Design and Optimization of Four Element Triangular Dielectric Resonator Antenna using PSO Algorithm for Wireless Applications

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Abstract
This paper portrays the design and optimization of a wideband four element triangular dielectric resonator antenna (TDRA) using PSO. The proposed antenna's radiation characteristics were extracted using Ansoft HFSS software. At a resonant frequency of 5-7 GHz, the four element antenna provides nearly 21 percent bandwidth and the optimized gives 5.82 dBi peak gain. The radiation patterns symmetry and uniformity are maintained throughout the operating bandwidth. for WLAN (IEEE 802.16) and WiMAX applications, the proposed antenna exhibits a consistent symmetric monopole type radiation pattern with low cross polarisation. The proposed antenna's performance was compared to that of other dielectric resonator antenna (DRA) shapes, and it was discovered that the TDRA uses a lot less radiation area to provide better performance than other DRA shapes and PSO optimized antenna increases the gain of the antenna

Keywords:
Wideband, WLAN, and WiMAX triangular dielectric resonator antenna (TDRA), Probe feed.

1. Introduction

Dielectric resonators are non metallic objects that perform the same functions as metallic cavities. With different excitation methods such as microstrip line, coaxial probe, aperture coupling, and co-planer waveguide feed, the DR can be used as a radiating element and act as a DR antenna. Dielectric resonator antennas (DRAs) come in a variety of shapes, including cylindrical, rectangular, and spherical. It has several appealing characteristics, including small size, low profile, high radiation efficiency, flexible feed arrangement, simple geometry structure, light weight, low cost, and a wide range of material dielectric constants, giving the antenna designer more flexibility[1][3][4]. When compared to rectangular and circular disc DRAs, triangular dielectric resonator antennas (TDRA) are smaller. For practical application of DRAs, bandwidth enhancement is a major design consideration. Several techniques exist to improve the bandwidth of DRAs, including changing the aspect ratio of the DRA, varying the dielectric constant of the material, sectoring and splitting of the basic structure using stacked DRAs and multi-segments, multi-element, and introducing an air gap between the ground and the DRA element. Inserting a low-dielectric material beneath a high-dielectric material improves bandwidth as well. Some DRA studies for monopole type radiation patterns have been reported in the literature [5]. Guha and Antar investigated multi-element cylindrical DRAs and half split hemispherical DRAs for monopole-like radiation patterns with wide bandwidth, and found that introducing a multi-element and splitting basic structure increased bandwidth. Similarly, with monopole radiation pattern investigated for bandwidth enhancement, four elements rectangular DRA excited with coaxial probe gives more percent bandwidth [2]. Furthermore, through simulation and experimentation for X-Band applications a three-element dual-segment TDRA with a monopole-like radiation diagram has been investigated.. By increasing the probe length, A half hemispherical DRA with array of slots has been introduced , a shift in resonance frequency has been observed, and it behaves like a monopole DRA[6]-[15].

In this paper the experimental studies and simulation of a four-element TDRA fed by a 50 V coaxial probe feed is presented. The proposed antenna array is simulated using Ansoft HFSS software, which is commercially available. For the proposed antenna, the simulation and measured results are in good agreement. When compared to single element TDRA and Four element TDRA , the four element antenna input characteristics show a significant increase in bandwidth. when the antenna is optimized using PSO it shows a great improvement in gain. The proposed antenna produces a monopole-

Manuscript received October 5, 2023
Manuscript revised October 20, 2023
https://doi.org/10.22937/IJCSNS.2023.23.10.9

like radiation pattern with a resonant frequency of 5-7 GHz over the entire bandwidth.

2. Literature Survey

. Keyrouz1 and D.Caratelli[1] The current literature overview of relevant methodologies for manipulating the circuital features and radiation parameters of dielectric resonator antennas is presented in this work (DRAs). The primary advantages of DRAs are thoroughly explained, as well as the most effective antenna feeding and size reduction strategies. Individual DRAs' realised gains are also investigated using advanced design strategies. This allows radio frequency (RF) front-end designers to choose from a variety of antenna topologies that will assist them achieve the desired antenna performance in terms of frequency response, gain, and polarisation. The progress made in the application of DRA technology is examined.
Khalily, Mohsen[15], and others For wideband circular polarisation, introduce a new dielectric resonator antenna (DRA) (CP). A CP mode is induced by loading two unequal inclined slits on the square DR's diagonal. The impact of changing the slit length ratio on CP and impedance characteristics is investigated. A suitable tapered strip is used to excite the DR, which is coupled to the input microstrip line on one side and matched by a chip resistor on the other. The position of the excitation and matching lines, as well as the impedance of the chip resistor, are carefully tuned as critical parameters to adjust and improve the CP. The proposed architecture provides a bandwidth of roughly (21-25) percent about 5.8 GHz, gain between 5 and 6 dBi, for an optimized one and a relatively small and easy-to-fabricate feeding network.

