

AI-Enabled Framework for Intelligent Dielectric Resonator Antenna System

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DOI: 10.29218/srmsmaths.v11i1.02	Abstract
Keywords: Artificial intelligence, Dielectric resonator antenna, Automation	The development and analysis of a rectangular dielectric resonator antenna for 5G novel radio applications are discussed in this work. This antenna has a central frequency of 4.5 GHz and works in the n-79 band. This antenna offers low latency, high speed, high fidelity and reliable communication. It will play a pivotal role in applications in automation, robotics, sensor networks and broadband internet. The potential of integrating an AI-driven system with traditional DRA design for 5G networks is highlighted in this study. we have proposed a conceptual artificial intelligence framework which discusses how we can incorporate AI in our antenna design to make it smarter.

INTRODUCTION

High-speed communication is necessary in today's rapidly expanding world to guarantee the lowest latency and enable extremely fast solutions. The dielectric resonator antenna (DRA), a front-end device with a low profile, minimal conductor losses, and high gain, is regarded as a cornerstone of communication systems. Compared to traditional microstrip antennas, DRA offers a number of benefits, such as increased radiation efficiency, broad bandwidth, and suitability for 6G communication.[1] Artificial intelligence has made our systems increasingly intelligent, and we can include AI into our antennas to make them intelligent as well. AI can be applied to interference reduction and beam steering. The design of a dielectric resonator antenna operating at 4.5 GHz is presented in this paper together with a conceptual framework for intelligent antenna systems enabled by artificial intelligence. strong radiation stability despite temperature drift, particularly at resonant frequency. Dielectric resonator antennas were initially developed by Professor S. A. Long in 1980 [2-5]. Since then, a lot of study has been done in this area, and other shapes, such as rectangular, spherical and cylindrical, etc., have been investigated. Rectangular DR antennas operating at their basic mode of operation were found to radiate like a magnetic dipole [6-10].

Antenna Structure

The proposed design is made up of a dielectric resonator antenna that is positioned on top of a substrate, with a ground plane that is positioned beneath it and has the same dimensions as the substrate to provide full coverage. Table 1 summarizes the design parameters for this design. RogersR03010 (tm) makes up the substrate. We use a microstrip line to feed our antenna, and we have a stub in the centre of our DRA. We used the Ansys HFSS (Ansys High Frequency Structure Simulator) 14.0 simulation software and the finite element method to calculate the resulting values. Fig. 1 shows our antenna design. The DRA is positioned on substrate and we have used microstrip-line for feeding it; Fig. (a) shows the antenna's side perspective, while Fig. (b) shows its top view.

The RDRA measures 9.3 mm by 9.3 mm. Because the back side of the substrate is printed with perfect electrical conductor, it functions as an infinite ground plane. Power is transmitted from the source to the antenna via a 47.7 mm x 10.6 mm microstrip line. The RDRA's exact shape and material are illustrated in Table 1.

Resultand Analysis

Fig.3.3 illustrates the plot of return loss versus frequency graph. We can interpret from the graph that this antenna operates around 4.5 GHz with narrow impedance bandwidth [11-12]

The frequency is marked on x axis whereas S₁₁ is marked on y axis of the graph and measured in dB, indicates that when the S₁₁ is minimum at around 4.5 GHz nearly around -20 dB hence it shows that antenna is good radiator.The VSWR versus frequency graph, which exhibits the ratio of incident to reflected voltages, is illustrated in Fig. 3.4. Although it should ideally be taken below 1, below 2 is more significant for some distortion-less practical input output.Frequency is measured on x axis, and VSWR is measured on y axis. From the above figure it shows that VSWR is minimum at around 4.5 GHz.

