1×4 Dielectric Resonator Antenna Array with Corporate Feed for C-Band RADAR

Nelapati Ananda Rao, Sekhar M

Abstract*: *A four element 1×4 dielectric resonator antenna array with corporate feed structure has been designed and investigated in this paper. microstrip feed has been used to power the corporate feed structure. Proposed antenna radiates at the C-band frequency of 6.5GHz which is widely used for the RADAR applications. For the design of corporate feed equal split Wilkinson power divider concept is been used. Arlon material has been used as base to the antenna which is having a thickness of 0.79mm. Proposed antenna is having a gain of 12dB. From the return loss and smith chart plots we can observed the impedance matching characteristics of the antenna array. A beam width of 25^0 is obtained with a SLL of 15dB which is best acceptable for array applications.

Index Terms: ***Antenna Array, C-Band, Strip feed, Power Divider.***

I. INTRODUCTION

Microstrip antenna are replacing all the conventional antennas in many applications with their unique properties of low profile, less weight, conformal nature etc. Even though microstrip antennas have become one of the promising candidate for replacement of conventional antenna they are also facing limitations in terms of gain and bandwidth. These limitations of the microstrip patch antennas are due to the surface waves and conductor losses generated by the metal which is used as radiating element. To overcome these limitations of the microstrip antennas is a major challenge to any antenna designer. Many researchers presented [1-8] different techniques to develop the antenna gain, bandwidth and to minimize the conductor losses and surface currents. One of the promising technique to increase the antenna gain is to form array of antennas in such a way that the radiation form the individual antenna elements will add up and produce high gain and to reduce the surface currents is to use a dielectric material instead of conductor as a radiating element which are called as Dielectric Resonator Antennas.

To feed the individual antenna elements separately we need to have separate transceiver circuits for each element. This will again increase the complexity of the communication system and the interferences between the transceiver circuits will reduce the performance of systems. So to overcome this limitation we need to have a minimal number of transceiver circuits for multiple antenna elements. For this the best solution is to have a feeding structure which will unite multiple radiating elements and distribute the power to all the elements equally.

Proper care has to be taken in designing the feed structure such that it will not add negative effect to the antenna array radiation. Depending upon the application the feed network can be designed to distribute the power equally or unequally to all the elements. Most important parameter to be considered while designing the feed network is that it should not add any additional phase to the input signal. Otherwise it will have a huge impact on antenna array performance in terms of radiation.

Proposed is a hemispherical Dielectric resonator patch antenna array with corporate feed structure which is been excited using single strip feed. The corporate feed has been designed based upon the Wilkinson power divider concept. Proposed antenna will radiate for the C-band frequency of 6.5GHz which is used for RADAR applications widely.

II. ANTENNA DESIGN AND CONFIGURATION

Proposed 1×4 antenna array used Arlon material as base which is having a thickness of 0.79mm. linear array configuration is considered to form the antenna array. The feed network is a Wilkinson power divider network which is been designed to deliver the power from the stripline to all the elements. The final dimensions of antenna after optimization are presented in the schematic diagram below in first figure. The basic radiating elements is a hemispherical DRA for which a high dielectric constant material with €r value of 20 is used which is connected to the feed network through a microstrip line.

The dimensions of the hemispherical radiating element is calculated based upon the following equation. Equations 1 is used for the calculation of the radius of the hemisphere[9-13]

$$Fr = \frac{4.775 * 10^7 * Re(Ka)}{(\sqrt{€r}) * r} \quad (1)$$

Where

Fr - Resonant Frequency
€r – Dielectric constant of HDRA
r - Radius of HDRA (in cm)
Ka – Wavenumber in the Dielectric

The wavenumber is calculated using the standard graph which is in the following Figure 1 and in the figure 2 and figure 3 depicts the simulated strip fed corporate dielectric resonator antenna array model and the optimized dimensions of the antenna array.

