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Comparision of Performance Analysis of Rectangular and Circular Phased Arrays Using HFSS

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Abstract

In this paper, we have proposed a comparison of phased antenna arrays of 2x4 rectangular grid with circular and rectangular patch for radar applications designed at 6 GHz frequency. The antenna array simulations are carried out by using HFSS software. FR4 epoxy with dielectric constant 4.4 and thickness 5.6mm is used as substrate. Details of the antenna array design are presented and simulation results are discussed. Phased antenna arrays are useful for many types of applications such as traffic control and collision avoidance radars, smart base station antennas for WLAN and cellular communication.

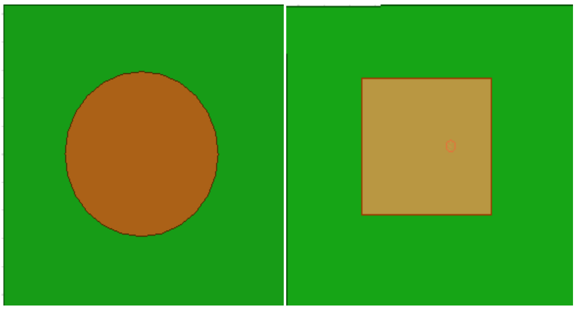
Keywords: Phased arrays, beam steering, phase shifter.

Introduction

Phased array antenna is a multiple-antenna system in which the radiation pattern can be reinforced in a particular direction and suppressed in undesired directions. This can be achieved by varying electronically the phase of the radiating elements, thereby producing moving a pattern electronically with high effectiveness managing to get minimum side lobe levels and narrow beam widths. The direction of phased array radiation can be electronically steered obviating the need for any mechanical rotation. These unique capabilities have found phased arrays a broad range of applications since the advent of this technology. Phased arrays have been traditionally used in military applications for several decades. Recent growth in civilian radar-based sensors and communication systems has drawn increasing interest in utilizing phased array technology for commercial applications. Phased array antennas are common in communications and radar and offer the benefit of far-field beam shaping and steering for specific, agile operational conditions. They are especially useful in modern adaptive radar systems where there is a trend toward active phased arrays and more advanced space timeadaptive signal processing. In phased arrays all the antenna elements are excited simultaneously and the main beam of the array is steered by applying a progressive phase shift across the array aperture.

Design of Microstrip Array Antenna

Microstrip patch antennas are important as single radiating elements but their major advantages are realized in application requiring moderate size arrays. The primary radiator microstrip antenna is designed with frequency f = 6GHz which gives single element microstrip antenna as shown in Figure 1.and the feed is shown in the Figure 2. The dimensions of the patch are calculated using formulae found in [4][5]. Single patch is extended to eight element microstrip array shown in Figure 3. And the eight element feed is shown in Figure 4.Further, to achieve beam steeringthe input phase angel of the individual element is changed so as to achieve the required output. The above antennas are simulated and optimized using commercially available HFSS software.various antenna parameters are shown in Table 1.



(a) (b)