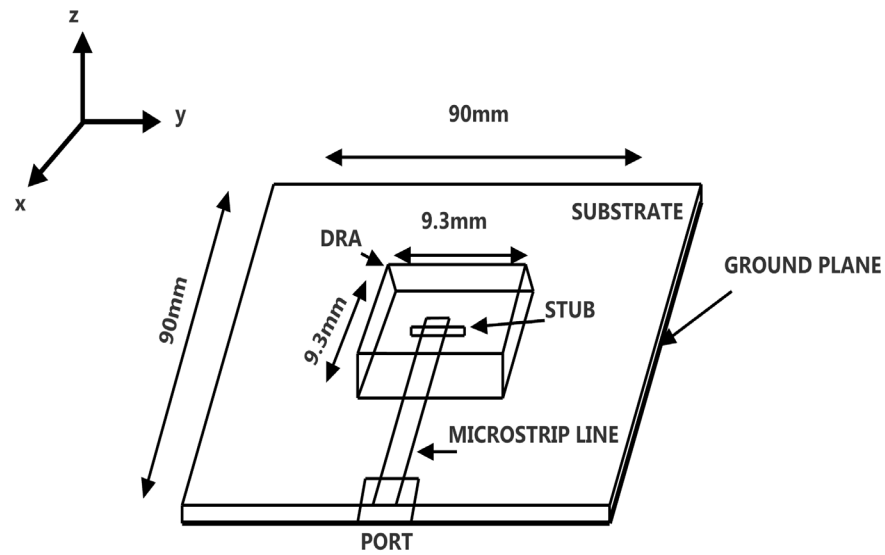


Fig. 1(a): Side views of the antenna

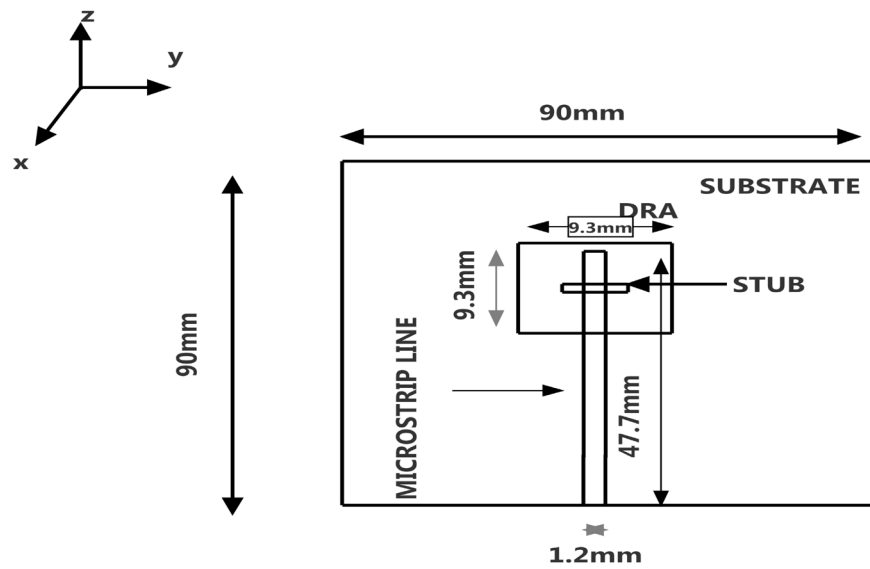


Fig. 1(b): Top view of the antenna

Table 1: Details of the Geometry and Material of the RDRA

Structure	Length	Width	Height	$\tan \delta$
Substrate	90 mm	90 mm	1.7 mm	0.0009
DRA	9.3 mm	9.3 mm	4.6 mm	0.0023
Stub	1 mm	6 mm	NA	0.0023
Microstrip Line	47.7 mm	10.6 mm (w)	NA	0.008

