International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1S5, December 2019

A 2×2 Antenna Array for X Band Phased Array RADAR Applications

K.Alekya, M.Sekhar

Abstract: ***A Four element rectangular patch antenna array has been designed for the Phase array RADAR applications in the X Band with an operating frequency of 10GHz. The four patches are been connected to four different transmitter circuit with which we can control the phase of the input signal. A 50Ω coaxial probe feed has been used to excite the antenna. The overall dimension of the antenna is 212mm×212mm×1.6mm. The Proposed antenna is having an gain of 10.2dB at the operating frequency of 10GHz. The directivity of the antenna at the operating frequency is 10.31dB. Low cost FR4 material is been used as the laminate base for the antenna which will act as the dielectric material.***

Keywords: Coax Feed, Phased Array, RADAR Applications.

I. INTRODUCTION

To meet the requirement of long coverage area of the modern communication systems the need for antennas with high gain is increasing day by day and it has become a challenge for the designers to achieve high gain from microstrip antennas which are known for their disadvantages of low gain and low radiation efficiency. One of the technique to achieve high gain is to form an antenna array from individual antenna elements such that the radiated power from each antenna is in phase with the remaining antennas and the power from all the antenna elements will be combined into single beam.

In [1] an four element antenna array has been proposed where all the four elements are been excited with a single feed and because of this the control over the phase of the input signal is not possible which is very essential in the phased array antenna applications especially in RADRA's where we need to steer the beam in different directions. In [2] an four element antenna array has been proposed where a separate feeding structure has been used to excite the individual antenna elements. For this proximity feeding concepts are been used which will require two different substrates for the development of the antenna and is not encouraged as it will increase the cost of the antenna. In [3] an four element antenna array has been proposed to achieve high gain but to excite the antenna elements a complex directional coupler network has been used and this is bringing difficulty in antenna fabrication and also the feed network is generating some surface waves which will reduce the overall efficiency of the antenna.

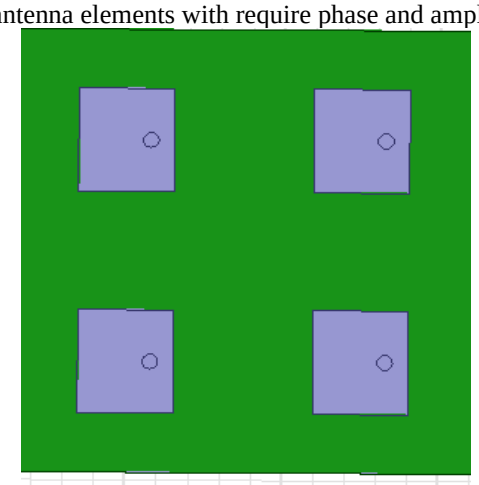
Manuscript published on 30 December 2019.
* Correspondence Author (s)
K.Alekya, UG Student, Dept. of E.C.E, Vignan's Foundation for Science Technology and Research, Guntur, India.
M.Sekhar, Assistant Professor, Dept. of E.C.E, Vignan's Foundation for Science Technology and Research, Guntur, India.

In [4] an four element antenna array has been proposed where all the four elements are been excited with a single feed and because of this the control over the phase of the input signal is not possible which is very essential in the phased array antenna applications especially in RADRA's where we need to steer the beam in different directions. In [5] an four element antenna array has been proposed where a separate feeding structure has been used to excite the individual antenna elements. For this proximity feeding concepts are been used which will require two different substrates for the development of the antenna and is not encouraged as it will increase the cost of the antenna.

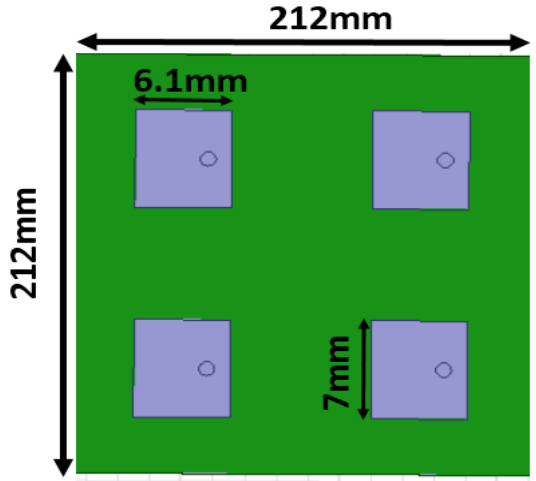
In this paper, we proposed a four element antenna array with individual feed to each antenna element which is used to control the phase of the input signal. By using individual feed elements there is no need of any additional feed network or substrate material or any chance of generation of unwanted surface waves because of the feed network.

