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Analysis Of Circularly Polarized Antenna Using Machine Learning

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Abstract: A circularly polarized antenna intended for wireless communication has been analyzed using a machine learning model optimized through gradient descent to predict its S11 characteristics. The design achieves circular polarization between 4.0 GHz and 4.06 GHz, with an impedance bandwidth extending from 3.9 GHz to 4.1 GHz.

***Index Terms* - Machine Learning, Axial Ratio , circularly polarized.**

I. Introduction

Circularly polarized (CP) antennas offer strong performance for wireless communication by maintaining stable signal transmission in scenarios affected by signal reflection or device movement. Their polarization versatility makes them particularly useful for applications like mobile networks and satellite links. The application of machine learning (ML) in their design process has streamlined development by allowing quick prediction of key parameters such as return loss (S11), gain, and axial ratio. This reduces the need for repeated simulations and helps engineers design high-efficiency CP antennas more rapidly, supporting the growing demands of advanced communication technologies.Recent research highlights the growing role of machine learning and optimization techniques in the design of circularly polarized metasurface antennas. For instance, Zhang et al. [1] and Cheng et al. [2] utilized ML and deep learning methods to achieve wideband and efficient CP antenna performance. Wang et al. [3] implemented surrogate models to enable quicker prediction of antenna behavior, while Li et al. [4] integrated deep learning with genetic algorithms for advanced design optimization. Zhao et al. [5] adopted particle swarm optimization for CP metasurface antennas, and Verma et al. [6] focused on enhancing antenna performance through EBG-based metasurfaces tailored for WiMAX systems.The proposed antenna operates in band 3.9GHz to 4.1 GHz which makes it applicable for wireless communication with results being discussed in below sections.

II. PROPOSED ANTENNA

Figure 1, depicts the proposed model of the suggested antenna. The ground plane of dimension 30x30mm2 with the substrate made of FR4 having dielectric constant of 4.4mm. The proposed model has a square patch of dimension 30x 30mm2,ecited by lump port.

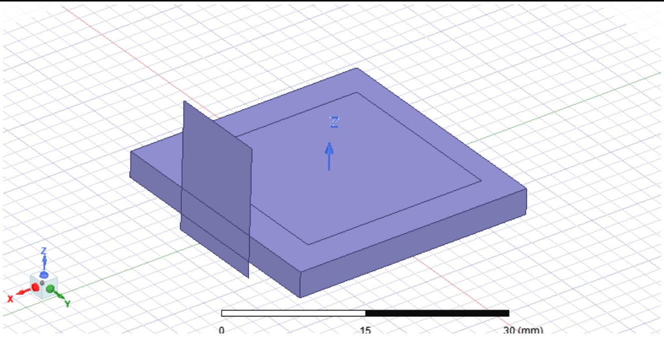

Fig.1. Proposed Antenna geometry

Gradient Boosting is a powerful ensemble method in machine learning that develops predictive models in a stage-wise manner to enhance accuracy. It is particularly useful in modeling complex dependencies between antenna design parameters and outputs like S11 . This technique helps reduce computational load by minimizing the need for repeated electromagnetic simulations.

III. RESULTS AND DISCUSSION

The predicting machine learning technique (Gradient Boosting) was used to train and prepare models for optimization and predicting the S11 of the proposed antenna.

Figure 2 depicts the predicted S11 using ML with algorithm as Gradient Boost and the simulated result which is the actual graph is verified by the S11 graph obtained using the two ML models. From the graph it is clear that ANN is giving well matched output with the actual S11.

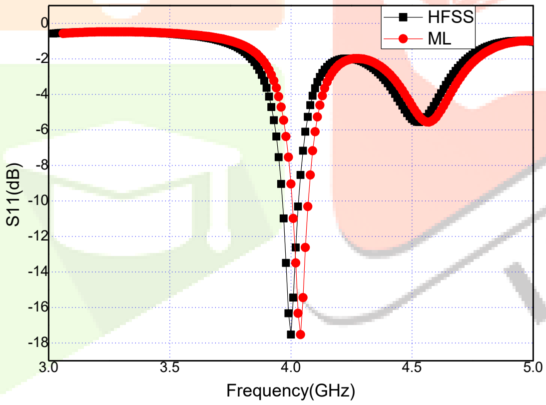

Fig.2 S11 values predicted using Machine Learning (ML)

