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Dual-Polarized 3:1 Bandwidth Antenna Array with Inverted BoR Elements

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Summary

This paper presents a new type of 3:1 bandwidth array antenna based on inverted body-of-revolution (BoR) elements. The antenna elements are electrically similar to the conventional BoR elements, but they are manufactured by forming cavities inside dielectric material and metallizing their inner surface. The advantages of the new manufacturing technique are potentially cheaper fabrication cost, lower weight, and reduced profile of the element in comparison with conventional arrays. The possible drawbacks of the proposed antenna element are worse radiation efficiency and power-handling capability in comparison with its all-metal counterparts.

1. Introduction

The benefits of Vivaldi elements in wideband (WB) and ultra-wideband (UWB) antenna arrays are well known. There are numerous variations of the Vivaldi element, for example, the body-of-revolution (BoR) element [1], which are developed to improve some specific performance characteristics. In this paper, we describe the development of a new BoR antenna array variant, namely an inverted BoR array [1], [2].

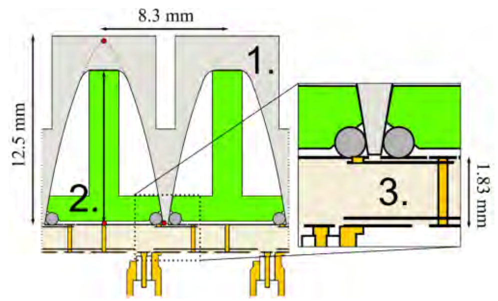
We present the antenna structure, analyze its operating principle, and compare its performance against conventional Vivaldi-type arrays. Prototypes covering 2–6 GHz and 6–18 GHz have been manufactured and their function verified in measurements.

2. Antenna Structure and Operating Principle

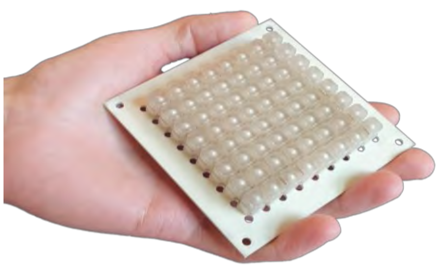
The operating principle of the inverted BoR antenna element is similar to that of a conventional BoR element array. The main electrical difference is the dielectric material in the tapered slot between the two antenna cones.

The complete antenna array covering 6–18 GHz [2], including the feeding structure, is depicted in Fig. 1. The antenna structure consists of three layers shown in Fig. 1(a):

1) A dielectric block of Rexolite with silver-plated BoR-shaped cavities;
2) A connection layer with canted coil springs to electrically connect the cavity walls and the feeding PCB;
3) The feeding PCB that contains contact pads, balun, and SMPS connectors. The canted coil springs of the connection layer are supported by plastic inserts that press the spring toward the cavity walls and the PCB.



(a)



(b)

Figure 1. (a) A cross-section of one antenna element and (b) an assembled prototype array covering 6–18 GHz [2].