II. DESIGN OF PROPOSED ANTENNA

Proposed design is a four element antenna array. It is having individual feed and excitation is provided to individual antenna element. The radiating elements were rectangular patches which are designed to operate at an operating frequency of 10GHz. Flame Retardent Glass epory material has been used as the substrate material with a thickness of 1.6mm. Substrate has been considered as a rectangle with a dimension of 212mm×212mm. The radiating patch is a rectangle and is been fed with an probe feed. Proposed antenna elements were excited with four individual feed elements which can provide the input signal to the antenna elements with require phase and amplitude.



(a) Top View of proposed antenna



(b) Schematic Model of Patch

Fig. 1. Proposed antenna

III. RESULTS AND DISCUSSION

The performance of the antenna is measured by analyzing various parameters which includes impedance matching and radiation characteristics. Under impedance matching we will verify two parameters namely return loss also called as S_{11} and Voltage standing wave ratio which is simply called as VSWR. [6-7]. Figure 3 and Figure 4 below shows the impedance matching characteristics of the antenna. Figure 3 shows the S_{11} plot of the antenna from it we can know that the antenna is radiating in the frequency range of 9.29GHz to 10.34GHz with a operating centre frequency of 10GHz. It is observed that the return loss value is -28.49dB which indicated that there is a good impedance matching for the antenna with the input power source.

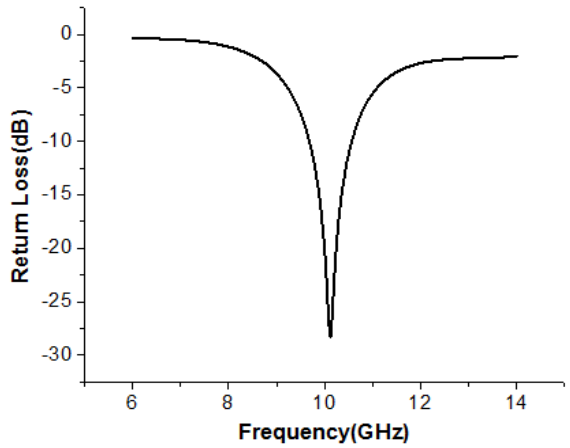


Fig. 3. Return loss

Figure 4 shows the VSWR plot of the antenna from it we can know that the antenna is radiating in the frequency range of 9.29GHz to 10.34GHz with a operating centre frequency of 10GHz. It is observed that the VSWR value is 1.04dB which indicated that there is a good impedance matching for the antenna with the input power source.

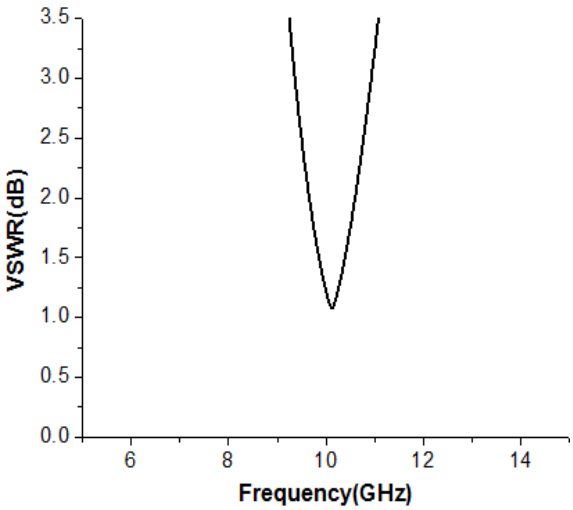


Fig. 4. VSWR

Figure 5, 6 and 7 below shows the 3D gain plot, 2D gain plot and the Directivity plot of the proposed antenna at the operating frequency of 10GHz, The image depicts that the gain value of the antenna is 10.2dB and the directivity of the antenna is 11.31dB. Figure 6 represents the two dimensional gain plot of the antenna it shows a uniform distribution of the power in different theta angles without any nulls which is very essential for the phased array RADAR applications [8,9]. It is also observed that the gain and directivity are nearly equal which represents that the losses in the proposed antenna are very low.