Figure 1: Single patch elements a. Circular b. Rectangular

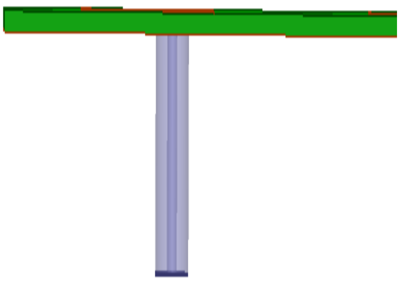
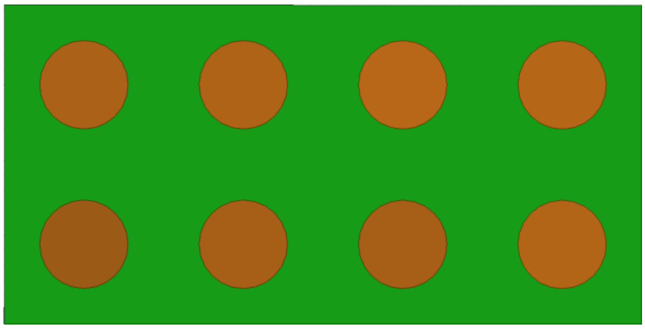
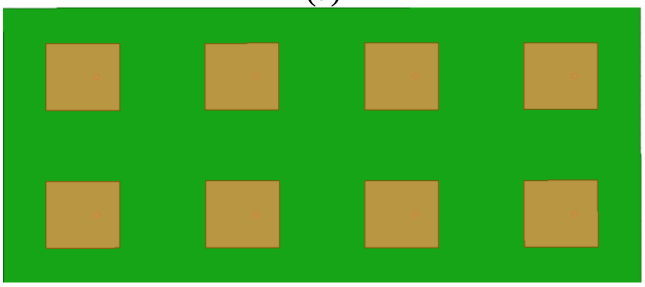


Figure 2: Single Element Feed

The array is developed without any spacing in between the individual antenna elements for both circular and rectangular array.



(a)



(b)

Figure 3: 2x4 patch array (a) Circular (b) Rectangular

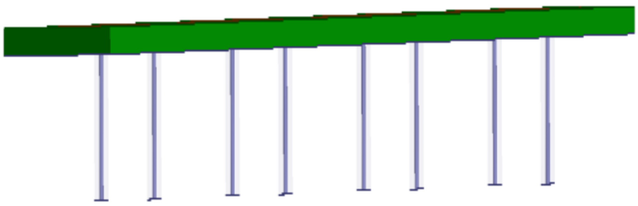


Figure 4: 8 element Feed

Table 1: Individual Antenna Parameters

Individual Antenna Parameters	Value (mm)
Length of Substrate	24
Width of Substrate	24
Circular patch radius	6.74
Length of Rectangular Patch	11.54
Width of Rectangular Patch	15.21

Results and Discussions

The S-parameter (return loss) of the proposed Circular and Rectangular patch antenna arraysare shown in the Fig. 5. andFig. 6. achieved a return loss of -18.92 dB and -18.47 dB at 6 GHz respectively.

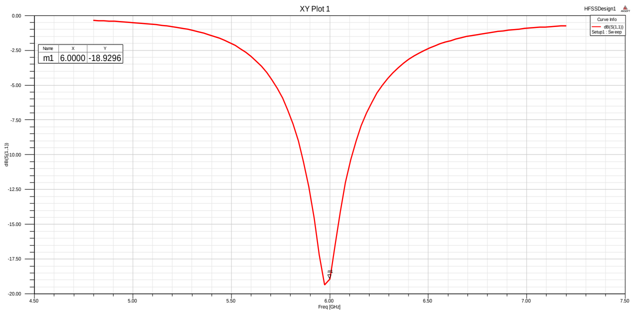


Figure 5: Return Loss Plot For Circular Patch Antenna

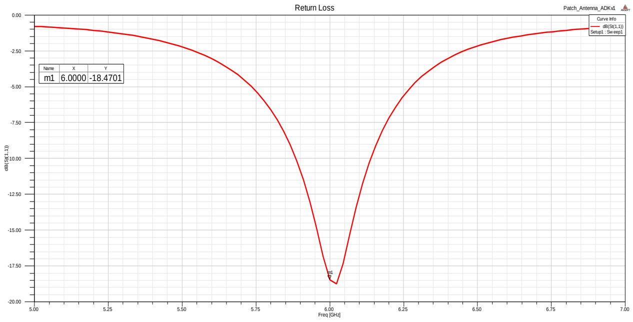


Figure 6: Return Loss Plot For Rectangular Patch Antenna

The VSWR of the proposed Circular and Rectangular patch antenna arrays are shown in the Fig. 7. and Fig. 8. achieved a VSWR value of 1.97 dB and 1.83 dB at 6 GHz respectively.

