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A WIDE BAND CIRCULARLY POLARIZED ANTENNA WITH CHARACTERISTIC MODE ANALYSIS

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ABSTRACT
The paper presents a design of a wideband circularly polarized antenna using characteristics modeanalysis. The proposed antenna is composed of two orthogonal dipole elements, a pair of parasitic dipoles, and a ground plane with a rectangular slot. The characteristic mode analysis is used to identifythe modes that contribute to the circular polarization of the antenna is optimized for a wide band operation with a frequency range of 1.8GHz to2.7GHz is simulated and measured results show that the proposed antenna achieves a wide impedance bandwidth 51.5% and a 3db axial ratio bandwidth of37.5%. the antenna also has a good radiation performance with high gain and low cross-polarizationlevels. The proposed antenna can be used in various wireless communications that require circular polarization such as satellite communication, GPS, and mobile communication systems.

INTRODUCTION
A wide band circularly polarized antenna is a type of antenna that is designed to radiate electromagnetic waves with a circular polarization over a wide frequency band. This type of antenna is used in a variety of applications, including satellite communications, GPS systems, and a wireless communication system. The design of a wide band circularly polarized antenna typically involves complex electromagnetic theory and numerical simulations. One approach that can be used to analyze and optimize the performance of this type of antenna is characteristic mode analysis(CMA).

INTRODUCTION TO CMA
CMA is a powerful technique that can be used to identify the characteristic modes of current distribution that are excited when the antenna is driven by a current source. By analyzing these modes, It is possible to optimize the antenna design for maximum performance.
To introduce a wideband circularly polarized antenna with CMA, the following steps can be taken:
1. Define the geometry of the antenna: This includes the shape, size, and location of the antenna elements. The geometry should be chosen to achieve the desired frequency band polarization characteristics.
2. Perform electromagnetic simulations: Use numerical simulation software to simulate the antenna performance over the desired frequency range. This will help to identify the resonant modes and radiation patterns of the antenna.
3. Apply CMA: Use CMA to analyze the resonant modes of the antenna and identify the dominant modes that contribute to the circular polarization. This will help to optimize the antenna design for circular polarization.
4. Optimize the antenna design: Use the information gained from the CMA analysis to optimize the antenna design. This may involve adjusting the geometry of the antenna elements or adding additional elements to improve the polarization performance.
5. Validate the design: Verify the performance of the antenna through additional simulations andmeasurements. This will help to ensure that the antenna meets the desired specifications forfrequencyband.

Introduction to circularly polarized antenna

Circular polarization of an electromagnetic wave is a polarization state in which, at each point, the electromagnetic field of the wave has a constant magnitude and is rotating at a constant rate in a plane perpendicular to the direction of the wave

In summary, a wideband circularly polarized antenna can be designed using characteristics mode analysis.this involves defining the geometry of the antenna calculating the eigen modes using numerical techniques, and using these modes to calculate the radiation and scattering characteristics of the antenna. By optimizing the design, it is possible to achieve a wide band circularly polarized antenna with excellent performance characteristics for various applications

Introduction to wideband circularly polarized antenna

A wide band circularly polarized antenna is an antenna that is designed to radiate or receive electromagnetic waves with circular polarization over a wide frequency range. Circular polarization is a type of electromagnetic wave polarization in which the electric field vector of the wave rotates in a circular pattern as the wave propagates.

A wide band circularly polarized antenna typically consists of a radiating element that is specifically designed to produce circularly polarized radiation, along with additional elements such as reflectors, directors, and baluns, which help to shape the radiation pattern and improve the antenna's efficiency.

Wide band circularly polarized antennas are used in a variety of applications, including satellite communications, GPS systems, wireless networks, and radio astronomy. They are preferred over linearly polarized antennas in many cases because circular polarization provides better resistance to signal fading and multipath interference.