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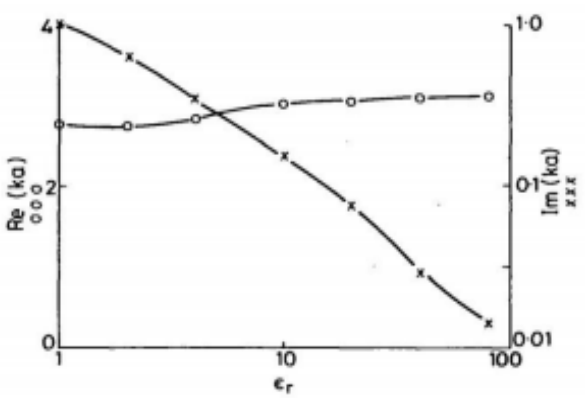


Fig. 1 Wave number Graph

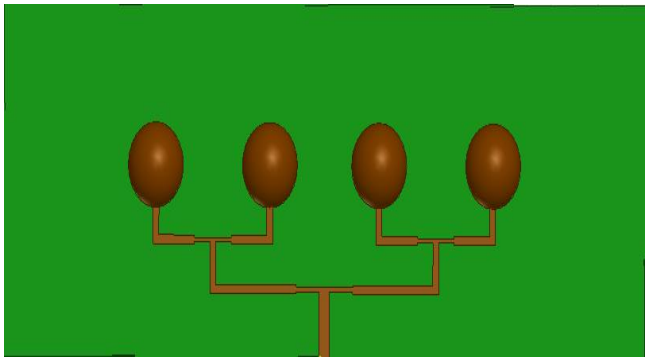


Fig. 2 Simulated array

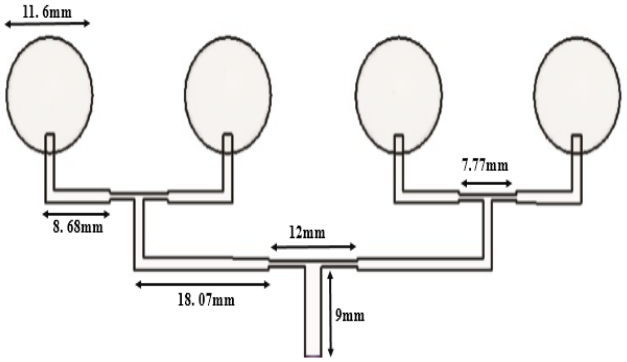


Fig. 3 Schematic of array

III. RESULTS AND DISCUSSION

Antenna array is designed, studied and analysed by Ansys HFSS software. Antenna parameters such as impedance matching, near field and far field characteristics, current distribution were studied. Figure 4 below depicts the impedance matching plot of the array antenna.

Observed a S_{11} value of -15.89dB for the proposed array antenna. From the graph it can be observed that the proposed antenna is operating at 6.5GHz and is having better impedance matching. Figure 5 below depicts graph of standing wave ratio for the array antenna. Observed a VSWR value of 1.38dB for antenna array at 6.5GHz.

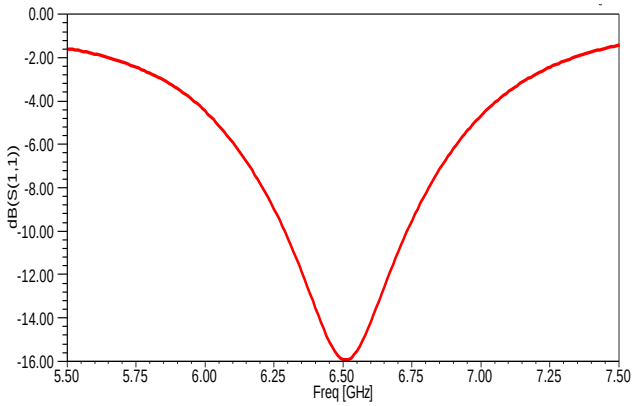


Fig. 4 Return loss of antenna array

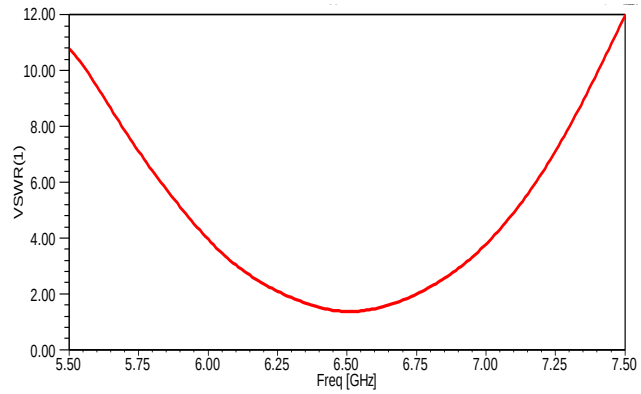


Fig. 5 VSWR plot

Figure 6 below depicts amount of power radiated by the array antenna. Observed a gain of 12.27dB at 6.5GHz. From power distribution pattern observed in the result it can be clearly seen that maximum power emitted by the antenna array is focused in a single direction forming the main lobe of the radiation pattern.

