Design and Analysis of 4 Group X-Band Corporate feed and 5 element Series Feed C-Band Shared Aperture Antenna Array for Spaceborne Synthetic Aperture Radar Applications

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Abstract

A dual-band C/X linear polarized shared aperture antenna (SAA) for spaceborne SAR applications is presented in this paper. The five-element series feeding C-band and the four group X-band corporate feeding form the planar SAA structure. The antenna's performance properties are evaluated. The proposed design achieved a bandwidth of 50 MHz and gain of 12.1 dBi for the C-band. For the X-band 305 MHz bandwidth and 12.7 dBi gain is attained. The total size of the SAA array is 110 x 106 × 0.8 mm.

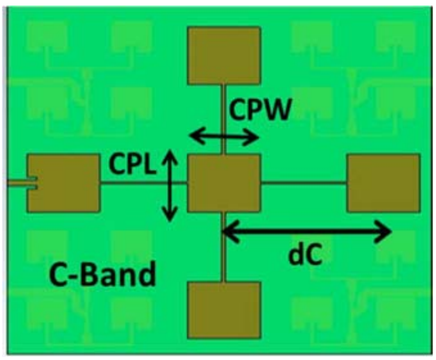
1. Introduction

Synthetic Aperture Radar (SAR) generates high resolution images of Earth's surface in day and night weather by using microwave signals. SAR systems are made up of a number of modules, including transmit and receive modules, which are critical to the radar's operation. These shared aperture antennas are necessary for large apertures, such as those seen in space and military surveillance radars. Radar is capable of scanning clouds and darkness, allowing SAR to collect data day and night in any conditions. SAR data will be used for analysing the changes in Earth's atmosphere. Microstrip patch array antennas find extensive usage across various applications due to their excellent antenna performance, compact size, shallow profile, and cost-effectiveness. A dual-band microstrip antenna array is presented in [1] for SAR applications. This array is multi-layered shared-aperture with dual polarized antenna and it provides excellent isolation. In this paper [2], a dual band shared aperture antenna with 3.5 GHz and 28 GHz is proposed. The single MW element and the 4 × 2 MMW array gives 6.9 and 14.6 dBi gain. This article presents a X/Ka band shared aperture antenna with high gain [3]. It provides a gain of 14.8 dBi/24.4 dBi at X/Ka-band. In this paper [4], 2x2 L-band is interleaved with 12x16 X-band array.

A C/X dual band shared aperture antenna with 1:1.8 frequency ratio is used in SAR applications [5]. A simple method for developing L-band microstrip patch antenna is described in [6]. The gain achieved is >14 dBi. In [7], a new approach to deploy dual circular polarization shared-aperture planar array antennas is presented. A 4 × 4 antenna array is fabricated in the X/Ku band. A new method to achieve a circularly polarized single feed is presented [8]. It includes a 2x2 array of C-band and a 4x4 array of X-band. New slot element designs and new array antenna configurations for L- and X-band synthetic aperture radar are presented in [9]. A K/Ka-band shared aperture antenna is presented in [10]. This antenna provides more than 40 dB of isolation at K/Ka-band. In [11], work presents about designing of several shared aperture antennas. In [12], [13], series feed and corporate feed X band antenna array is designed. In [14], [15], C/X-band shared aperture antenna is presented with linear polarization.

2. Design of Shared Aperture Antenna

This section describes the designing of shared aperture antenna with different feeding networks. Patch antenna provides better performance and they are utilized in different space programmes. A combined C/X-band shared aperture antenna is designed with 4 Group X-Band corporate feeding and 5 Element series feeding in C-band. Each group in the X-band is structured as a four-element (2 × 2) array with corporate feeding on a single layer. The operating frequency of C/X-band is 5.35/9.65 GHz. The simulations were done by using CST. Arrays use a 0.7λ antenna spacing. The proposed designs uses the RT/Duroid-5880 substrate with a loss tangent of tanδ = 0.0009 and a relative permittivity of εr = 2.2.



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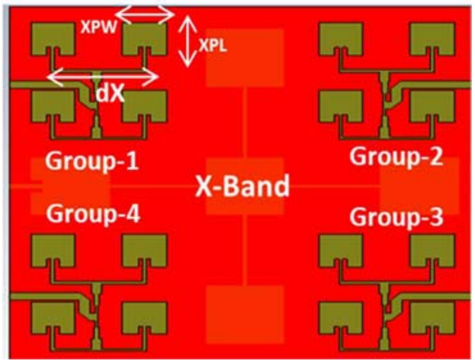

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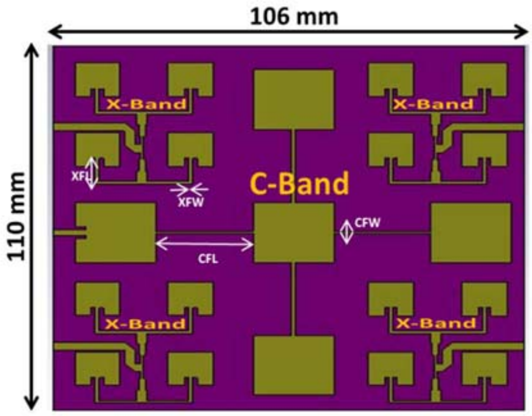


(c)

Figure 1. Design of shared aperture antenna : (a) C-band series feed antenna design (b) X-band corporate feed antenna design (c) C/X-band SAA design.