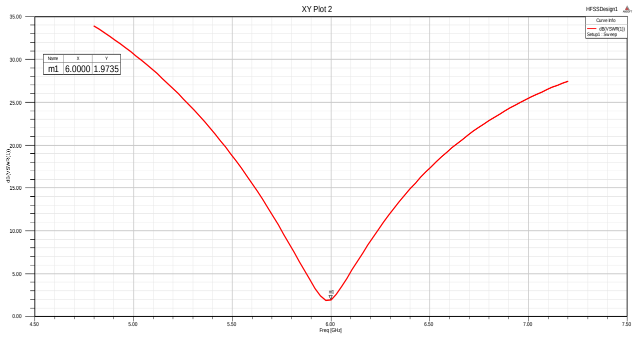


Figure 7: VSWR plot for Circular Patch Antenna

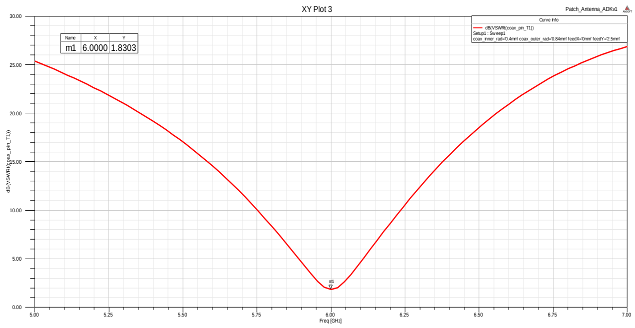


Figure 8: VSWR plot for Rectangular Patch Antenna

The radiation pattern (E-Plane and H-Plane) of the antenna arrays at different input phase angles are shown in the Fig. 9 to Fig. 20 from the results it is observed that the proposed antenna is a Omni Directional which is well suited for the radar applications.

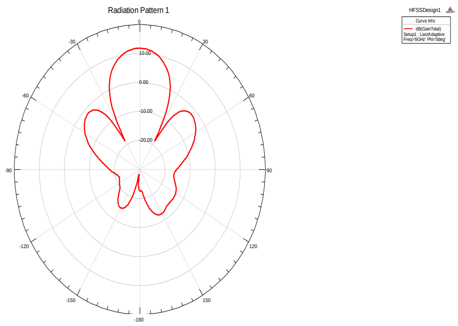


Figure 9: E - Plane plot for Circular Patch Antenna with 0^0 phase shift for individual element

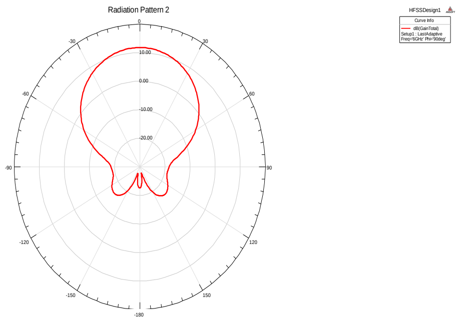


Figure 10: H - Plane plot for Circular Patch Antenna with 0^0 phase shift for individual element

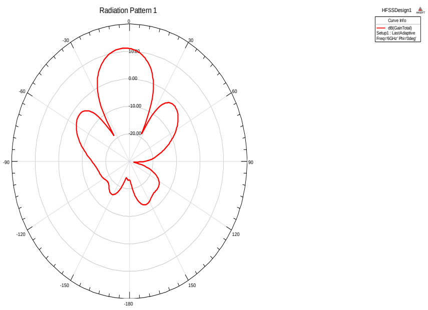


Figure 11: E - Plane plot for Circular Patch Antenna with 10^0 phase shift for individual element