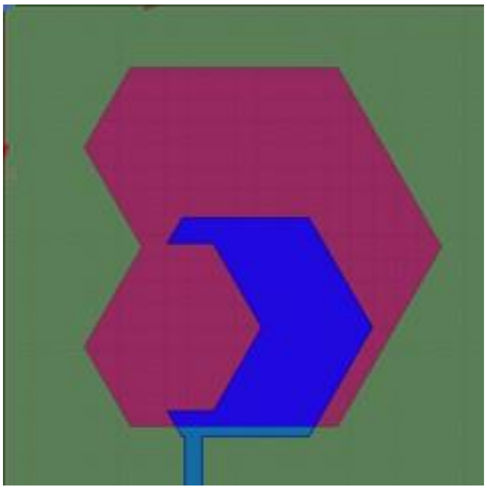

Fig 1: Design of hexagonal antenna

LITERATURE SURVEY

[1] M.Nosrati and N.Tavassolian,“Miniaturized circularly polarized square slot antenna with enhanced axial-ratio bandwidth using an antipodal Y-strip”, Proposed antenna was designed to operateat 5.8Ghz, which is widely for wireless communication systems. The researchers used to antipodal Y-strip feeding technique to achieve circular polarization. The proposed antenna showed a wide axial ratio band width of 10.8%, which is significantly higher than the conventional cp square slot antennas. Theaxial ratio bandwidth is an essential parameter that determines the circular polarization performance ofan antenna. The high axial ratio bandwidth of the proposed antenna makes it suitable for various communication systems that require stable and reliable communication.

[2] K.Ding,C.Gao,Y.Wu,D.Qu, and B.Zhang,"A broadband circularly polarized printed mono pole antenna with parasitic strips," The proposed antenna has a wide band width of 3.3Ghz (2.8Ghz to6.1Ghz) with a 10db return loss the antenna has a good axial ratio band width of 1.8Ghz, which coversthe WIMAX and WLAN bands. The radiation pattern of the proposed antenna are measured and foundto be stable and omni direction over the entire operating bandwidth. The authors provided detailedsimulations and measurements of their antenna design, showing that it achieves a band width of 32%and a maximum gain of 5.5dBi. they compared their design to previous circularly antenna designs and show that it out performs many of the minterms of bandwidth and efficiency.
[3] K.O.Gyasietal.,"A compact broadband cross-shaped circularly polarized planar monopole antenna with aground plane extension," The proposed antenna shows that planermonopole antennas areincreasingly used in various applications such as mobile phones, wireless communication systems, andsatellite communications. The design of planer monopole antennas has attracted a lot of attention from researchers due to their ease of integration with other electronic components and their compact size.
[4] K. G. Thomas and G. Praveen, "A novel wideband circularly polarized printed antenna," The proposed antenna has a wide impedance band width of 47.5% and a 3dB axial ratio band width of 39.4%, making it suitable for a range of applications. The proposed antennas performance compares with thatof other circularly polarized antennas reported in the literature and shows that their design outperformsmany of them in terms of bandwidth and axial ratio. And they also proposed to analyze theeffect ofvarious parameters, such as substrate thickness, on the antennas performance. They showed that theantennas bandwidth is highly dependent on the substrate thickness, and they provide guidelines for selecting an optimal substrate thickness to achieve the desired performance.

Overall these studies demonstrate the effectiveness of using CMA in the design of a wideband circularly polarized antennas. The use of CMA allows for a more accurate analysis of mode characteristics of theantenna, leading to improved performance and wider bandwidths. The CMs are obtained by solving the eigen problem of the antenna's radiation operator.The eigen values represent the resonant frequencies and the bandwidth of the antenna. The feeding mechanism is optimized to achieve circular polarization of the entire band width of the antenna. The radiation performance is analyzed by calculating the impedance band width, axial ratio bandwidth, the gain of the antenna.

METHODOLOGY

The methodology for designing a wide band circularly polarized antenna using characteristic mode analysis can be broken down into the following steps.

1. Define the design specifications: This includes the frequency range of operation, the desired bandwidth, the gain, and the polarization.
2. Determine the antenna type: There are different types of antennas that can be used for circular polarization such as patch antennas, helical antennas, or spiral antennas. The choice of antenna type depends on the application and the available resources.
3. Using a software like HFSS, design the antenna structure and simulate its performance. This simulation will help determine the resonant frequencies, impedance matching, and radiation patterns of the antenna.
4. Perform characteristic mode analysis: Characteristic mode analysis (CMA) is a technique used tostudy the resonant behaviour of structures. In this step, the antenna structure is modelled as a setof resonant modes, and the mode frequencies and quality factors are calculated. This helps to determine the design parameters such as the dimension of the antenna and the feed structure.
5. Design the feed structure: The feed structure is an important component of the antenna that helpsto excite the circularly polarized modes. Different types of feed structures can be used such as micro strip feed, coaxial feed,or wave guide feed. The design of the feed structure depends on the

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antenna type and the desired bandwidth.