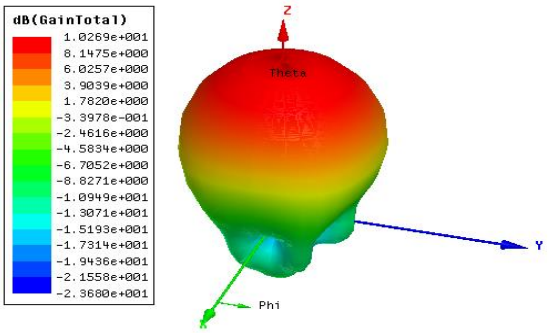


Fig.5. Gain at 10GHz

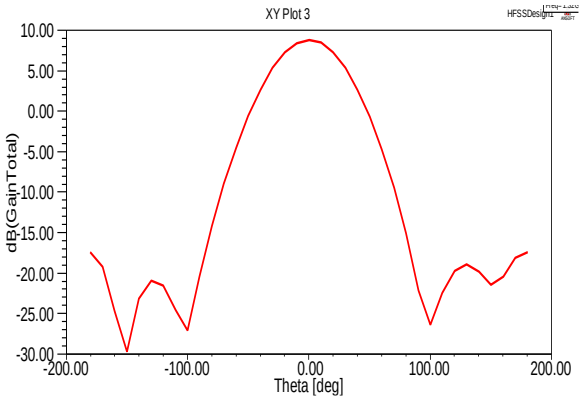


Fig. 6. Gain at 10GHz

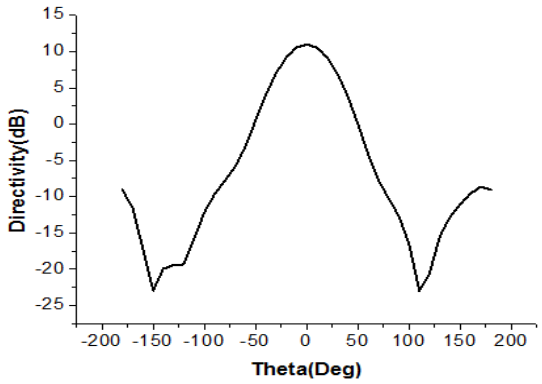


Fig.7. Directivity at 10GHz

The radiation characteristics of the antenna at the center frequency of 10GHz are shown below in Figure 8. To analyze the radiation characteristics of the antenna we need to check both the elevation plane and azimuthal planes. Here we can observe that at both the patterns are having uniform distribution of the power in different theta angles without any nulls which is very essential for the phased array applications for proper planning of the antenna coverage area. In the Elevation plane and azimuthal plane there are no traces of any side lobes for the antenna array which is very essential for the RADRA applications.

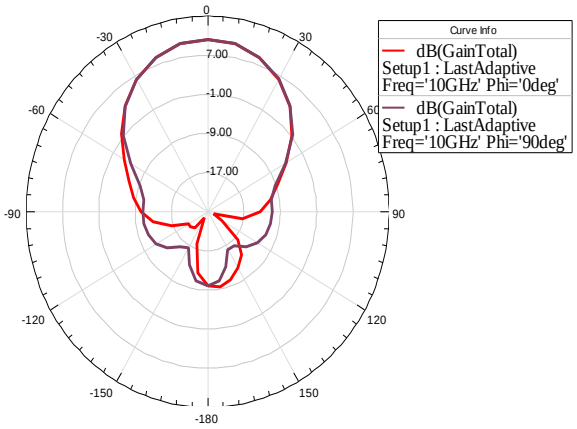


Fig. 8. Radiation Patterns

Figure 9 above shows the smith chart plot of the antenna which represents the variation of the antenna impedance with the frequency and it shows that the proposed antenna is having a good impedance matching of 50Ω at the entire operating frequency range.

