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Design and Analysis of 4x4 X-Band Conformal Antenna Array with Corporate Series Feeding for Spaceborne SAR Applications

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Abstract

A novel X-band 4 × 4 conformal microstrip patch antenna array using corporate series feeding technique is presented in this paper. A new concept of feeding network with parallel and series feeding is demonstrated. The amplitude weighting distributions and significant power dividing ratio can be resolved by the suggested feeding network. The proposed conformal antenna is designed at 9.65 GHz frequency and it achieved a bandwidth of 128 MHz, return loss is $|S11| < -15$ dB and a gain of 14.2 dBi. The total size of the array is 122 × 110 × 0.8 mm.

1. Introduction

Synthetic Aperture Radar (SAR) systems are made up of a number of modules, including transmit and receive modules, which are critical to the radar's operation. These antennas arrays are frequently used in spaceborne SAR applications due to their operational adaptability, which allows for a range of operation modes. SAR will provide regionally and spatially data for analyzing the changes in Earth atmosphere. Despite the lower cost, feeding networks are more important than other subsystems. Synthetic aperture radar is mounted on a moving platform and images are analyzed by using image processing techniques [1].

The popularity of conformal antennas has surged in recent years. Conformal integration is important and necessary for space applications. In [2], designing of conformal antennas with better performance are presented. Microstrip patch array antennas find extensive usage across various applications due to their excellent antenna performance, compact size, shallow profile, and cost-effectiveness. To minimize the radar cross section by using non-planar structures are reported in [3]. Conformal antenna for aircraft applications is presented in [4]. In [5], [6], [7], designing of conformal antennas are presented with different radius on a cylindrical structure and studied. The parameters performance is analyzed at different radius. In [8], [9], a series feed and corporate feed X band antenna array is designed respectively. In [10], [11], a shared aperture antenna array is designed at C and X-bands.

By combining parallel and series feed networks, it is possible to create a novel feed network that addresses the drawbacks of both individual configurations. In this paper, a corporate series fed X-band 4 × 4 conformal microstrip antenna array is presented.

2. Antenna Array Structure

This section describes antenna array design configurations. Conformal microstrip antennas gives better prominence for space applications. The operating frequency of antenna array is 9.65 GHz. The proposed antenna array simulations were done using CST software. Arrays use a 0.7λ antenna spacing. The proposed designs use the RT/Duroid-5880 substrate with a loss tangent of $\tan\delta = 0.0009$ and a relative permittivity of $\varepsilon r = 2.2$.

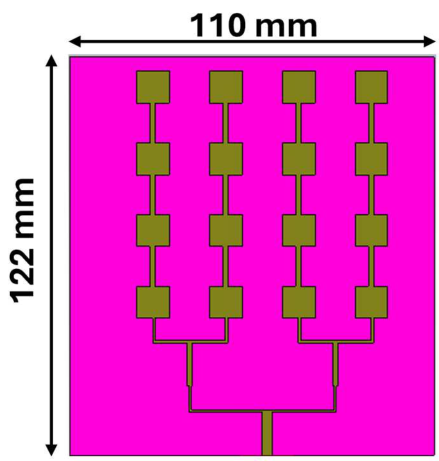

Figure 1. Design configuration of planar 4x4 X-band corporate series fed.

Figure 1 shows the planar 4x4 microstrip antenna array structure. Later this antenna is bent on a cylindrical structure to form a conformal antenna. The radius of cylinder is 60 mm. Figure 2 and Figure 3 shows front view and side view of 4x4 conformal corporate series feed.

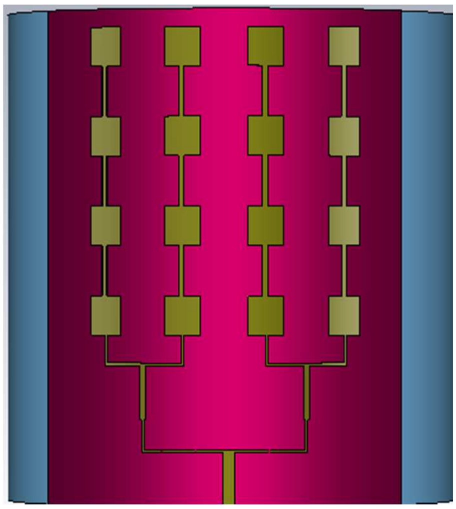

Figure 2. Front view design configuration of conformal 4x4 X-band corporate series fed.

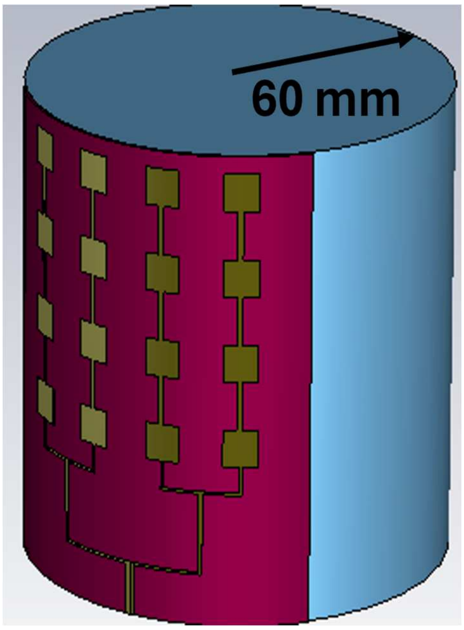

Figure 3. Side view design configuration of conformal 4x4 X-band corporate series fed.