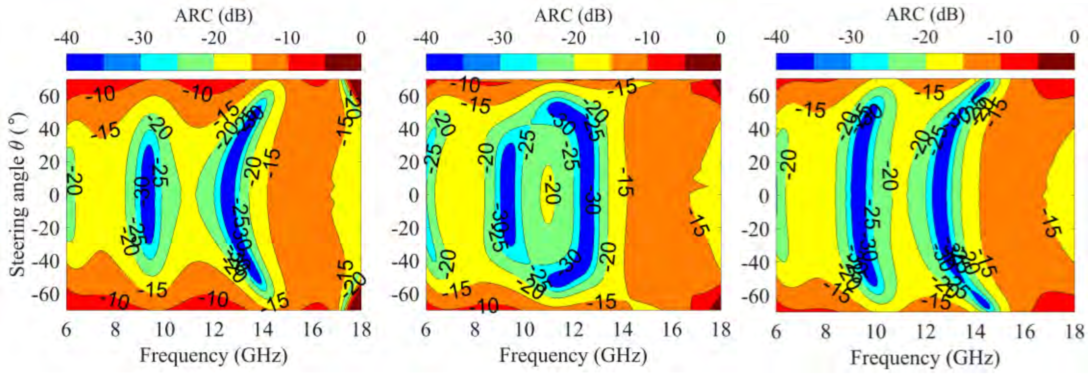
The shaped dielectric material of the 6–18 GHz array has three effects on the electrical performance [2]: 1) Due to the dielectric material, the wavelength is shorter in the tapered slot than in free space, reducing the profile of the element. 2) The grooves in the upper part of the dielectric block shape the radiated wavefronts. Thus, the radiated wavefronts are more spherical affecting the active reflection coefficient and the embedded element pattern. 3) The grooves also add an impedance step to the tapered slotline which results in improved impedance matching. Due to these properties, the antenna height, beam-steering range, and impedance bandwidth are excellent in the class of tapered slot antennas.

The concept has also been proven with a 2–6 GHz variant [3]. The design is slightly different, with a very light dielectric block of Rohacell 71 HF (corresponding to 1. in Fig. 1(a)) and a different connection layer (see 2. in Fig. 1(a)). The 2–6 GHz array is optimized for low weight and the 6–18 GHz variant (depicted in Fig. 1) is optimized for low profile.

3. Measurement and Simulation Results

The antenna array element was designed in CST Studio Suite using the unit-cell boundary condition. Thus, the simulation results correspond to the typical antenna element in a large antenna array.

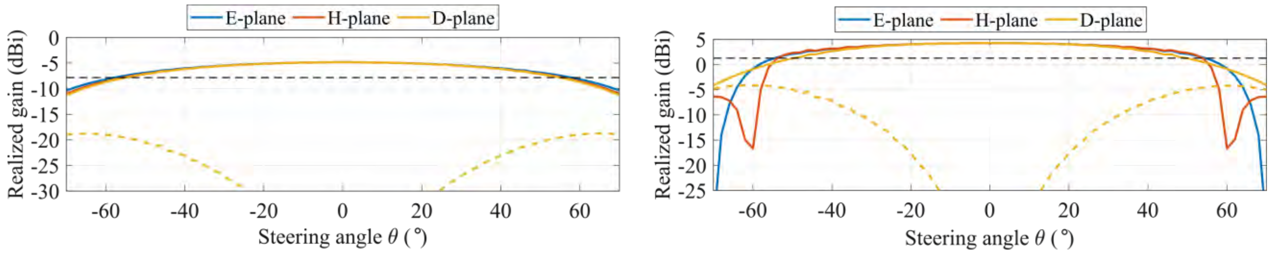
The simulated active reflection coefficient (ARC) across the frequency range of operation and steering angles is shown in Fig. 2. The results are given in the E-plane, H-plane, and intercardinal D-plane. It is shown that the proposed array element can steer the beam up to 50° with ARC < -10 dB over the complete system bandwidth of 6–18 GHz.



(a) (b) (c)

Figure 2. Simulated active reflection coefficient of an infinite array in (a) H-plane, (b) E-plane, and (c) D-plane [2].

Another important parameter, the embedded element pattern (EEP), is shown in Fig. 3. Simulations show that the scan loss of the co-pol component at 18 GHz is less than 3 dB up to 50° in H-, E-, and D-planes. Furthermore, the cross-polarization levels are lower than typically with the conventional BoR antennas, due to the relatively low profile of the antenna element [2].



(a) (b)

Figure 3. Simulated EEP of an infinite array at (a) 6 GHz and (b) 18 GHz [2]. Solid lines show the co-pol patterns, dashed, yellow lines are the cross-pol pattern in the D-plane, and black, dashed lines show the 3-dB scan loss level.

5. Acknowledgements

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References

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