Figures 1 (a) and 1 (b) illustrate the design of series feed C-band antenna and design of corporate feed X-band. Then both antennas are combined to form a single aperture. Figure 1 (c) shows the design of a C/X-band SAA. Table 1 lists the optimal values of C/X-bands.

Table 1: C/X-band optimized parameters

C-Band		X-Band	
Parameter	Value (mm)	Parameter	Value (mm)
CPL	18.10	XPL	10.12
CPW	18.10	XPW	10.12
CFL	21.90	XFL	5.5
CFW	0.7	XFW	0.85
dC	40	dX	22

3. Results and Discussion

The proposed antenna design is simulated at C-band 5.35 GHz and X-band 9.65 GHz. All simulations are run in the CST Microwave Studio. Figure 2 describes the C-band electric field distribution of SAA. Figures 3 (a), (b), (c), and (d) depict the X-band electric field distribution of SAA at for Groups: 1, 2, 3, and 4.

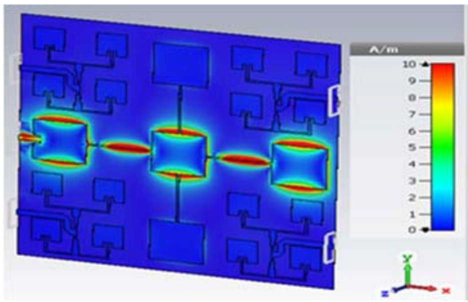
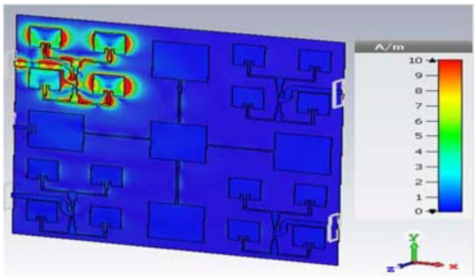


Figure 2. C-band surface current distribution



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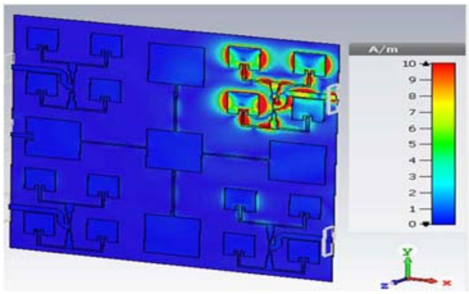

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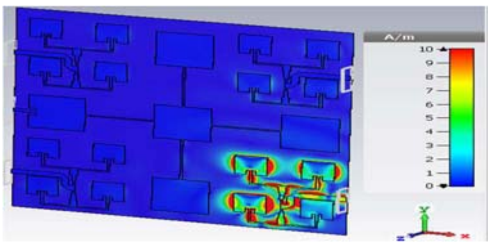

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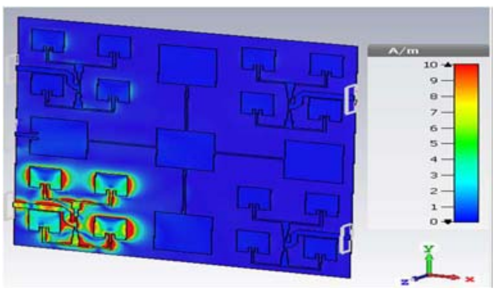

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Figure 3. X-band surface current distribution (a) Group-1 (b) Group-2 (c) Group-3 (d) Group-4.

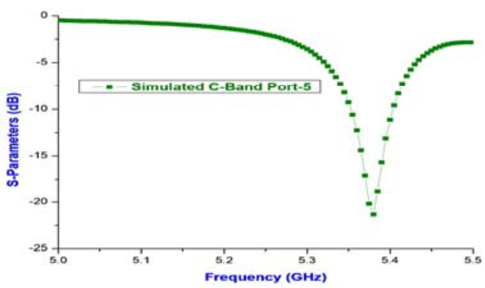


Figure 4. Simulated C-band S-parameters of SAA

Figures 4 and 5 demonstrate the simulated return loss for the C and X bands. The impedance bandwidth and return loss for C-band planar array is 50 MHz and -21.3 dB, Similarly X-band planar array return loss and impedance bandwidth is -21.8 dB and 300 MHz for Group-1, -24.7 dB and 305 MHz for Group-2, -21.2 dB and 303 MHz for Group-3, and -23.5 dB and 296 MHz for Group-4.