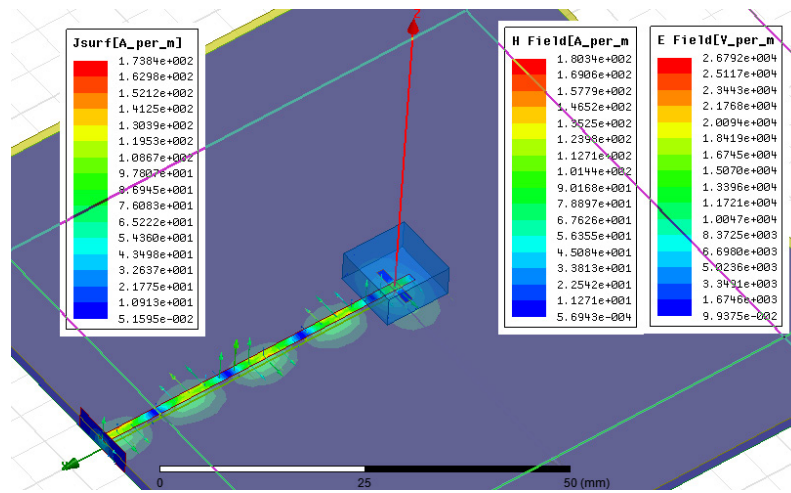


Fig. 2: The surface current density, E field, H-field

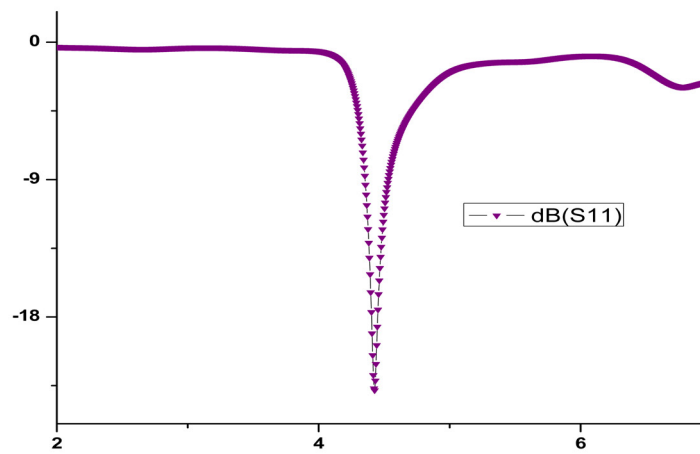


Fig. 3: S11 Vs. frequency

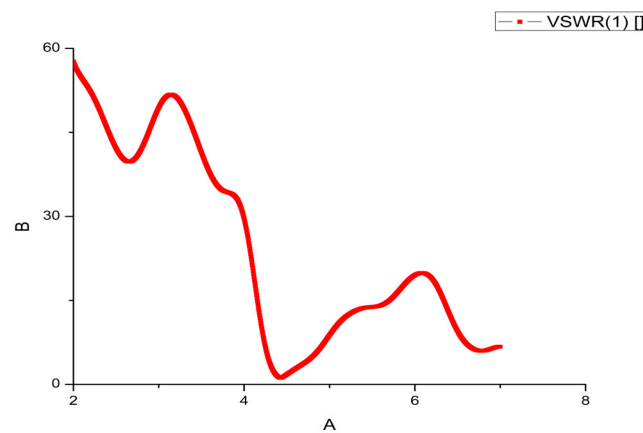


Fig. 4: VSWR versus frequency

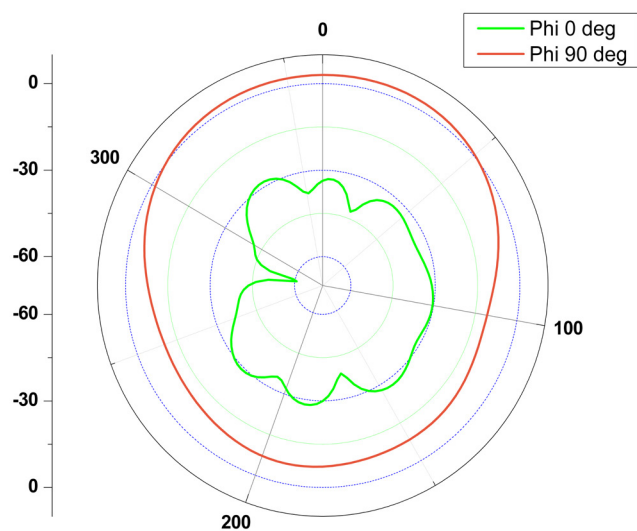


Fig. 5.1: (a) Co and Cross Polarization in H-Plane

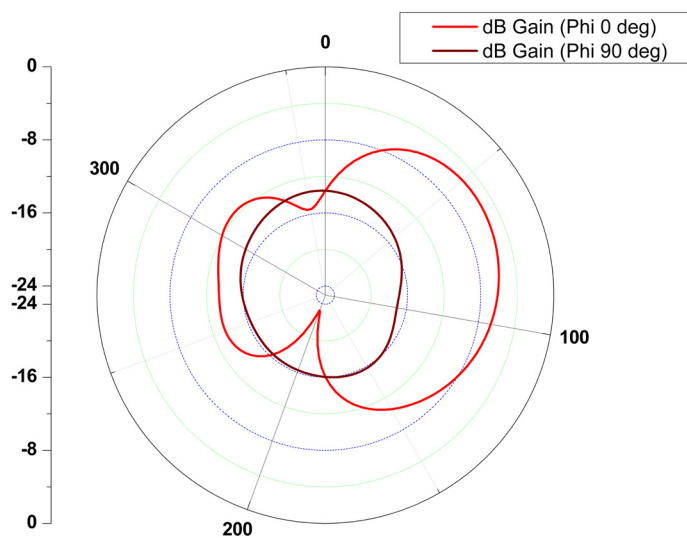


Fig. 5.1: (a) Co and Cross Polarization in H-Plane

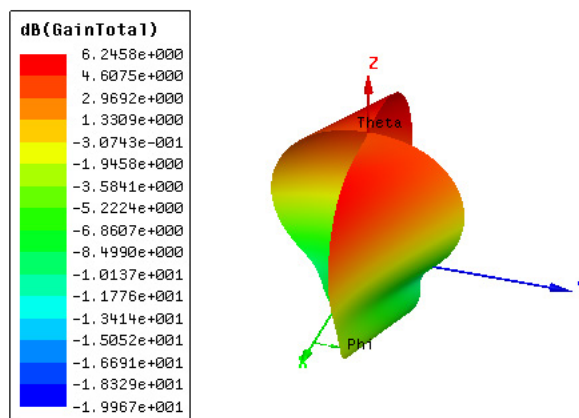


Fig. 6: Radiation pattern of the antenna (Gain in dB)

The radiation pattern and gain versus frequency graph can be observed in figure 3.5(a). At 4.5 GHz, there is a gain of 6.24dB. Cross and Co polarization of our antenna design are demonstrated in Fig. 3.5(b).

The radiation pattern generated by our antenna following the successful completion of our HFSS simulation is illustrated in the above figure. The primary lobe of radiation and fields are evident. The integration of AI approaches can improve the intelligence of antenna systems in the future, Signal phase and amplitude changes, received signal indicator (RSSI), and channel status data can all be analyzed by machine learning techniques. Electronic beam steering may also be aided by an array of additional elements, and AI is able to forecast the best phase excitation weights and dynamically steer the beam in the direction of the intended user. The suggested method is in line with developments in intelligent 5G and 6G communication networks; the AI integration improves adaptability at the system level without altering the antenna's fundamental construction. One of the most significant phenomena in any communication system is beam steering, which provides outstanding connection by utilizing AI to estimate weights and orient the beam toward the user's location.

Conclusion

An intelligent dielectric resonator antenna system is designed and simulated. This antenna operates at 4.5 GHz with a narrow impedance bandwidth. The operating frequency of 4.5 GHz is considered the sweet spot frequency for both coverage and capacity in 4G LTE and 5G New Radio applications. It is suitable for data-intensive applications, 4K/8K video streaming, and in AR/VR applications. This frequency band of operation exhibits less congestion compared to the 2.4 GHz and 5 GHz bands. This front-end device can interface with AI-based, high-data-driven applications for low latency. This design can be extended to an array format to improve its gain and dynamism in data-centric applications. conventional or old school antenna use to calculate adaptive weights to steer the beam but with the help of Artificial intelligence it would require less computation to calculate the weights as AI will predict the weights by itself to steer the beam.

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