW2	22
SW3	18

A. Design Steps for 4 Port mimo Fractal Antenna

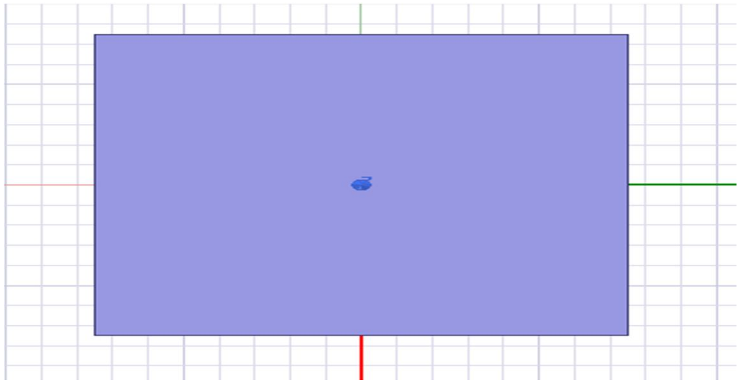


Fig 1 : create a box with substrate material

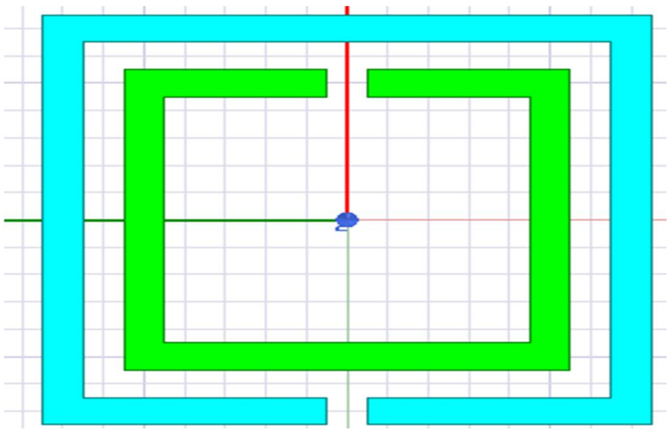


Fig 2: Design ground plane

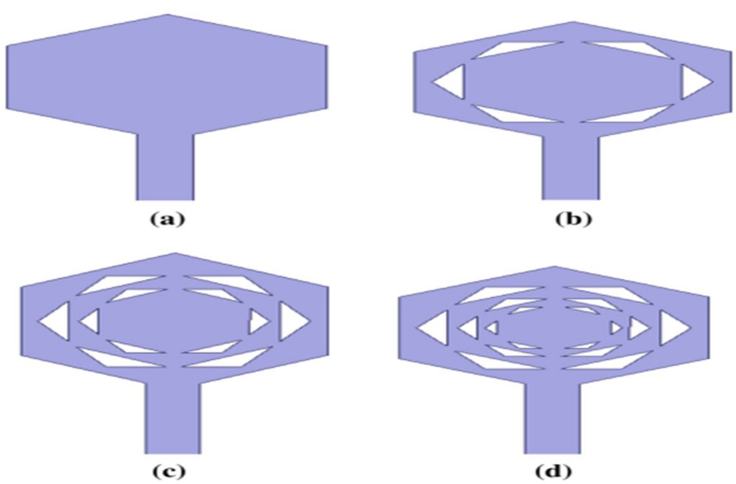


Fig 3: design Fractal antenna
(a) 0^{th} iteration
(b) 1^{st} iteration
(c) 2^{nd} iteration
(d) 3^{rd} iteration