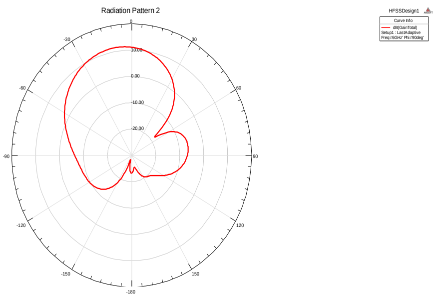


Figure 12: H - Plane plot for Circular Patch Antenna with 10^0 phase shift for individual element

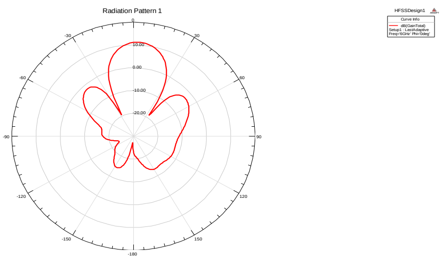


Figure 13: E - Plane plot for Circular Patch Antenna with -10^0 phase shift for individual element

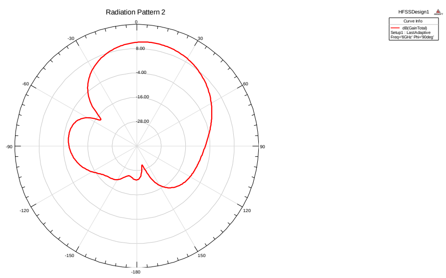


Figure 14: H - Plane plot for Circular Patch Antenna with -10^0 phase shift for individual element

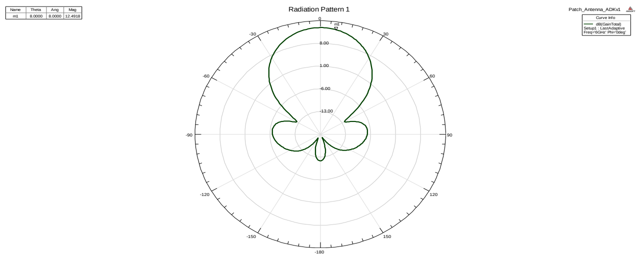


Figure 15: E - Plane plot for Rectangular Patch Antenna with 0^0 phase shift for individual element

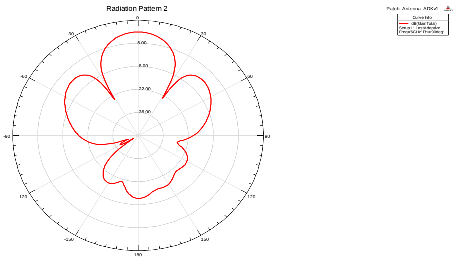


Figure 16: H - Plane plot for Rectangular Patch Antenna with 0^0 phase shift for individual element

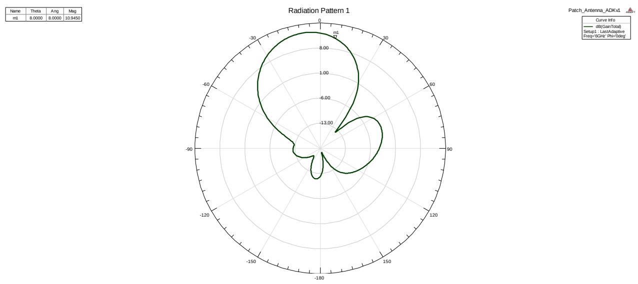


Figure 17: E - Plane plot for Rectangular Patch Antenna with 10^0 phase shift for individual element

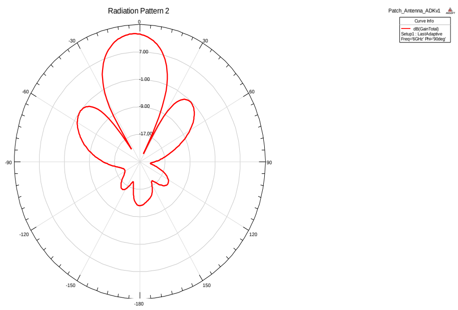


Figure 18: H - Plane plot for Rectangular Patch Antenna with 10^0 phase shift for individual element

