Dual-wideband And Dual-polarized Shared Aperture Antenna

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1. Introduction

Dual-band dual-polarized (DBDP) antennas can offer a lot of advantages for Remote Sensing applications. The dual-band operation of the antennas can provide frequency diversity to such sensors. Dual-polarization operation can enhance the information content by providing two co-polarization and two cross-polarization back scatter information. By sharing the same antenna aperture, the overall size and weight of the array can be reduced. Microstrip antenna is usually selected for such work for its low profile and simplicity in fabrication. Therefore, a number of DBDP shared-aperture antenna arrays based on microstrip patch technology have been proposed and studied. The typical configuration of DBDP array includes perforated patches and patches [1,2], interlaced slot/dipole with patch[3-5].

The configuration of interlaced slot/dipole with patches is attractive because the lower frequency band elements (slot/dipole) can be easily placed between two higher frequency band elements; regardless of the frequency ratio between higher and lower frequency. An example is the DBDP array of L/C-band interlaced slots with patches. [3]. Another example is an S/X-band array composed of interlaced dipoles with patches which is proposed by Zhong S.S *et al* [5]. However, as the space between the higher frequency band elements is very small for lower frequency band elements, the bandwidth of the lower frequency band is usually narrow. If the frequency ratio between higher frequency and lower frequency is a multiple of 2, the patches and perforated patches configuration may be more attractive. A C/X and L/X shared aperture array designs with the configuration of perforated patches and patches are presented in [1] and [2]. Both of the two arrays have good performances, including VSWR and patterns.

In this paper, a wideband dual polarization L/X-band shared aperture antenna is presented. As the frequency ratio is about 8, the configuration of perforated patch and patch antenna is selected. To increase the bandwidth, stacked patch antennas are used for both L- and X- bands. The antenna consists of one antenna element for L-band and an 8×8 planar array for X-band. To obtain good patterns over the whole frequency band, corporate feed network is used in the X-band array. The element with high isolation and low cross polarization characteristics introduced in [6] was used in the X-band array.

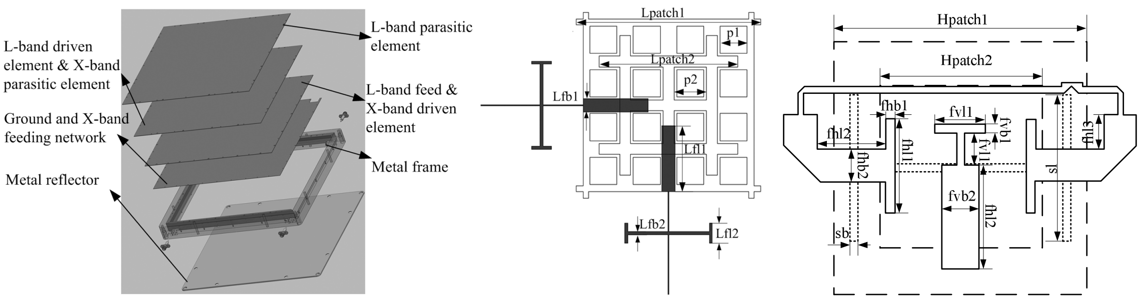


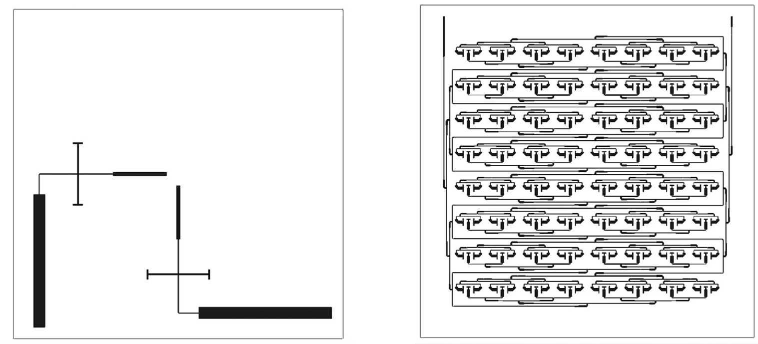
Figure 1. Configuration of the antenna (a) exploded view, (b) L-band element, (c) X-band element

