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Hybrid Subarray Configuration of Microstrip Patches and Dielectric Resonators: New Possibility of Realizing Wideband Array Antennas

Chandreyee Sarkar*(1) and Debatosh Guha(1)
(1) Institute of Radio Physics and Electronics, University of Calcutta, 92, A. P. C. Road, Kolkata-700009, India

Abstract

This work explores a new possibility of an advanced array design by reconfiguring the radiating antenna elements. Unlike, conventional arrays, in here we have excited an equal combination of metallic and non-metallic radiating elements together by a corporate feed network. Circular microstrip and cylindrical dielectric resonators have been considered for the present work. The proposed design exhibits remarkable improvement in bandwidth by 100% compared to its homogeneous microstrip or dielectric versions maintaining comparable radiation features. A prototype has been experimentally studied to validate the proposition.

1. Introduction

The last two decades have witnessed remarkable advancement in the domain of low profile antennas, namely microstrip patch antennas as well as dielectric resonator antennas (DRAs), covering a wide range of microwave and wireless applications [1-2]. Microstrip arrays are widely in use for the industrial and practical applications [3-5]. DRA arrays, being inherently a bit wider in bandwidth, have also gained popularity over the last decade [6-9]. However, one of the major concerns while designing an array is the antenna bandwidth. Though arrays are capable of producing high-gain characteristics, bandwidth enhancement using unperturbed/simple structures have always remained a challenge.

This investigation for the first time identifies a new possibility of designing a wideband array employing equal share of microstrip patch and dielectric resonators as the radiating elements. The study incorporates a design, its characterization, and experimental studies. This ensures the salient features increment of bandwidth by 100% maintaining over 20 dB co-cross pol isolation and comparable peak gain with its conventional versions bearing either microstrip patches or dielectric resonator elements.

2. The Configuration

The idea of the microstrip patch and DRA hybrid array has been depicted through Figure 1. A 2 × 2 subarray unit is shown in Figure 1. Rectangular apertures etched on an RT Duroid 5870 substrate are excited by a corporate feed line. Two units of cylindrical dielectric resonator blocks shaped from an Ecostock HIK material with ε_r=10 and two units of circular microstrip patches have been used to realize a prototype shown in Figure 2. The prototype has been fabricated using our in-house facilities and studied experimentally. Some representative results indicating the characteristics features and comparative superiority have been furnished in the following section.

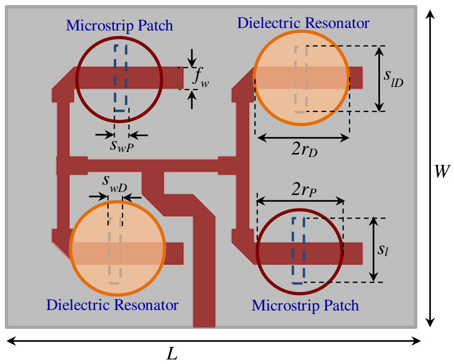


Figure 1. Schematic representation of the corporate-fed proposed 2 × 2 subarray unit.

Figure 2. Fabricated prototype of the proposed hybrid subarray unit

3. Design, Experiment, and Characterization

The antenna characteristics have been initially examined using a commercially available EM tool [10]. Figure 3 shows the impedance characteristics of the proposed sub-

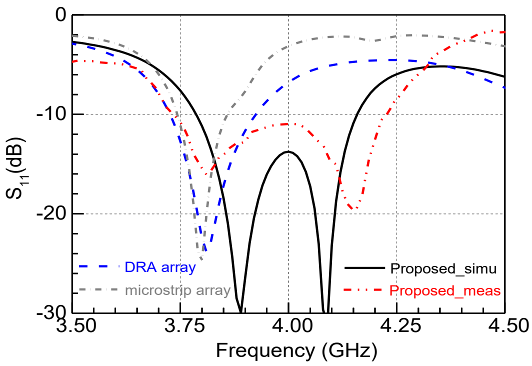
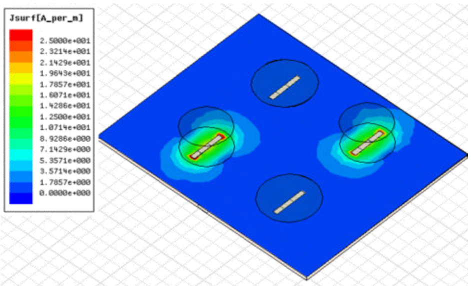
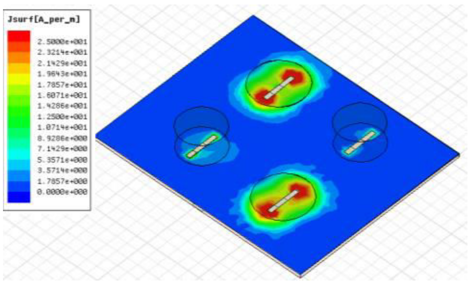


Figure 3. Comparison of simulated and measured S_{11} characteristics of the proposed 2 × 2 subarray unit with the conventional microstrip and DRA array. Parameters: $r_D=h=10$, $r_P=11$, $W=80$, $L=100$, $s_{lD}=s_{lP}=14$, $s_{wD}=s_{wP}=2$, $f_w=4.8$ (all dimensions in mm).