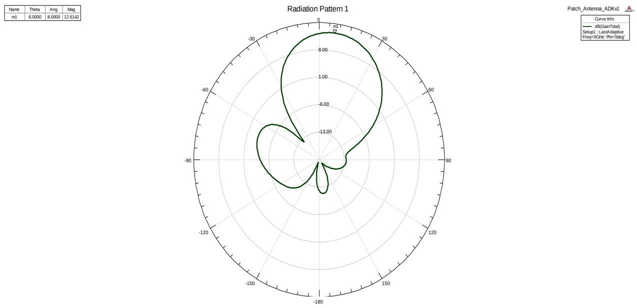


Figure 19: E - Plane plot for Rectangular Patch Antenna with -10^0 phase shift for individual element

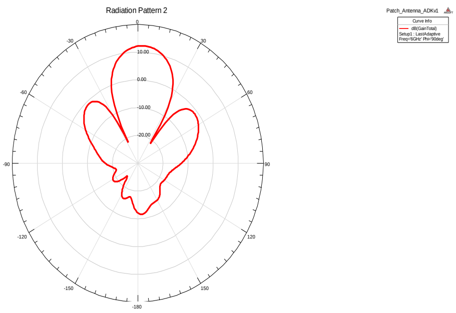


Figure 20: H - Plane plot for Rectangular Patch Antenna with -10^0 phase shift for individual element

The 3D Polar plot of the antenna at different input phase angles are shown in the Fig. 21 to Fig. 26 from the results it is observed that the proposed antenna is having a stable gain for all th einput phase angles.

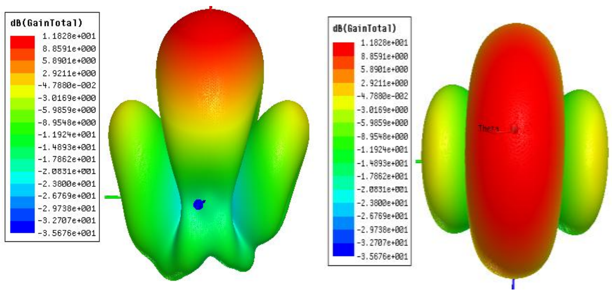


Figure 21: 3D-Polar Plot for circular patch array with0^0 phase shift for for individual element

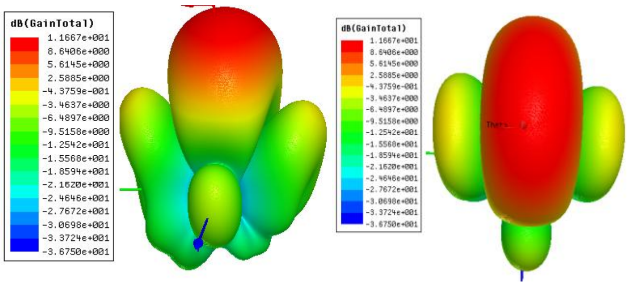


Figure 22: 3D-Polar Plot for circular patch array at 10^0 phase shiftfor individual element

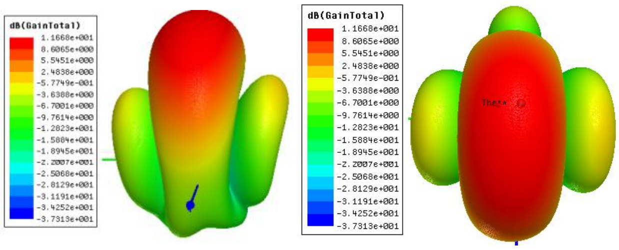


Figure 23: 3D-Polar Plot for circular patch array at -10^0 phase shiftfor individual element