3. Results and Discussion

The proposed design of 4x4 antenna array is simulated using CST software. The simulations are carried at X-band frequency 9.65 GHz. Figure 4 demonstrates the simulated surface current distribution. Figure 5 shows the return loss for the planar and conformal structures. The obtained return loss for the planar array is -20 dB and -15 dB for the conformal antenna array. The impedance bandwidth for the planar array is 150 MHz and 128 MHz for the conformal array.

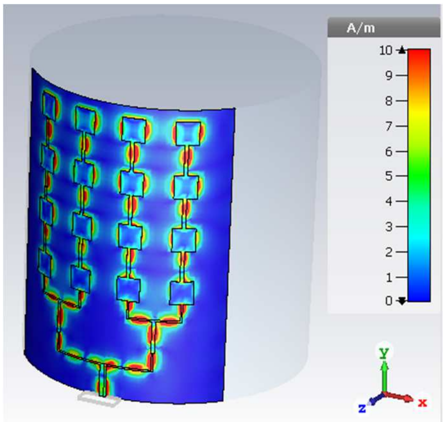

Figure 4. Surface current distribution of conformal 4x4 X-band corporate series fed.

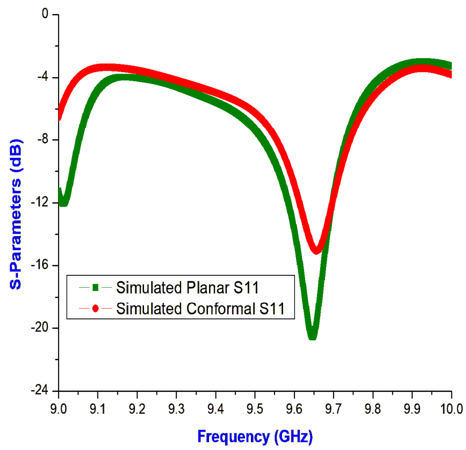

Figure 5. Simulated S-parameters of planar and conformal 4x4 X-band corporate series fed.

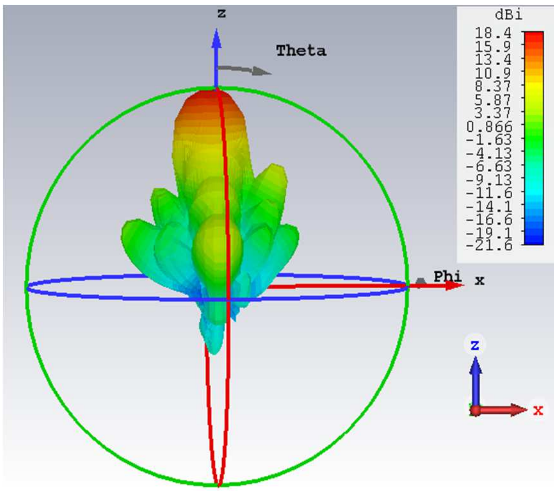

Figure 6. Simulated planar 4x4 far field gain

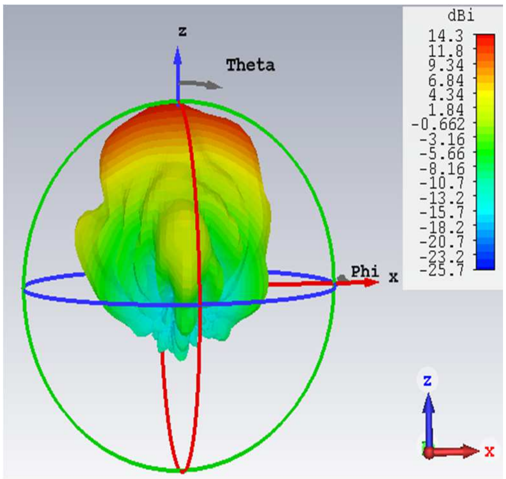

Figure 7. Simulated conformal 4x4 far field gain

Figure 6 demonstrate gain for planar antenna array. It achieved a gain of 18.4 dBi and SLL is -12 dB. Figure 7 demonstrate the gain for conformal antenna array. It achieved a gain of 14.2 dBi and side lobe level is -11 dB. The gain is slightly reduced due to conformal nature.

4. Conclusion

This research paper describes a 4 × 4 conformal microstrip patch antenna array with corporate series feeding network. The proposed design includes a smaller loss in the gain as compared with planar structure. This type of conformal antennas is required to reduce the radar cross section in space borne radars. The proposed antenna array is widely used in stealth technology applications. This work can be extended for the development of SAR on unmanned aerial vehicles.

5. References

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