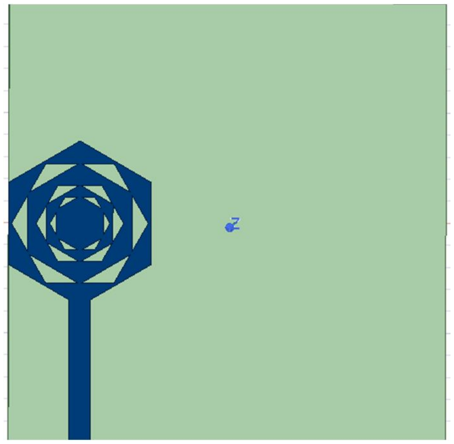


Fig 4: design port 1 antenna

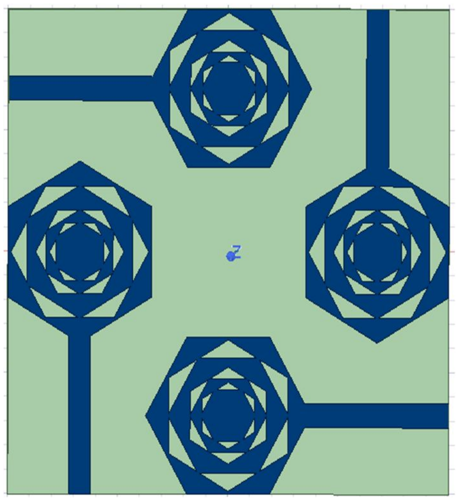


Fig 5 : design port 2,3,4 antennas

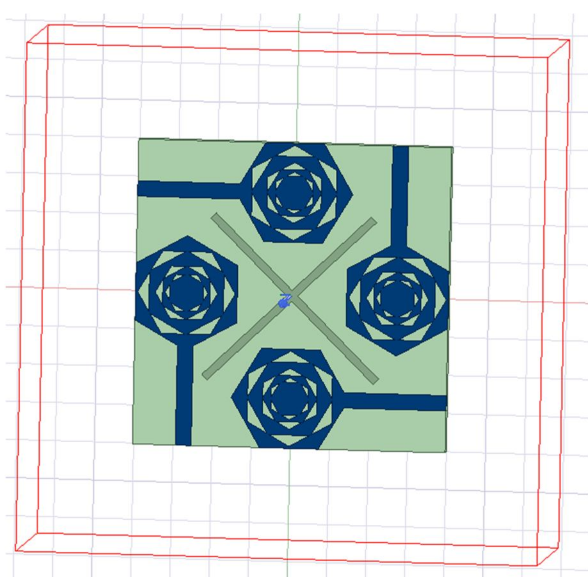
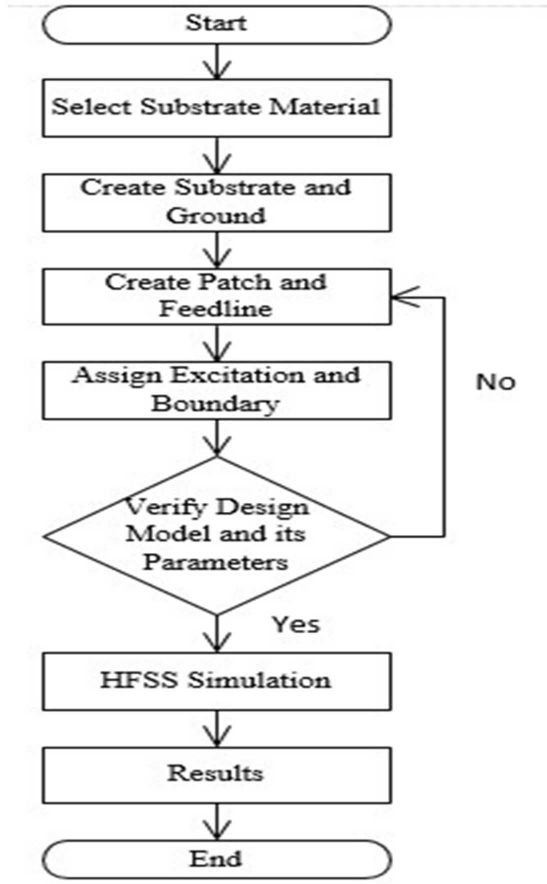