2. Design of Antennas

The configuration of the proposed antenna is shown in Figure 1. The antenna consists four Taconic TLY-5 substrate (ε_r=2.2) layers. From top to bottom, the first layer is 0.787mm thick for

L-band perforated parasitic patch. The L-band perforated driven patch and X-band parasitic patches are echoed on the top of the second layer, whose thickness is also 0.787mm. The third layer is used for X-band driven patches and L-band microstrip feeding lines. The last layer is for the ground plane with the slots for X-band on the top and for the feeding network for X-band on the bottom. These substrate layers are supported by the plastic blocks which are fixed in a metal frame. The plastic blocks are also used to separate the substrate layers, so several air layers between substrate layers are formed. From top to bottom, the thicknesses of the air layers are 6mm, 4mm and 2mm respectively. To ensure the antenna immune to the platform effect, a metal reflector is placed behind the antenna, which is 8mm from the ground of the antenna.

As seen in Figure 1, the L band patch is proximity-coupled by the microstrip line. The X band patches are excited by slots in the ground plane, which is in turn coupled by the microstrip line below the ground. The feed lines for L-band and X-band antenna are place on the opposite side of the ground, which improves isolation between the two bands. The slot designs for the orthogonal polarization in the X-band design are dissimilar. For the horizontal polarization the slots are place on the edge, and for the vertical polarization the slots are place on the center, which has been introduced in [6]. The details of the antenna element dimensions are given in Table 1.



(a) (b)

Figure 2. Configuration of the feeding network for the array (a) L-band, (b) X-band

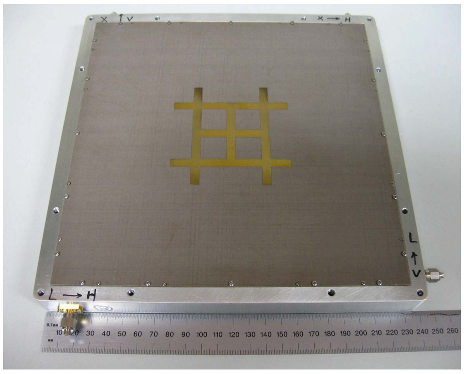


Figure 3. Photograph of the antenna

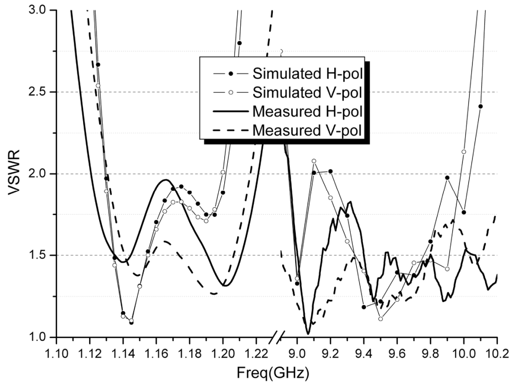


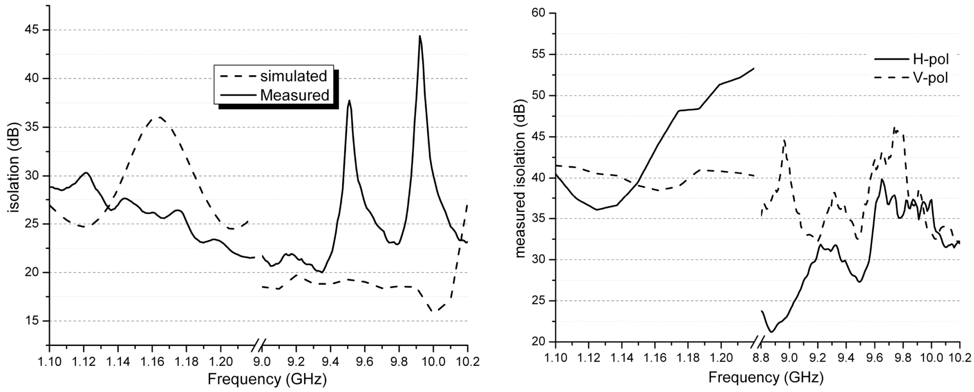
Figure 4. Measured and simulated VSWR of the antenna