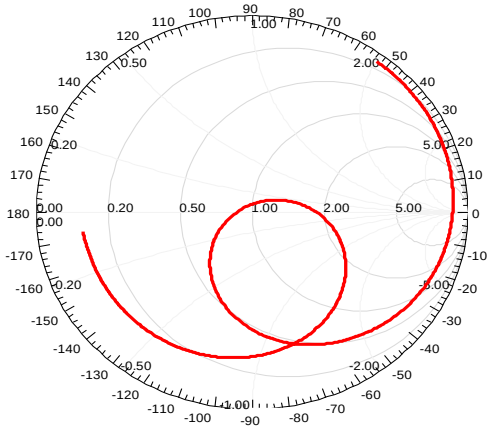


Fig. 9. Smith Chart

IV. CONCLUSION

A Four element rectangular patch antenna array has been designed for the Phase array RADAR applications in the X Band with an operating frequency of 10GHz. The four patches are been connected to four different transmitter circuit with which we can control the phase of the input signal. A 50Ω coaxial probe feed has been used to excite the antenna. The overall dimension of the antenna is 212mm×212mm×1.6mm. The Proposed antenna is having an gain of 10.2dB at the operating frequency of 10GHz. The directivity of the antenna at the operating frequency is 10.31dB. Low cost FR4 material is been used as the laminate base for the antenna which will act as the dielectric material.

REFERENCES

1. E. Kusuma Kumari, A.N.V.Ravi Kumar. (2017). Wideband High-Gain Circularly Polarized Planar Antenna Array for L Band Radar. IEEE International Conference on Computational Intelligence And Computing Research, Tamilnadu College of Engineering. Tamil Nadu.
2. E. Kusuma Kumari, A.N.V.Ravi Kumar. (2017). Development of an L Band Beam Steering Cuboid Antenna Array. IEEE International Conference on Computational Intelligence And Computing Research, Tamilnadu College of Engineering. Tamil Nadu.
3. Sunkaraboina Sreenu, Vadde Seetharama Rao. (2017). Stacked Microstrip Antenna For Global Positioning System. IEEE International Conference on Computational Intelligence And Computing Research, Tamilnadu College of Engineering. Tamil Nadu.
4. Rao N.A, Kanapala S. (2018). Wideband Circular Polarized Binomial Antenna Array for L-Band Radar. Panda G., Satapathy S., Biswal B., Bansal R. (eds) Microelectronics, Electromagnetics and Telecommunications. Lecture Notes in Electrical Engineering, vol 521. Springer, Singapore
5. Kanapala S, Rao N.A. (2018). Beam Steering Cuboid Antenna Array for L Band RADAR. Panda G., Satapathy S., Biswal B., Bansal R. (eds) Microelectronics, Electromagnetics and Telecommunications. Lecture Notes in Electrical Engineering, vol 521. Springer, Singapore.
6. Sunkaraboina Sreenu, P. Gnanasivam, M. Sekhar (2018). Circular polarised Antenna Array for C Band Applications. Journal of Advanced Research in Dynamical & Control Systems, Vol. 10, 14-Special Issue.
7. K. Ashwini, M. Sekhar, Sunkaraboina Sreenu. (2018). Mutual Coupling Reduction Using Meander Square EBG Structures for C-Band Radars. Journal of Advanced Research in Dynamical & Control Systems, Vol. 10, 12-Special Issue.
8. Sekhar M, S Naga Kishore B, Siddaiah P. (2014). Triple Frequency Circular Patch Antenna. IEEE International Conference on Computational Intelligence And Computing Research, Park College Of Engineering And Tekhnology. Tamil Nadu.
9. J Lavanya, S Nagakishore Bhavanam, Vasujadevi Midasala "Design of Spiral Antenna for Multiband Applications" International Journal of Innovative Technology and Exploring Engineering, Volume-8 Issue-5 March, 2019.