Fig 6: design rectangular plane between 4 port MIMO antenna and create radiating

B. Flow chart for Design Antenna



III. RESULTS

A. Without Copper Rectangular Plane

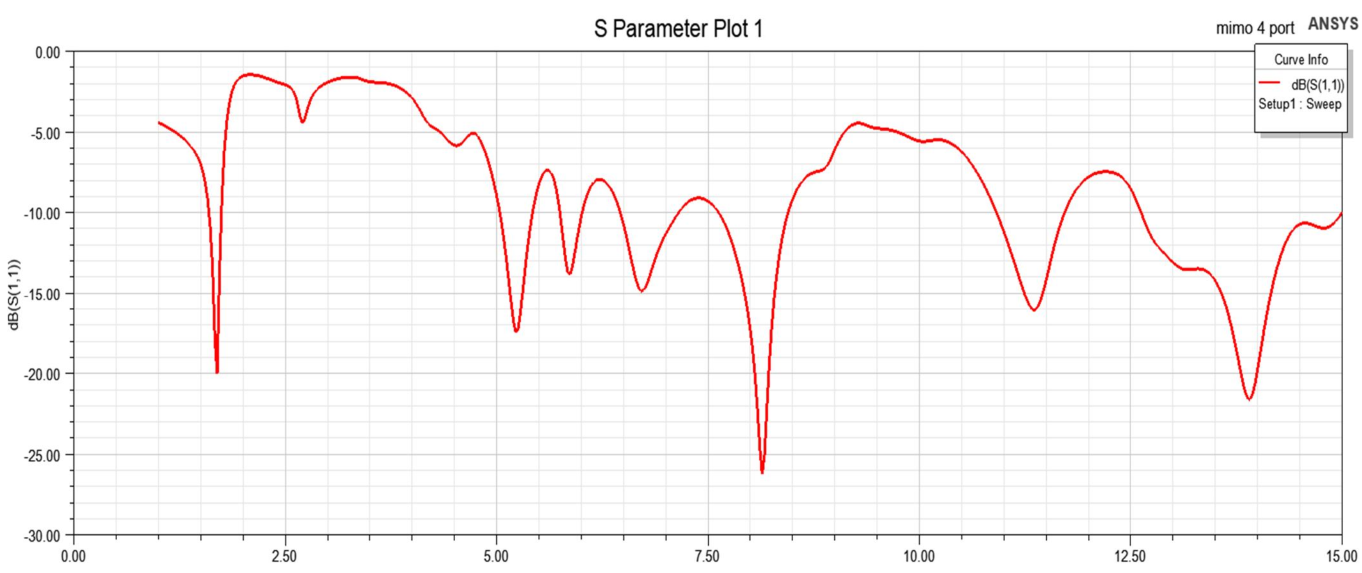


Fig 7:Return loss S(1,1)

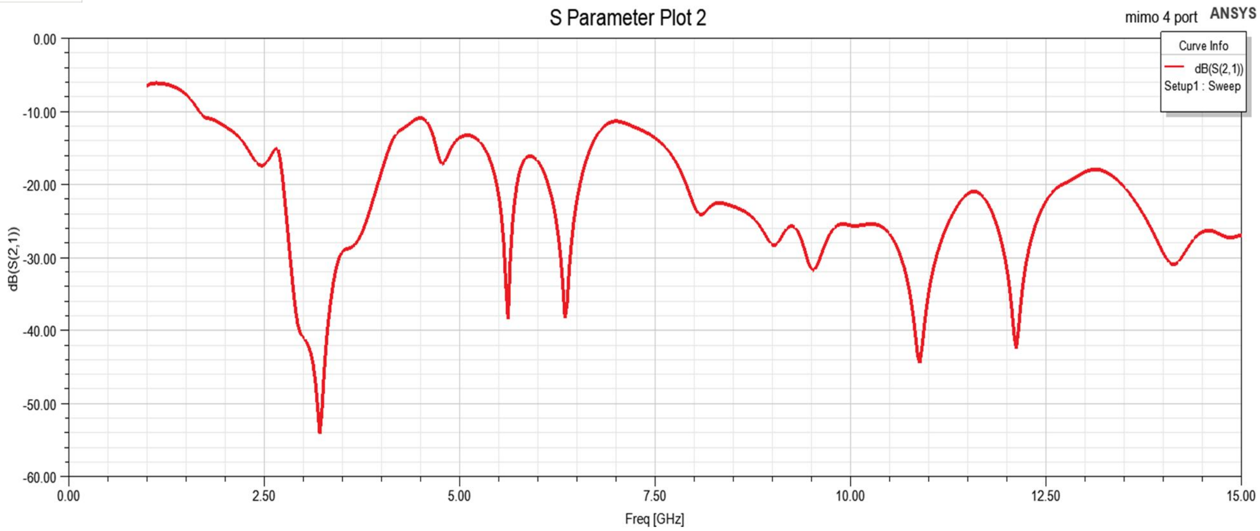


Fig 8: Return loss S(2,1)