Table 1: Dimensions of the antenna and its feeding lines

Symbol	Size	Symbol	Size	Symbol	Size
Lpatch1	96 mm	Lfb2	1.6 mm	fvl1	2.7 mm
Lpatch2	76 mm	Hpatch1	11.4mm	fvl2	1.7 mm
p1	15 mm	sb	0.5 mm	fvl3	5.5 mm
p2	18 mm	fhl1	5.0 mm	fhb1	0.5 mm
Lfl1	36 mm	fhl2	3.6 mm	fhb2	2.2 mm
Lfl2	11 mm	fhl3	1.8 mm	fvb1	0.5 mm
Lfb1	7.3 mm	sb	0.5 mm	fvb2	2.0 mm

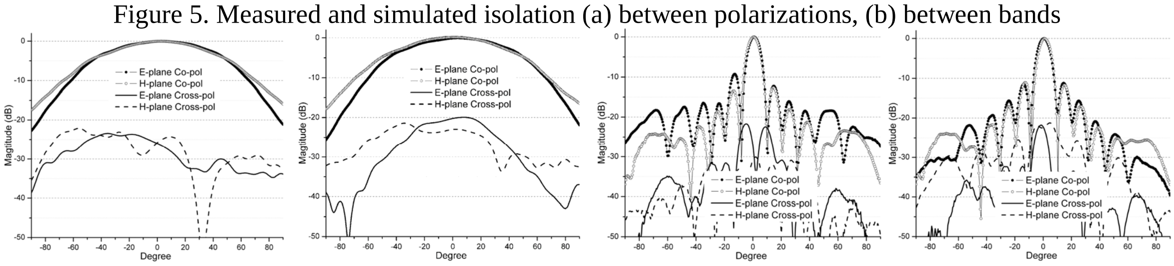
The layout of the feeding line for L-band and the feeding network for X-band are shown in Figure 2. Corporate feed network is adopted in X-band to ensure good patterns over a wide frequency band. Two-step impedance transformers are used to transform the impedance from 50 Ω to 100 Ω. The characteristic impedances of the two transmission line are 59.5 Ω and 84.1 Ω respectively. Each the length of the transmission line of the impedance transformer is ¼λg. However, as the space between the elements is limited, the transmission lines in the feeding network are very close to each other. The resulting coupling between adjacent transmission lines makes the transmission lines' characteristic impedance vary somewhat at different locations. In this design, this coupling is considered and each part of the transmission line is carefully adjusted.

3. Results of the antenna

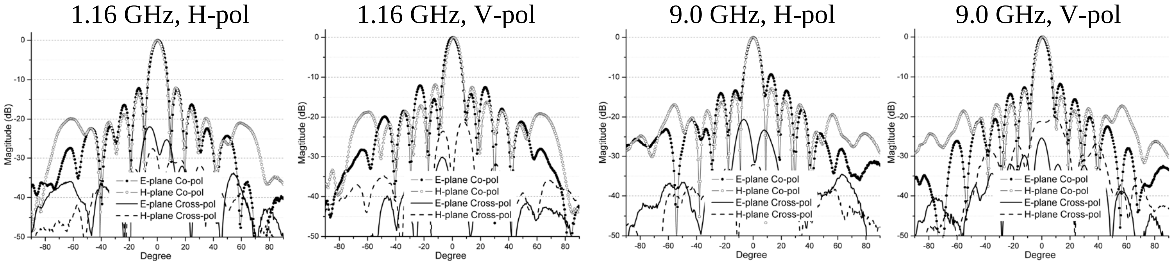


(a) (b)

Figure 5. Measured and simulated isolation (a) between polarizations, (b) between bands



1.16 GHz, H-pol 1.16 GHz, V-pol 9.0 GHz, H-pol 9.0 GHz, V-pol



9.6 GHz, H-pol 9.6 GHz, V-pol 10.0 GHz, H-pol 10.0 GHz, V-pol

Figure 6. Measured radiation patterns of the antenna

An antenna prototype was built and its photo is presented in Figure 3. The size of the antenna is about 240 × 240 × 25 mm^3. There are a total of 4 ports for the antenna. Port 1 is for X-band vertical polarization, Port 2 is for X-band horizontal polarization, Port 3 is for L-band horizontal polarization and Port 4 is for L-band vertical polarization. The simulated and measured results of the antenna are introduced in below.

