1×4 Antenna Array with Corporate Feed for L-Band RADAR

Sekhar M, P Krishna Chaitanya

Abstract --- A four element 1×4 antenna array with corporate feed structure has been designed and investigated in this paper. Coax feed has been used to power the corporate feed structure. Proposed antenna radiates at the L-band frequency of 1.35GHz which is widely used for the RADAR applications.

For the design of corporate feed equal split Wilkinson power divider concepts are been used. FR4 material is been used as base to the antenna which is having a thickness of 62mils. Proposed antenna is having a gain of 6.99dB. From the return loss and smith chart plots we can observed the impedance matching characteristics of the antenna array. A beam width of 250 is obtained with a SLL of 14dB which is best acceptable for array applications.

Key words- Antenna Array, X-Band, Coax feed, Mutual Coupling.

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. 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 and bandwidth. 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.

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 over come 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 rectangular patch antenna array with corporate feed structure which is been excited using single coax probe. The corporate feed has been designed based upon the Wilkinson power divider concept. Proposed antenna will radiate for the L-band frequency of 1.35GHz which is used for RADAR applications widely.

II. ANTENNA DESIGN AND CONFIGURATION

Proposed 1×4 antenna array used FR4 material as base which is having a thickness of 62mils. 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 coaxial probe 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 rectangular patch which is connected to the feed network through a inset microstrip line.

The dimensions of the rectangular radiating element is calculated based upon the following equations. Equations 1 to 5 are used for the calculation of the perimeter of the rectangular patch in terms of length and width[9-10]

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}} \tag{1}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \tag{3}$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \tag{4}$$

$$L = L_{eff} - 2\Delta L \tag{5}$$

The simulated coax fed corporate antenna array model is depicted below in figure 1.

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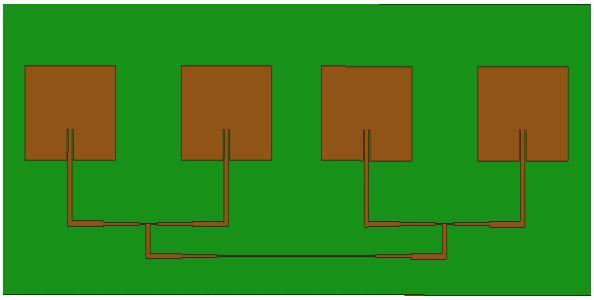


Fig. 1 Simulated array

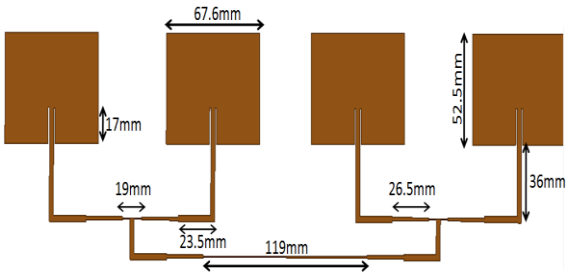


Fig. 2 Schematic of array

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 3 below depicts the impedance matching plot of the array antenna. Observed a S_{11} value of -16.5dB for the proposed array antenna. From the graph it can be observed that the proposed antenna is operating at 1.35GHz and is having better impedance matching.

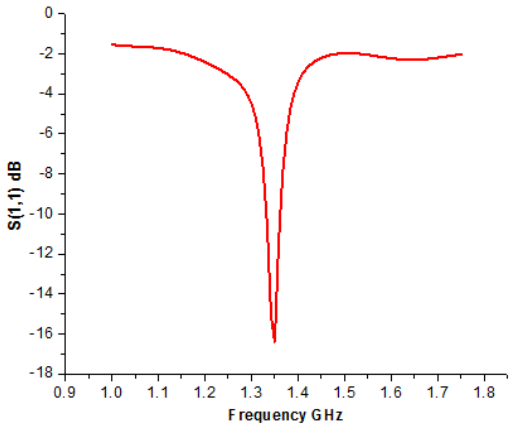


Fig. 3 Return loss of antenna array

Figure 4 below depicts graph of standing wave ratio for the array antenna. Observed a VSWR value of 1.25dB for antenna array at 1.35GHz.

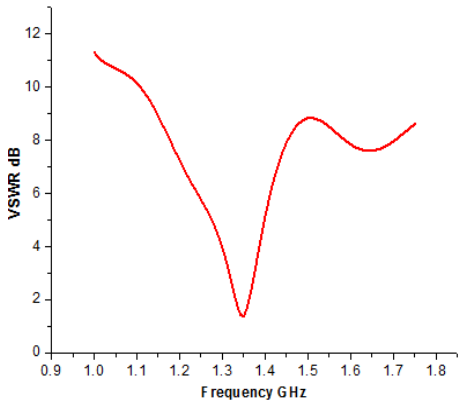


Fig. 4 VSWR plot

Figure 5 below depicts amount of power radiated by the array antenna. Observed a gain of 6.99dB at 1.35GHz. 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.