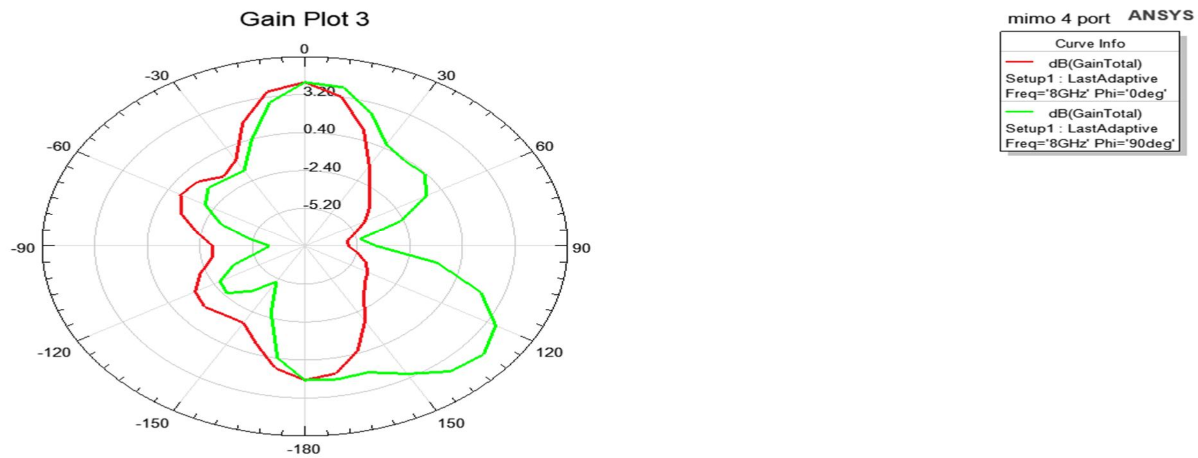


Fig 9: Gain

B. Using Copper Rectangular Plane

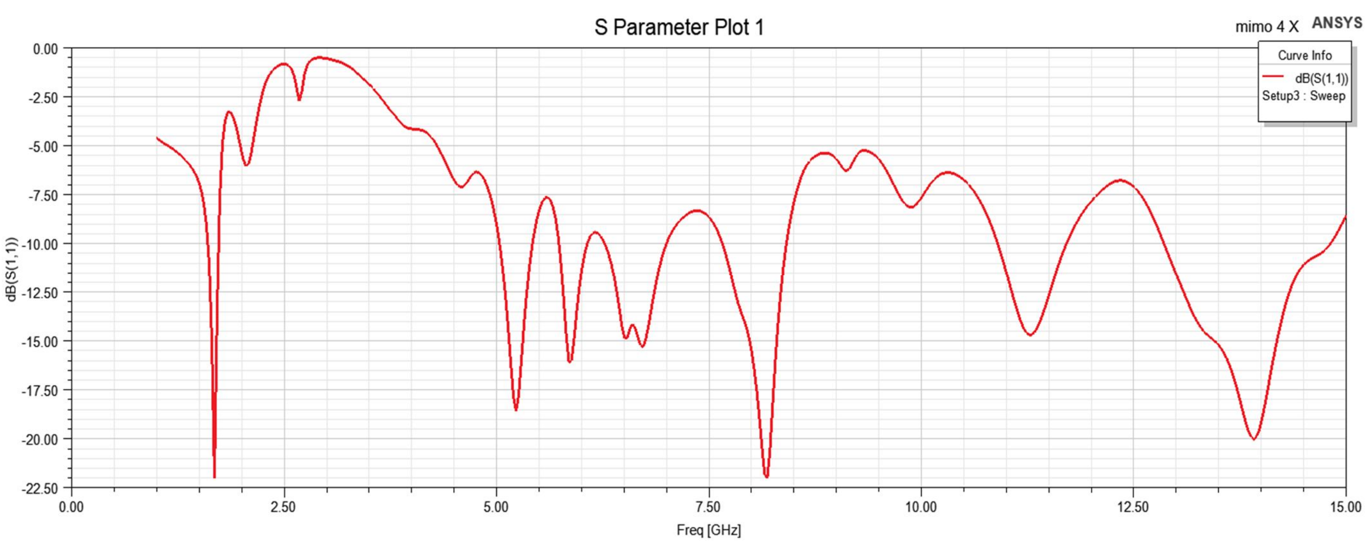


Fig 10:Return loss S(1,1)