(a)

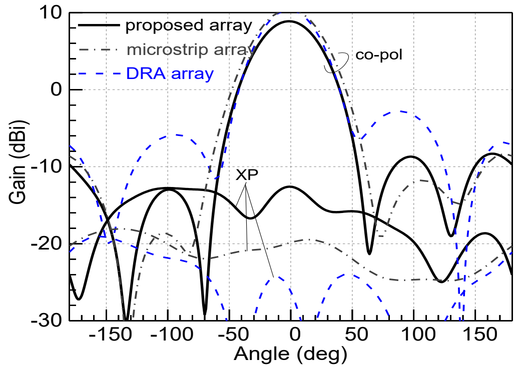


(b)

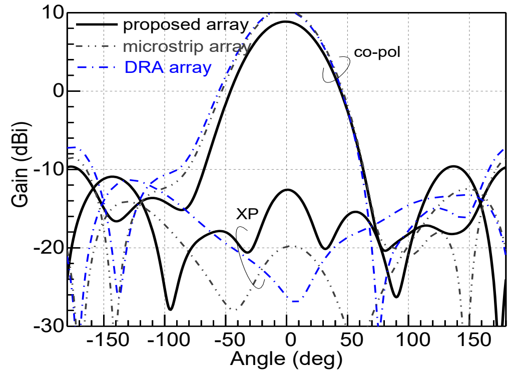
Figure 4. Ground plane currents of the proposed array at (a) first resonance and (b) second resonance.

array and compares the same with those of identical counterpart using only 2 × 2 patches or only 2 × 2 DRAs.

The proposed subarray resonates around 4 GHz, spanning over 3.79 GHz to 4.16 GHz. This is closely corroborated by the measured results ensuring two adjacent resonances and about 9.3% matching bandwidth. It is important to note that the identical array by pure microstrip patch or DRA can provide a maximum of 4.5 % matching bandwidth, indicating 100% improvement in the proposed configuration.



(a)

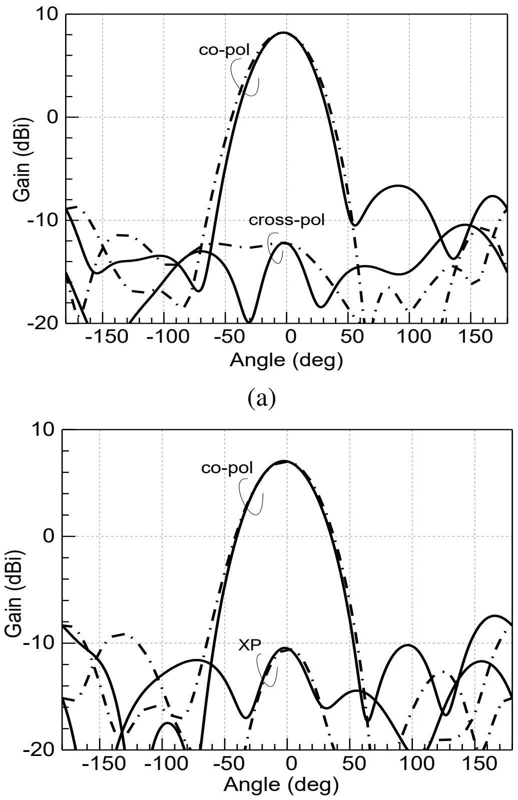


(b)

Figure 5. Radiation characteristics at the first resonance of the proposed 2 × 2 subarray compared with 2 × 2 microstrip and DRA arrays (a) E-plane and (b) H-plane. Parameters as in Figure 3

The resonances have been identified through a study shown in Figure 4. The ground plane current over the DRA footprints in Figure 4(a) clearly confirms that the first resonance is primarily due to the DRAs. While the ground plane current portrayed in Figure 4(b), which are taken at the same strength, indicates the second resonance is due to the microstrip patch elements.

The array far-field characteristics are studied through Figures 5–7. Figure 5 shows the radiation characteristics at the first resonance. It shows broadside uniform pattern with a peak gain of about 9.5 dBi. Both the E-plane and H-plane cross-pol (XP) peak is about -13 dBi. It also compares the same with that of a standard microstrip and DRA array. The main lobe beamwidth remains unchanged for both E and H-plane. Almost 5 dB improvement is observed in E-plane side lobe levels as compared to DRA arrays. The XP levels have increased significantly both across E and H-planes. However, 20 dB isolation is maintained throughout between the co-pol and XP peaks.
Figure 6(a) and (b) shows the radiation characteristics across the second resonance and midband of the hybrid subarray unit respectively. It reveals a similar pattern with 9 dBi peak gain and 20 dBi co-cross pol isolation. Figure 7 compares the gain over the full operating band with



(a)

(b)

Figure 6. Radiation characteristics at (a) second resonance at 4.09 GHz and (b) mid-band resonance at 4.0 GHz. Parameters as in Figure 3.

those of the traditional microstrip and DRA arrays respectively.

4. Conclusion

The study successfully proposes a new concept of designing hybrid arrays combining both metallic as well as non-metallic structures as radiators. Attentions towards improving the gain and XP levels are being targeted. The proposed array is two-times wider than the other conventional DRA or microstrip arrays, just at the cost of about 1.5 dBi peak gain.

5. Acknowledgements

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6. References

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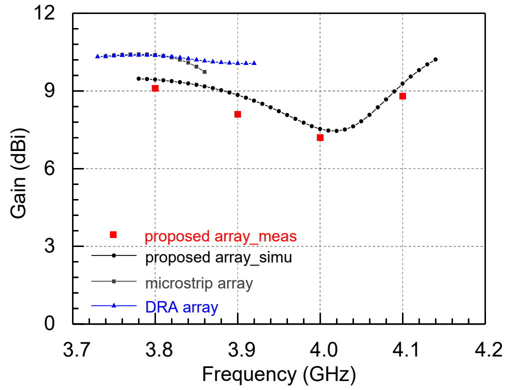

Figure 7. Comparison of the gain variation over the full operating band of the proposed array with 2 × 2 microstrip and DRA arrays.

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