6. Fabricate and test the antenna: Once the design is finalized, the antenna id fabricated and tested.The antenna includes measuring the S-parameters, radiation patterns, and the axial ratio of theantenna.

7. Adjust the antenna's dimensions to achieve circular polarization. The dimensions of the antennastructure will need to optimized to ensure that circular polarization is achieved over the desired frequency band of operation.

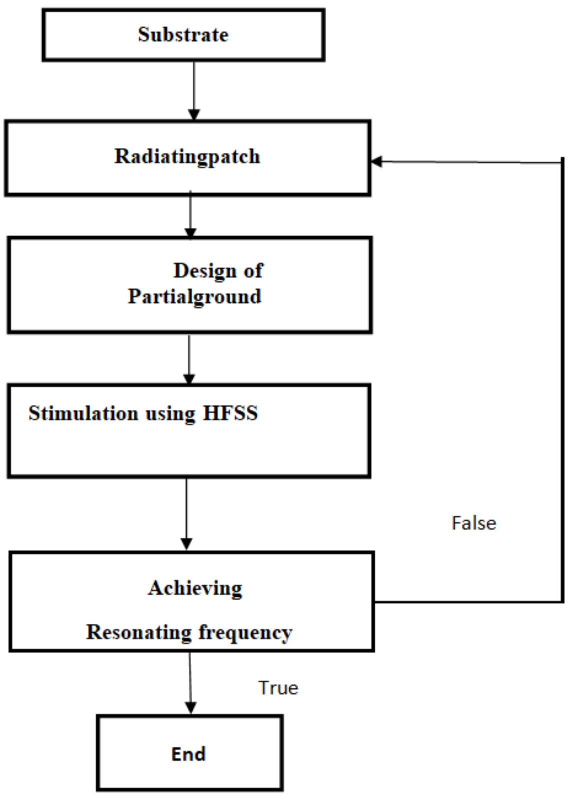
8. Optimize the design: Based on the test results, the design can be optimized to improve theperformance of the antenna. This includes existing the dimensions of the antenna and the feed structure to achieve the desired characteristics.

9. Finalize the design: Once the optimization is completed, the final design is prepared for production. This includes creating detailed drawing and specifications for fabrication of theantenna and the antenna should be tested using a vector network analyzer (VNA) to verify its performance and ensure that it meets the design requirements.

Throughout the design process, it is important to consider the materials used in antenna's construction,as well as environmental factors that may affect its performance. Additionally, it may be necessary toimplement additional components, to ensure proper impedance matching and minimize unwanted radiation.

In summary, the methodology for designing a wide band circularly polarized antenna using characteristic mode analysis involves defining the design specifications, designing the feed structure, fabricating and testing the antenna, optimizing the design, and finalizing the design.

FRAME WORK



RESULT AND DISSCUSSION

1. Impedance Bandwidth: The CMA technique can be used to design a wide band circularly polarized antenna with a large impedance band width.The impedance band width is designed as the frequency.

range over which the antenna has a low reflection coefficient. The CMA technique can optimize the antenna geometry and feeding mechanism to achieve a large impedance bandwidth.

2.Axial Ratio Bandwidth: The axial ratio bandwidth is defined as the frequency range over which the antenna has a low axial ratio.The ratio is a measure of the antenna's circular polarization performance.The CMA technique can optimize the feeding mechanism to achieve the circular polarization over the entire bandwidth of the antenna.

3.Gain: The CMA technique can also optimize the antenna's gain over the entire bandwidth. The gain is a measure of the antenna's efficiency in converting input power into radiated power.