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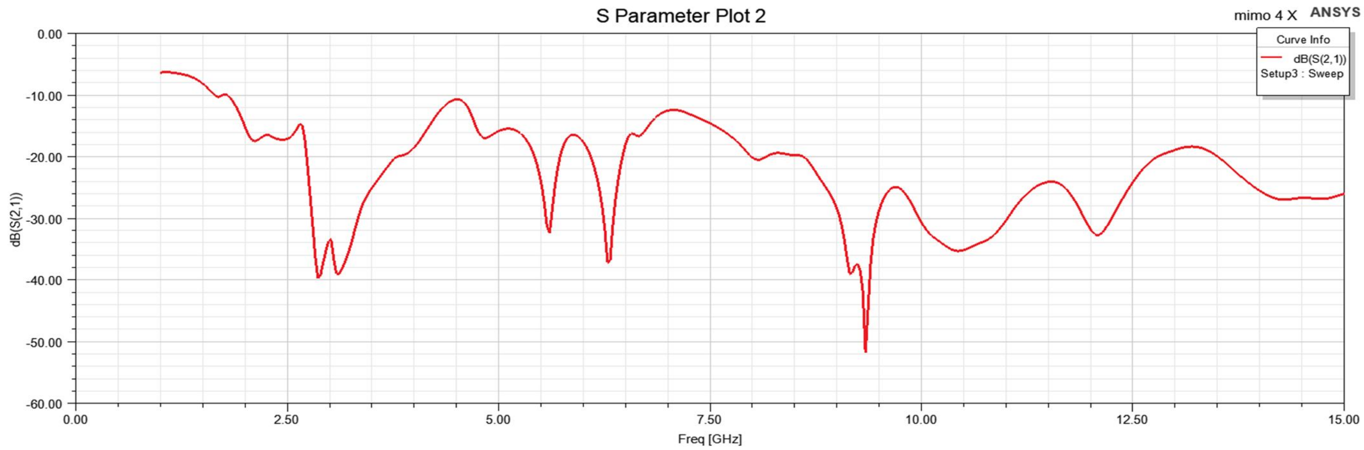

Fig 11:Return Loss S(2,1)

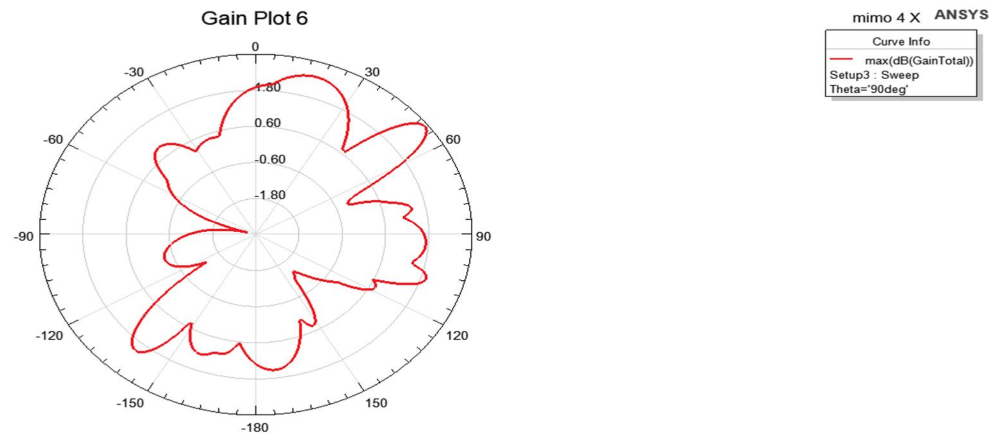

Fig 12: Gain

IV. CONCLUSION

UWB MIMO 4-port fractal antenna is an antenna designed to operate across a wide range of frequencies, support multiple input/output channels simultaneously, and have a compact size thanks to its fractal geometry-inspired design. This type of antenna would be well-suited for wireless communication systems that require high data rates, reliability, and flexibility in challenging environments. UWB MIMO Antenna structure Mutual coupling between the four radiating elements is obtained to be less than - 25 db. The patterns of radiation are stable over the operating range and a peak gain of 4.5 dB is obtained at 7.5GHz and Return loss is obtained less than 10dB. Simulation is conducted using HFSS simulation tool and printed on a 30 X 30 X 1.6 mm^3 FR4 material. 4 linear SRR structures are used between adjacent elements to ensure good isolation. The inclusion of a rectangular copper plane in a 4-port fractal MIMO antenna ensures effective isolation, which plays a vital role in boosting data rates, expanding capacity, enhancing signal quality, and fortifying system reliability in modern wireless communication systems, especially when compared to 4-port fractal MIMO antennas lacking this feature.