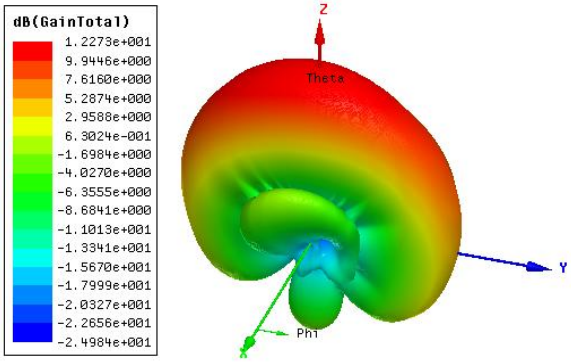


Fig. 6 Gain of antenna array

Figure 7 below depicts the 2D radiation pattern for proposed array antenna. A beam width of 25^0 is obtained for the antenna array of 4 elements. The radiations in unwanted directions will form side lobe and their levels in the antenna array are also very low with a SLL value of 15 dB. Here we can observe that the most essential parameters of an antenna array like beam width and sidelobe levels are upto the satisfying levels.

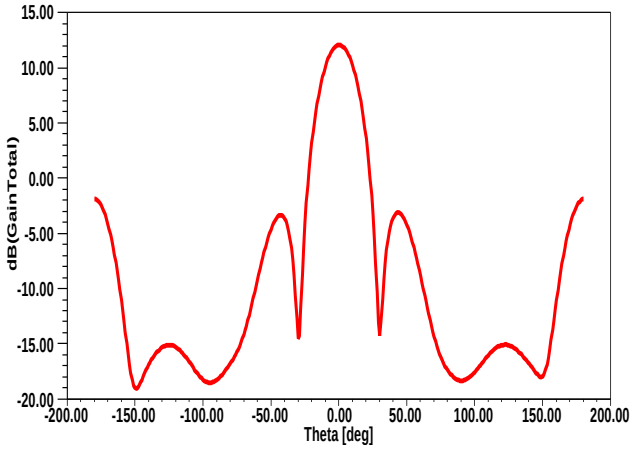


Fig. 7 2D Radiation Pattern

Figure 8 below depicts the Directivity of the antenna array. Observed a directivity of 12.25dB for the proposed antenna array.