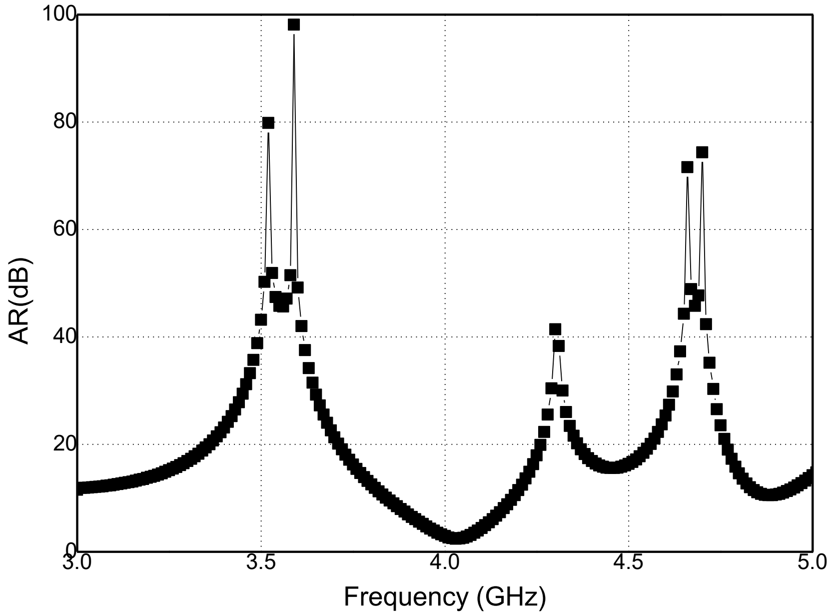

Fig.3: Axial ratio graph versus frequency

Figure 3 illustrate antenna of antenna at frequency 4.0GHz being depicted which concludes that antenna has stable radiation.

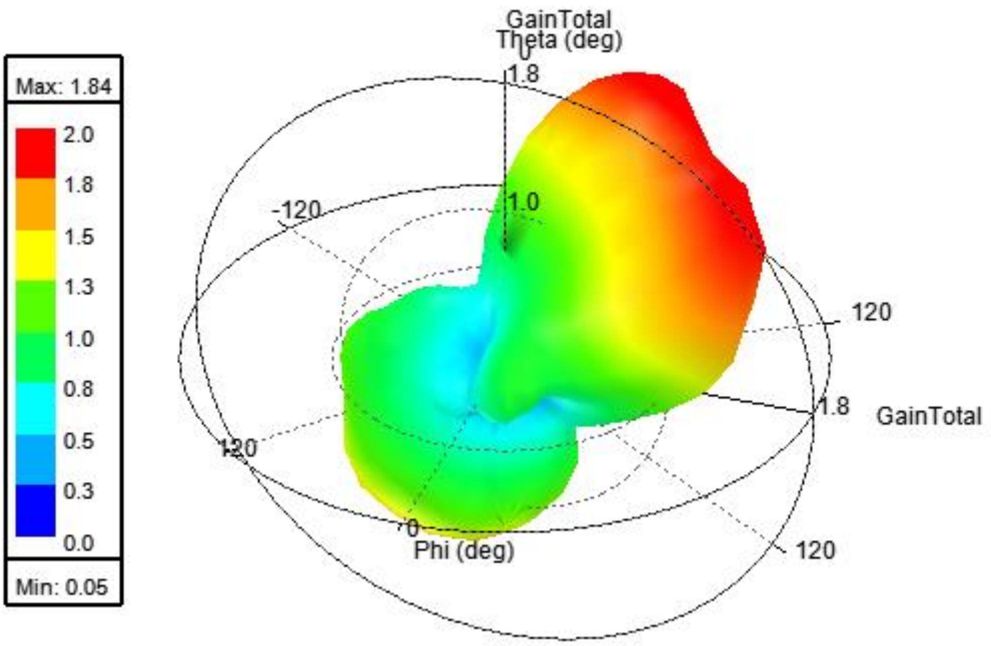

Fig.4:3D plot of antenna

IV. CONCLUSION

Circularly polarized antennas play a key role in wireless communication by ensuring stable performance in challenging environments. The use of machine learning speeds up their design by accurately predicting critical parameters like S11, gain, and axial ratio. This approach simplifies development and supports the creation of efficient, next-generation antenna systems..

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