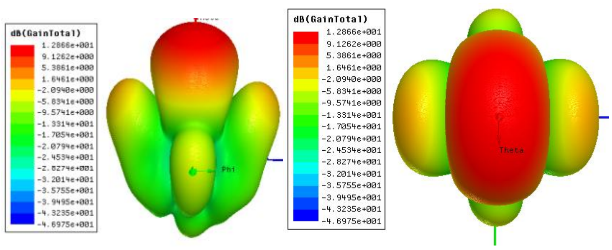


Figure 24: 3D-Polar Plot for Rectangular patch array with0^0 phase shift for for individual element

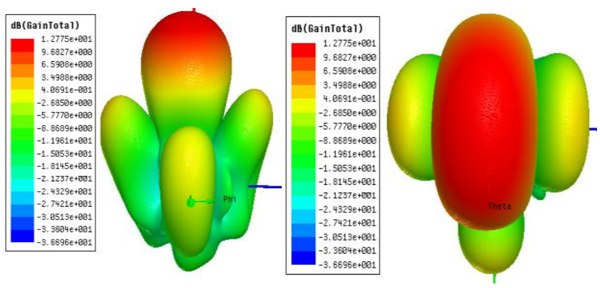


Figure 25: 3D-Polar Plot for Rectangular patch array with10^0 phase shift for for individual element

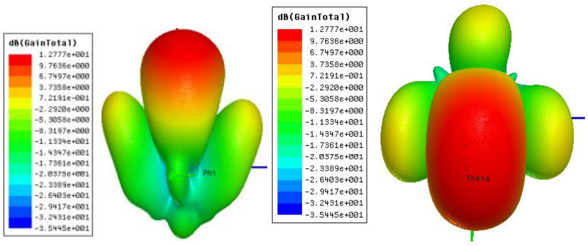


Figure 26: 3D-Polar Plot for Rectangular patch array with-10^0 phase shift for for individual element

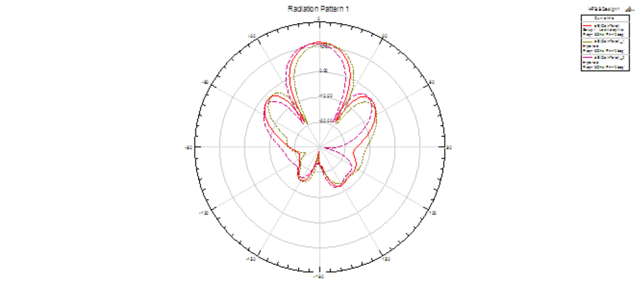


Figure 27: E - Plane plot for Circular Patch Antenna with different phase shift for individual element

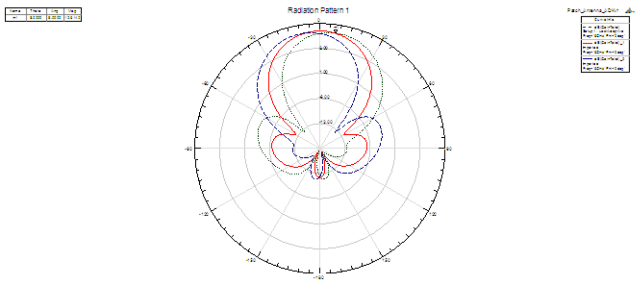


Figure 28: E - Plane plot for Rectangular Patch Antenna with different phase shift for individual element

Table 1: Comparison of Circular and Rectangular Patch Arrays

Antenna Parameters	**Circular Array**	**Rectangular Array**
Frequency of operation	6 GHz	6 GHz
Return Loss (dB)	-18.92	-18.47
VSWR (dB)	1.97	1.83
Gain (dB)	11.82	12.86
Radiation Pattern	Narrow Beam Width	Wide Beam Width

Conclusion

Phased array, capable of providing a directional beam that can be electronically steered, can significantly enhance theperformance of sensors and communications systems. The directional beam of a phased array also allows for a more efficient power management. In addition, the spatial filtering nature of the phased array systems alleviate the problem of multipath fading and co-channel interference by suppressing signals emanating from undesirable directions.

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