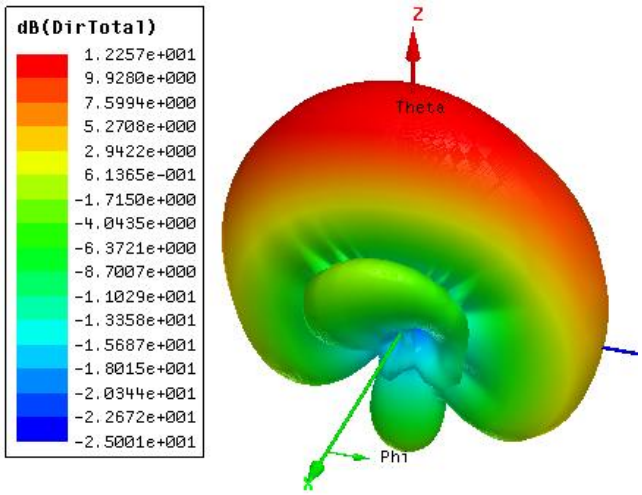
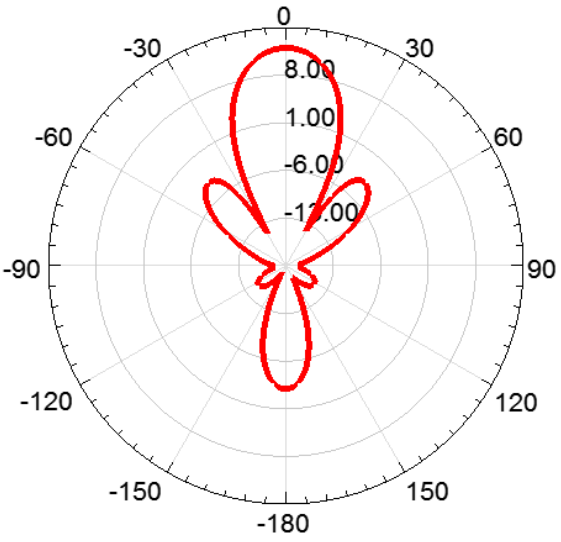
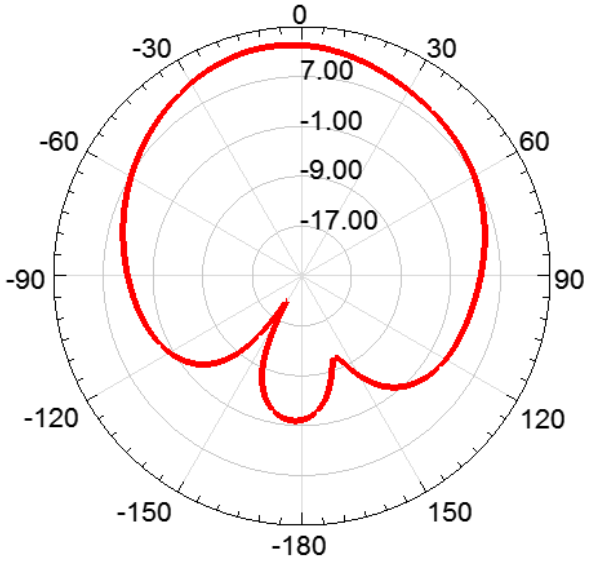


Fig. 8 Directivity of antenna array

Figure 9 below depicts the elevation plane and azimuthal plan radiation patterns of the antenna array. Observed a uniform radiation pattern without any nulls for both the patterns. An omni directional radiation pattern is observed in both the radiation planes.



(a) Elevation Plane



(b) Azimuthal Plane

Fig. 9 Radiation Pattern of array

Figure 10 below depicts the smith chart plot of the antenna array. From the plot it is evident that the proposed antenna is having proper impedance matching.

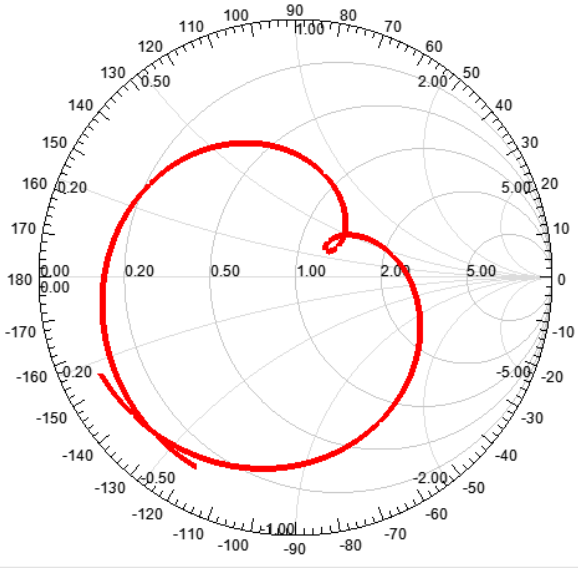


Fig. 10 Impedance Matching of antenna array

IV. CONCLUSION

In this paper, a 1×4 dielectric resonator antenna array with corporate feed is proposed with hemispherical radiating patch for the C-band frequency of 6.5GHz which is used for the RADAR applications. Arlon material is been used as substrate layer to design the antenna. Proposed antenna array is fed by a single strip feed and a corporate feed structure has been employed to transfer the power from the single source to the four elements equally. Various performance analysis studies have been performed on the antenna parameters. From the return loss and smith chart plots it is observed that the antenna array is having good impedance matching. A beam width of 25^0 is obtained for the antenna array with a side lobe level of 15dB.

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