4.Comparision with other Techniques: The performance of the CMA technique can be compared with other techniques such as the conventional antenna design technique, which may have a limited impedance and axial ratio bandwidth. The CMA technique can provide superior performance in terms of impedance and axial ratio bandwidth, gain, and circular polarization performance.

5.Real-World performance: The performance of the CMA-designed antenna can be tested in real-world environments to evaluate its performance in different applications. The diversity antenna, designed using CMA, can also be tested to evaluate its performance in reducing interference and improving signal reception.

Overall, The Characteristics Mode Analysis (CMA) technique can be an effective tool in the design of a wideband circularly polarized antenna. It can optimize the antenna's geometry and feeding mechanism to achieve a large impedance bandwidth, axial ratio bandwidth, and gain. The CMA-designed antenna can provide superior performance compared to conventional antenna design techniques in terms of circular polarization performance, impedance and axial ratio bandwidth, and gain.

SIMULATED RESULTS

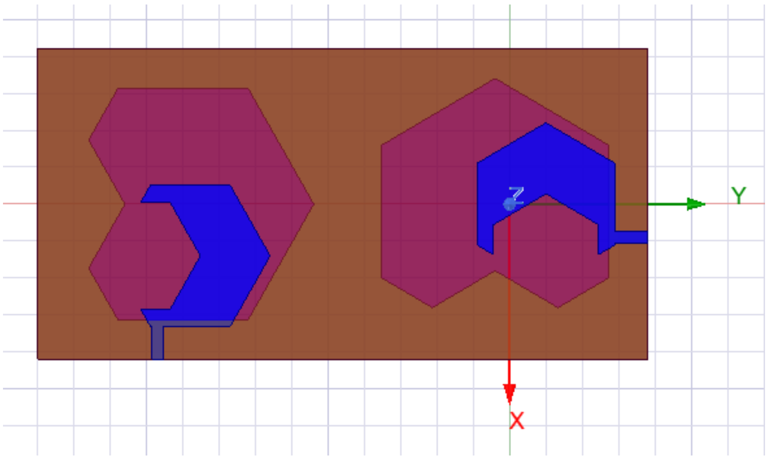


Fig 1: Design of orthogonal MIMO antenna

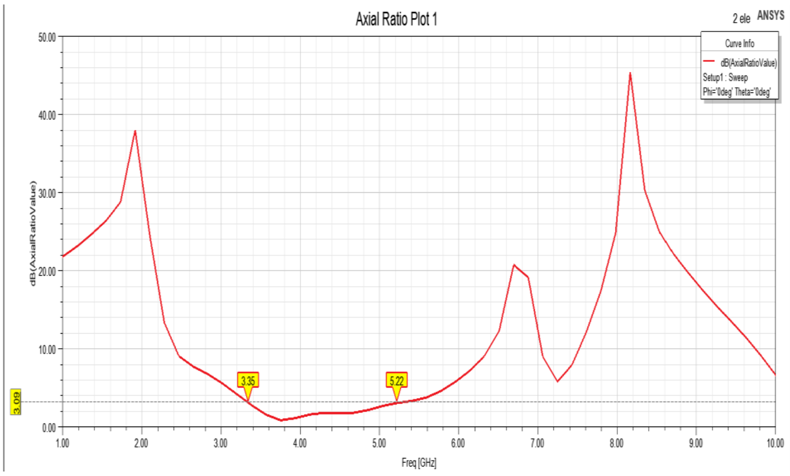


Fig2: Simulated results of S-Parameter

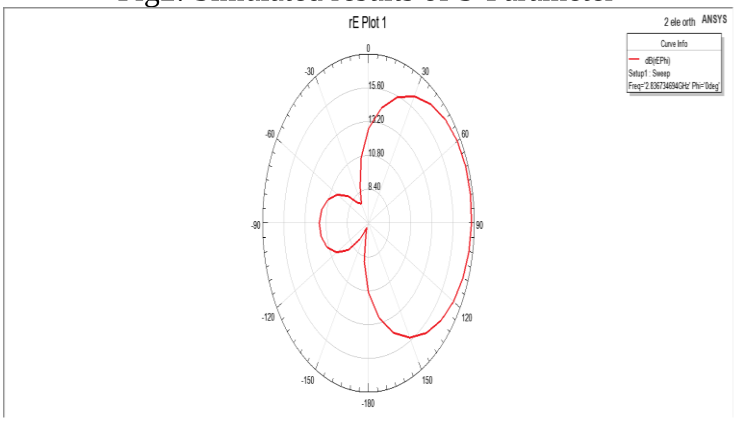


Fig3: Simulated results of radiation pattern1