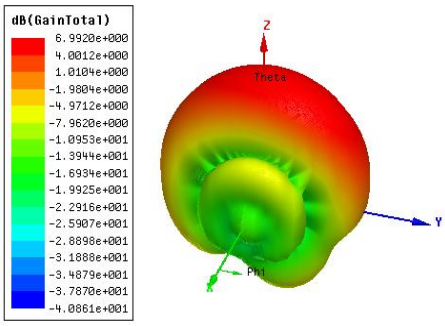


Fig. 5 Gain of antenna array

Figure 6 below depicts the 2D radiation pattern for proposed array antenna. A beam width of 250 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 14 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.

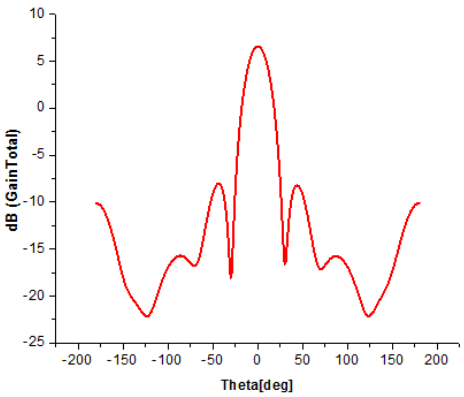


Fig. 6 2D Radiation Pattern

Figure 7 below depicts the Directivity of the antenna array. Observed a directivity of 12.14dB for the proposed antenna array.

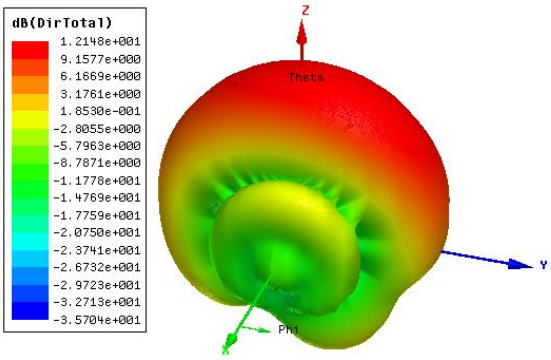
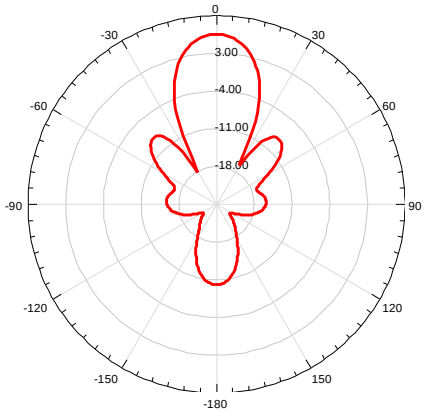
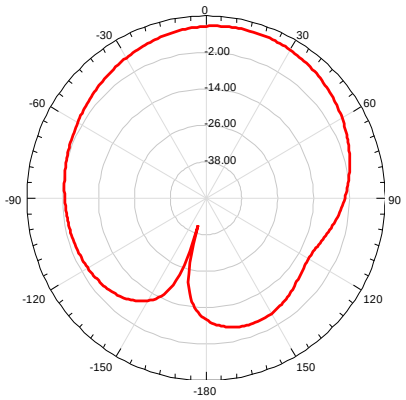


Fig. 7 Directivity of antenna array

Figure 8 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. 8 Radiation Pattern of array

Figure 9 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.

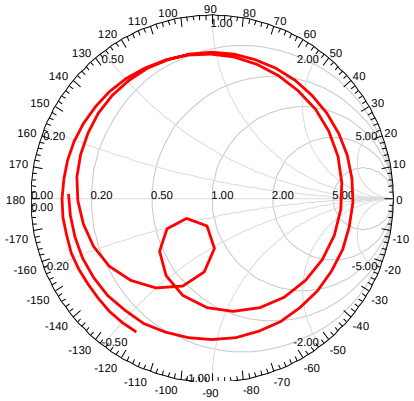


Fig. 9 Impedance Matching of antenna array

IV. CONCLUSION

In this paper, a 1×4 antenna array with corporate feed is proposed with rectangular radiating patch for the L-band frequency of 1.35GHz which is used for the RADAR applications. FR4 material is been used as substrate layer to design the antenna. Proposed antenna array is fed by a single coax 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 14dB.

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