PSO Algorithm

Optimization algorithms are used for optimization. We chose PSO because of its unique characteristics. The set of rules is an improvised collection of rules that can be used to solve hard-to-solve problems in a variety of settings. The policies are based on the social interaction between unbiased detritus, for a specified period of time, as they are an enhanced set of regulations. Every term has a position vector x that represents the capacity answer. Every term's changing pace represents a resource in a pace vector v. Every term preserves the route of that term's best function, which is linked to the good health it has achieved thus far via vector p. Brilliant performance among the debris received up to this time in the populace is saved to the tune of pg.

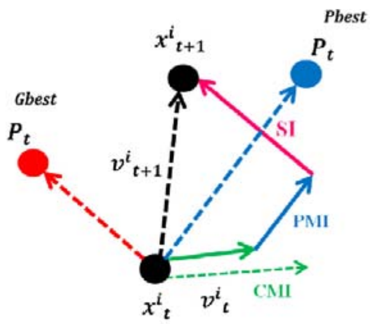
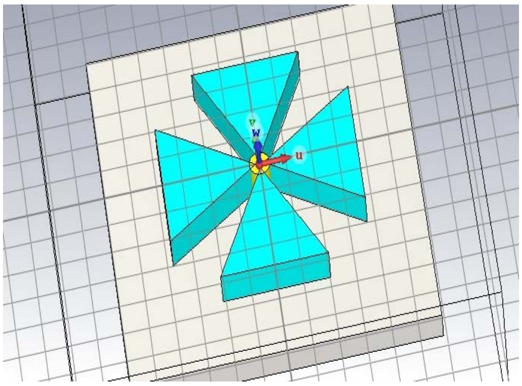


Figure 1: Illustration of velocity and position updates in PSO algorithm.

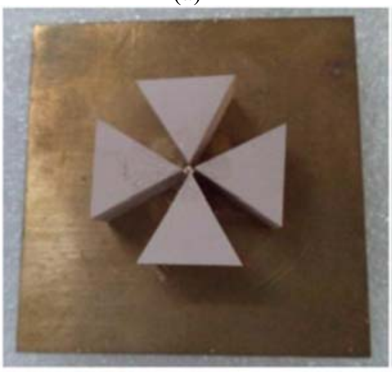
The major PSO operators are term's velocity replace and position replace, which may be written as:
v(τ+1) = wv(τ)+$c_1 r_1$ (pi(τ)-x(τ))+$c_2 r_2$(pg(τ)-x(τ))
x(τ+1) = x(τ)+v(τ+1)
r1,r2 represent evenly distributed random numericals , while c1,c2 represent acceleration constants. The range of time is constrained. If the feed reaches its limit, the miles have reached the appropriate limit. The issue of inertia weight is represented by w. The miles calculated according to the following equation:
W = $w_{max} - w_{max} - w_{min}$T•τ
Where w_{max} and w_{min} are the higher and lower weighting element fees, respectively. T represents the larger number of iterations, whereas the current iteration range is τ [16][17][18].

3. Antenna Design Configuration

The layout and geometry of the proposed four-element TDRA showed in Figures 1. Each DR of the structure has a=13.34 mm width and height=10 millimetres. The material's dielectric constant is ε_r =12(TCI Ceramics Inc, K-12, tanδ=2.0 ×10^{-4}, USA) is an used for each of the antenna's proposed elements. The composite structure's DR elements are compactly packed on a metallic ground plane with dimensions of 50 mm x 50 mm x 3 mm. The proposed antenna has sparked interest a coaxial probe with a voltage of 50 volts that touches the corner edge of all elements are packed together in the four elements of the TDRA.



(a)



(b)

Figure 2: (a) Design of 4 element TDRA using HFSS (b) prototype fabricated

The main advantage of TDRA is that it provides a smaller area for a given height and resonant frequency than either a cylindrical or rectangular DRA. As a result, it is advantageous for application for antenna arrays if you need a larger amount of space, the bandwidth is increased by combining TDRA elements.