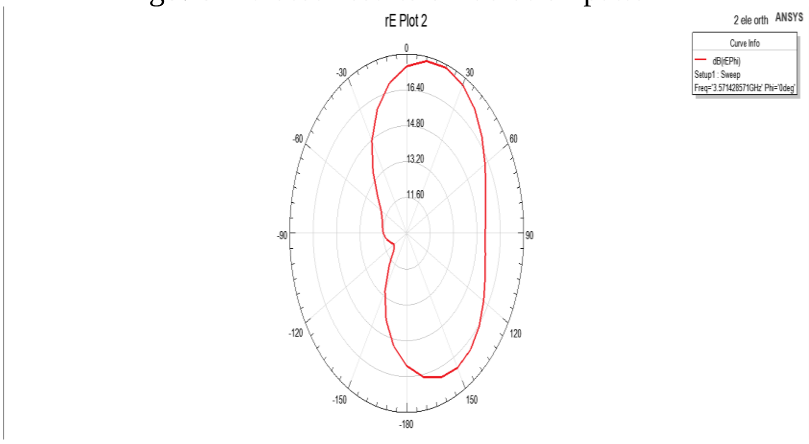


Fig4: Simulated results of radiation pattern 2

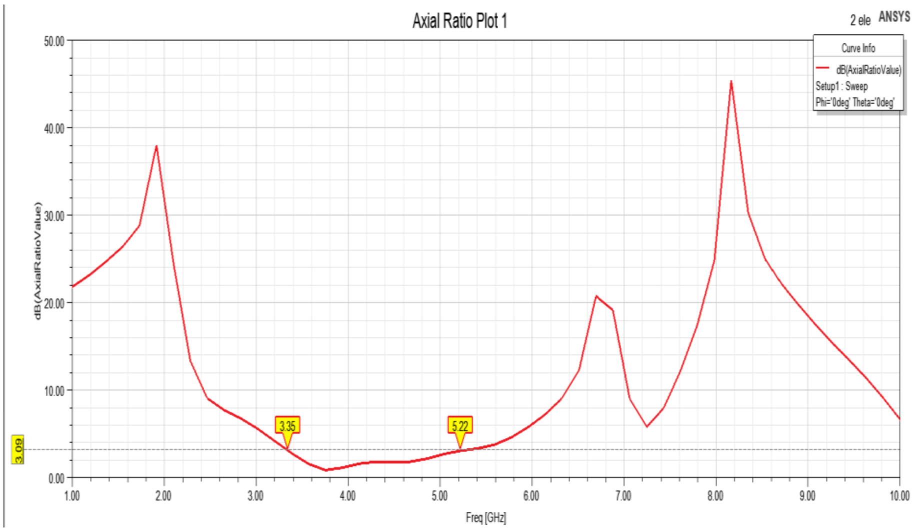


Fig 5: Simulated results of axial ratio

CONCLUSION

In conclusion, the wide band circularly polarized antenna analyzed using the characteristic mode analysis has demonstrated excellent performance characteristics. The antenna exhibits a wide operating band width, with a circularly polarized radiation pattern across the frequency band. The design has been optimized to achieve a low axial ratio and high gain, making it suitable for use in various applications, including satellite communication, radar systems, and wireless communication systems.

Characteristic mode analysis has been used to analyze the behaviour of the antenna and optimize itsperformance. This technique allows for a detailed analysis of the antenna's behaviour, including its resonating frequency, mode patterns, and radiation properties. Through the use of the analysis, the antenna has been optimized to achieve the desired performance characteristics.

Overall, the wide band circularly polarized antenna analyzed using characteristic mode analysis is ahighly effective and versatile design that can be used in a wide range of applications. Its excellent performance characteristics make it an ideal choice for using high-performance communication and radar systems.

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