The antenna was simulated via HFSS 12.1and the measured results are obtained from the Agilent N5244A vector network analyzer. The measured and simulated VSWR results of all the four ports are presented in Figure 5. It is seen that the measured VSWR of the antenna is less than 2.0 in the bands of 1.126 - 1.217 GHz & 9.0 - 10.2 GHz. The measured results agree with the simulated results well. The measured bandwidth is a little wider than the simulated bandwidth, which may be attributed to the losses in the material and the feed network. Figure 5(a) gives the measured and simulated isolation between orthogonal polarizations results both in L- and X-bands. It is seen that the measured isolation of the antenna is higher than 20 dB in both L- and X-bands. Figure 5(b) gives the measured isolation between the L- and X-bands results. Rigorously, there are two kinds of isolation measurements: for co-polarization and cross-polarization. As expected, the isolations between two cross-polarization ports in L- and X-bands are the higher, therefore only the co-polarization isolation is given. It is seen that in the worst case, isolation is about 25dB.

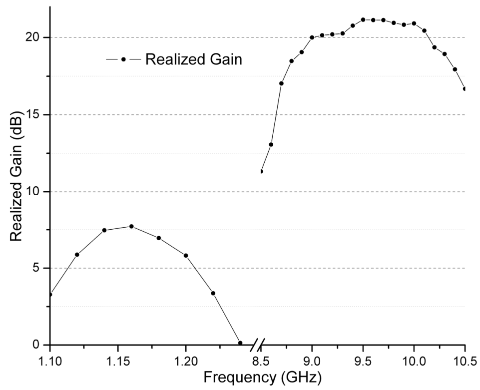


Figure 9. Measured gain of the antenna.

The radiation patterns are also measured. As the patterns in L-band are consistent over the frequency band, only the normalized patterns at centre frequency point (1.16 GHz) for L-band are presented, and patterns at 3 frequency points (9.0 GHz, 9.6 GHz and 10.0 GHz covering the X-band design) are given in Figure 6. It seen that the patterns for both H-pol and V-pol are good and all the cross-polarization results are less than -20 dB. Figure 7 gives the measured realized gain over the whole frequency band. The gain varies from 5.8 to 7.7 dB and from 20.0 to 21.2 dB in L- and X-band respectively.

4. Conclusion

A dual-band and dual-polarized stacked shared aperture patch antenna with low cross-polarization and high isolation is presented. Different slot and feeding types are used in the X-band antenna design to improve the cross-polarization and isolation. Corporate feeding networks are selected for both L- and X-band antenna and the coupling between the transmission lines in the network is considered in the network design. The prototype antenna is fabricated and measured. The performances of antenna (including VSWR, isolation and cross polarization) are good over the bands of 1.13-1.22 GHz and 9.0-10.0 GHz, even the VSWR bandwidth is wider in X-band.

References

[1] L. L. Shafai, W. A. Chamma, M. Barakat, P. C. Strickland and G. Seguin, “Dual-band dual-polarized perforated microstrip antennas for SAR applications”, IEEE Transactions on Antennas and Propagation, vol. 48, no. 1, 2000, pp: 58-66

[2] D. M. Pozar, S. D. Targonski. “A shared-aperture dual-band dual-polarized microstrip array”, IEEE Transactions on Antennas and Propagation, 2001, 49(2): 150-157

[3] R. Pokuls, J. Uher and D. M. Pozar, “Dual-frequency and dual-polarization microstrip antennas for SAR applications”, IEEE Transactions on Antennas and Propagation, vol. 46, no. 9, 1998, pp: 1289-1296

[4] X. Qu, S. S. Zhong and Y. M. Zhang, “Dual-band dual-polarized microstrip antenna array for SAR applications”, Electronics Letters, vol. 42, no. 24, 2006, pp: 1376-1377

[5] S. S. Zhong, X. Qu, Y. M. Zhang and X. L. Liang, “Shared-aperture S/X dual-band dual-polarized microstrip antenna array”, Chinese Journal of Radio Science, vol. 23, no. 2, 2008, pp:305-309 (in Chinese)

[6] S.G. Zhoua and T.H. Chio, "Dual linear polarization patch antenna array with high isolation and low cross-polarization", IEEE International Symposium on Antennas and Propagation, 2011, pp: 588-590