Table 1: Geometrical Parameters

Parameter	Measurements (in mm)
A	13.34
H	10
ε_r	12
Ground plane	50×3×50
Coaxial probe	50Ω
material	TCI Ceramics Inc

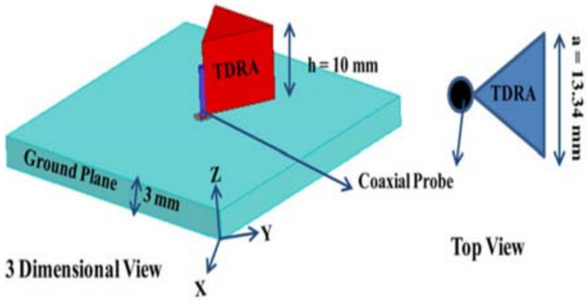


Figure 3: Geometrical view of antenna

Results and discussion

The simulated results are carried out by High Frequency Structure Simulator (HFSS) Software. Fig.2 demonstrates the simulated S11 results versus frequency for the proposed antenna. The simulated impedance bandwidths for 21% (5.85 GHz),at resonant frequencies 4GHz to 7 GHz respectively.

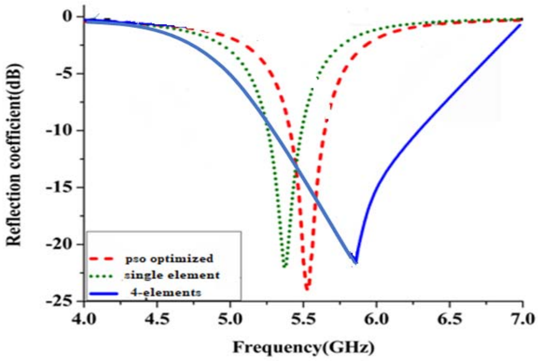


Figure 4: S_{11} Parameter Plot.

Table 2: performance comparison of SDRA and TDRA

Geometry	Resonant frequency	% Bandwidth
Single element TDRA(using HFSS)	5.3GHz	5.7%
Single element TDRA(Measured)	5.35 GHz	5.53%
four element TDRA(using HFSS)	5.8 GHz	21%
four element TDRA(Measured)	5.82 GHz	21.3%

Near field distribution

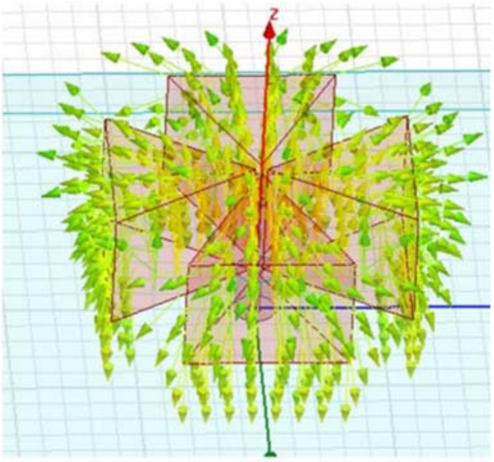


Figure 5: E-field of four element DRA

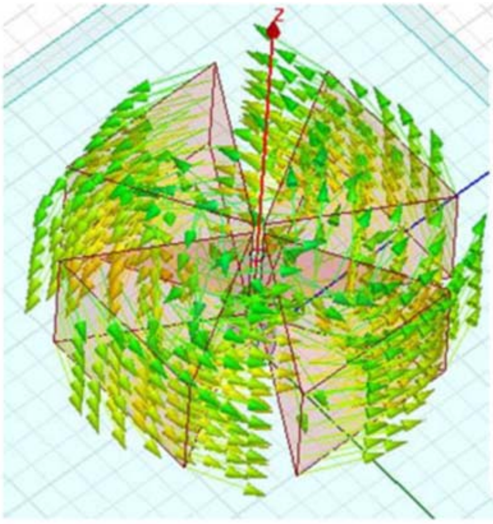
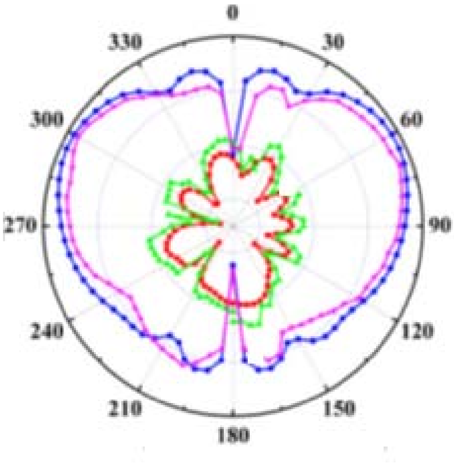