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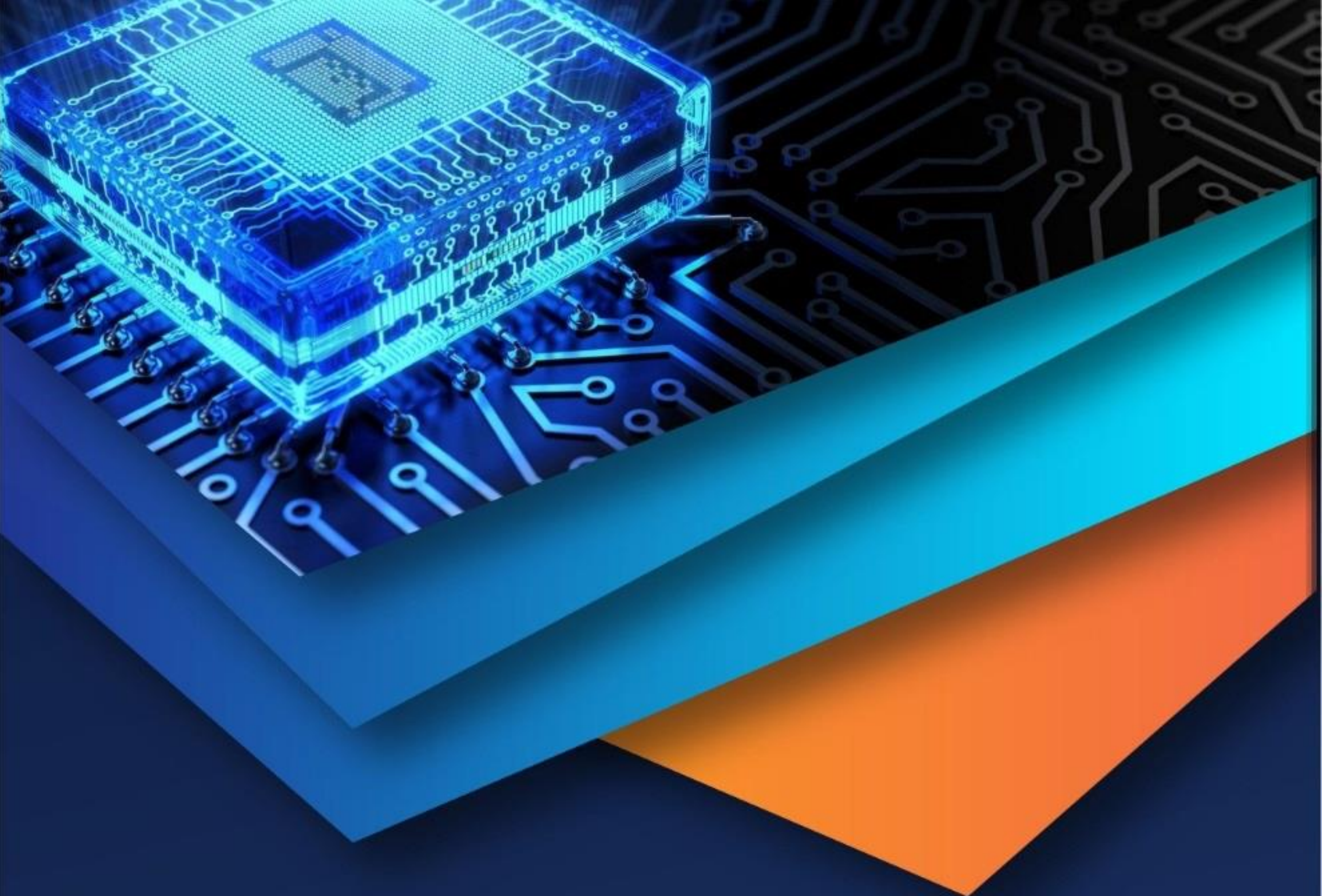

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