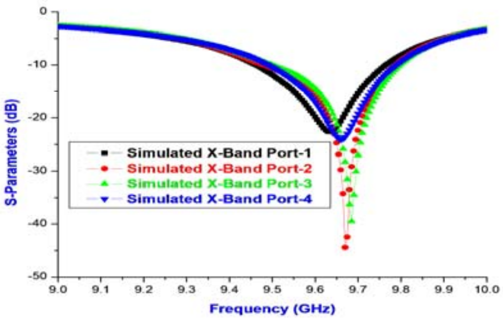


Figure 5. Simulated X-band S-parameters of SAA

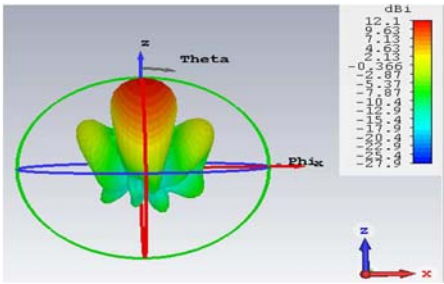
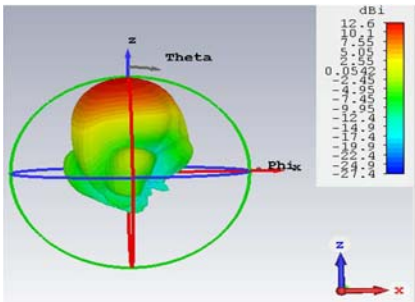
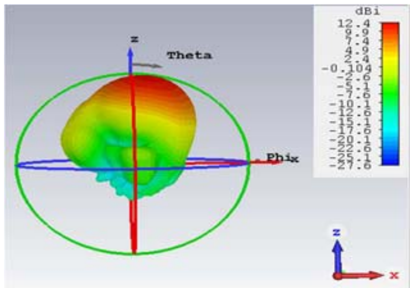


Figure 6. C-band simulated far field gain of SAA



(a)



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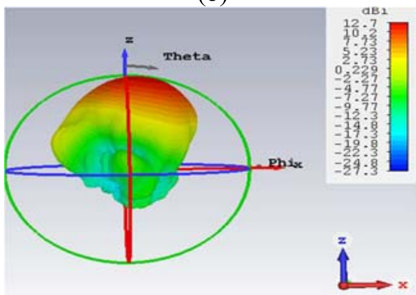

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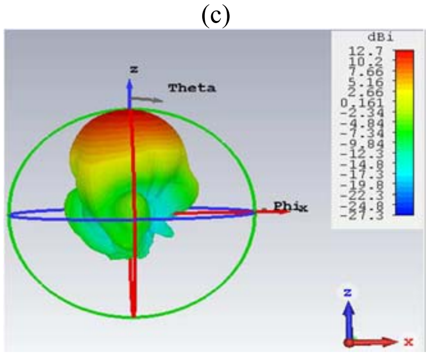

(d)

Figure 7. X-band simulated far field gain of SAA at (a) Group-1 (b) Group-2 (c) Group-3 (d) Group-4.

Figure 6 demonstrates the C-band simulated far-field gain. The gain and side lobe level are 12.1 dBi and -25.6 dB for C-band. Figure 7 illustrates the X-band simulated far-field gain. The simulated gain and SLL are 12.6 dBi & -13.3 dB for Group-1, 12.4 dBi & -15.5 dB for Group-2, 12.7 dBi & -13.5 dB for Group-3, and 12.7 dBi & -13.9 for Group-4, respectively. Summary of simulated results is in Table 2.

Table 2: Simulated Results

Parameters	C-Band	X-Band			
Array Type	5 Elements Series feed	4 Elements Corporate feed			
		Group 1	Group 2	Group 3	Group 4
Return Loss (dB)	-21.3	-21.8	-24.7	-21.2	-23.5
Bandwidth (MHz)	50	300	305	303	296
Gain (dBi)	12.1	12.6	12.4	12.7	12.7
SLL (dB)	-25.6	-13.3	-15.5	-13.5	-13.9
size	$110 \times 106 \times 0.8$ mm^3				

4. Conclusion

This paper presents the design of C/X-band shared aperture antenna on a single layer for spaceborne SAR applications. The proposed SAA has various benefits. This antenna has high gain and a low sidelobe level. These antenna arrays are designed majorly for space and military surveillance radars, must be used with large apertures. The suggested antenna array can be used in stealth technology applications, including deployment on aircraft and spacecraft.

5. References

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