Figure 6: H-field of four element DRA

Far field distribution



igure 7: Radiation pattern of proposed four elements TDRA in E-plane

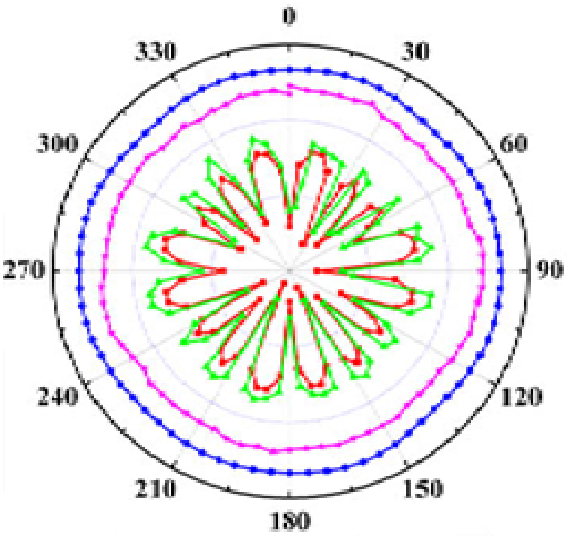


Figure 8: Radiation pattern of proposed four elements TDRA in H-plane

3D Radiation patterns

The radiation patterns of the antenna at resonance frequencies are studied. Fig. 4 shows the 3D radiation patterns at 4-7 GHz

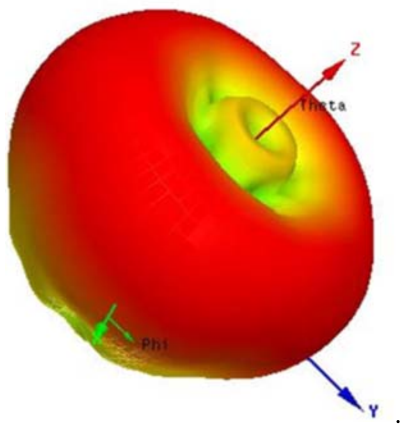


Figure 9: *3D radiation pattern of the 4-element antenna*

The radiation sample of the designed antenna of obtained frequencies are 4-7 GHz .The patterns are almost Omni-directional patterns in H-plane and bidirectional sample in E-plane inside the operating frequency at better frequencies, these styles were given distributed due to generation of better order modes and additionally found the 3D radiation styles for same frequencies in Fig.4

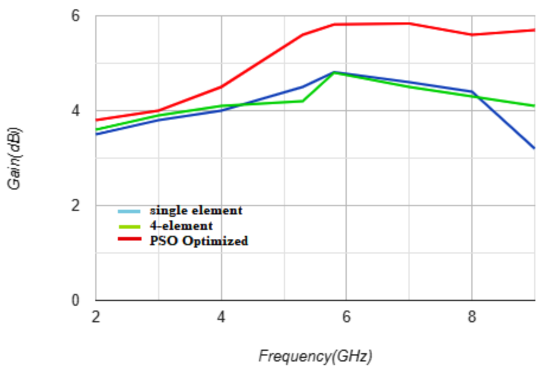


Figure 10: Gain Plot.

Fig 10 shows simulated gain curve for the PSO optimized proposed antenna, it is inferred that the peak gian of the antenna without optimization provides 4.76 dBi at resonant frequency,after the optimization it shows an improvement of 5.8 dBi peak gain .

Table 3: Gain comparision

Antenna geometry	**gain**
four element TDRA	4.6
Proposed PSO optimized antenna	5.8

Conclusion

A four-element wideband TDRA has been designed and built. Ansoft HFSS software was used to simulate the proposed antenna. The measured and simulated results are very similar. The proposed antenna was compared to a single element TDRA and found to have a higher bandwidth. According to the research, the proposed antenna's bandwidth is nearly 21%, and it produces a consistently symmetric monopole type of radiation pattern with 4.76 dBi peak gain at resonant frequency.The four element TDRA is optimized using PSO algorithm which cause an improovenet in antenna gain of 5.8 dBi. The performance of the proposed antenna was compared to that of other similar DRA shapes and found to be superior. The antenna is suitable for use in WLAN (IEEE 802.16) and WiMAX bands of communication.

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