High Gain Antenna with Improved Radiation Bandwidth using Dual 1-D EBG Resonators and Array Feed

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A high gain antenna made from dual 1-D electromagnetic bandgap (EBG) resonators is described. The combination of dual resonators with an array feed achieves a wide radiation bandwidth, thereby addressing a major limitation of EBG resonator antennas in general. The proposed antenna uses an array of 32 slots and a stripline corporate feed network to deliver energy to the dual resonator structure. Preliminary theoretical results on radiation patterns and gain of the antenna are discussed. Performance is compared with a classical 1-D EBG resonator antenna containing a single source to highlight the improvement in radiation bandwidth of the proposed configuration.

Introduction

EBG resonator antennas typically consist of an EBG material placed a half-wavelength above a ground plane containing a single source. The EBG material and ground plane forms a single resonator that acts as a spatial filter to the source and creates highly directional radiation characteristics. Several different types of EBG materials have been used to create these antennas, and the materials may be classified according to the dimensionality of the periodicity (ie 1-D, 2-D or 3-D). Various examples of resonators using 1-D [1-3], 2-D [4] and 3-D [5] EBG materials have been reported in the literature. It has also been shown that a frequency selective surface may be used to create a partially reflective surface instead of an EBG material to obtain an antenna with similar directive properties and a lower profile [6]. A major limitation common to all of these resonator antenna configurations is the low radiation bandwidth due to the high Q factor of the resonator structure. In cases where the Q factor is lowered to increase the radiation bandwidth, the directivity will decrease in proportion to the change. A recent paper showed that using an array of microstrip patches leads to a moderate increase in radiation bandwidth [7]. We demonstrate a technique for further increasing the radiation bandwidth of an EBG resonator antenna by using a dual resonator structure in combination with an array feed.

Antenna Configuration

The configuration of the proposed dual resonator 1-D EBG antenna is shown in the cutaway drawing of Fig. 1. It consists of two layers of Rogers TMM4 (ε_r=4.4, tan δ =0.002) and one layer of TMM3 (ε_r=3.3, tan δ =0.002) placed above a ground plane containing an array of 4x8 slots. The use of dual resonators increases the normal incidence transmission bandwidth through the EBG material from 0.5% (for a single resonator three-layer structure) to 9%. Hence the dual resonators enable the EBG material to act as a spatial filter over a wider range of frequencies, which increases the radiation

1-4244-0123-2/06/$20.00 ©2006 IEEE

bandwidth of the antenna. The slot spacing of the array corresponds to a half wavelength in the *x*-direction at 12.1GHz and a full wavelength in the *y*-direction. The slots are fed by a stripline feed network shown in Fig. 2, which is essentially a 32-way power divider delivering signals of equal amplitude and phase to each slot. The stripline is made from two layers of 0.787mm thick Rogers RT/Duroid 5880 substrate. In-house FDTD codes that have been shown to be very accurate [3,5] were used to design the EBG antenna. The computed *E*- and *H*-plane radiation patterns at 12.1GHz for the final design are shown in Fig. 3. The computed gain vs. frequency of the dual resonator antenna fed by a 4x8 slot array is compared with a classical single resonator structure [3] (consisting of three layers of TMM4 substrates a half wavelength above a ground plane containing a single microstrip patch) in Fig. 4. Also shown in Fig. 4 are results for a dual resonator antenna fed by an 8x16 slot array, where the slot spacing, slot size, material properties and separation between TMM sheets are the same as the configuration shown in Fig. 1; however the size of the TMM sheets are increased to 271mm x 271mm x 3.18mm to accommodate the extra slots. The computed radiation bandwidth of the classical structure is 1.3% while that of the dual resonator structure with 4x8 slot array is 12.9%. Use of the 8x16 slot array with the dual resonator structure gives a radiation bandwidth of 15.5%.

Conclusion

A 1-D EBG resonator antenna configuration that gives a dramatic increase in radiation bandwidth has been demonstrated. It combines a dual resonator EBG structure with a slot array feed to give an improvement in radiation bandwidth of one order of magnitude compared to a classical 1-D EBG resonator antenna with a single source. The profile of the antenna is also only slightly higher than the classical structure. The maximum computed gain for the dual resonator EBG antenna with 4x8 slot array was 23dBi, while for the 8x16 slot array feed it was 27.0dBi. More details on the dual resonator antenna, including measured results, will be presented at the conference.

Acknowledgements

This research was funded by an ARC Linkage Postdoctoral Fellowship (CSIRO). B. C. Sanders acknowledges support from Alberta's iCORE fund.

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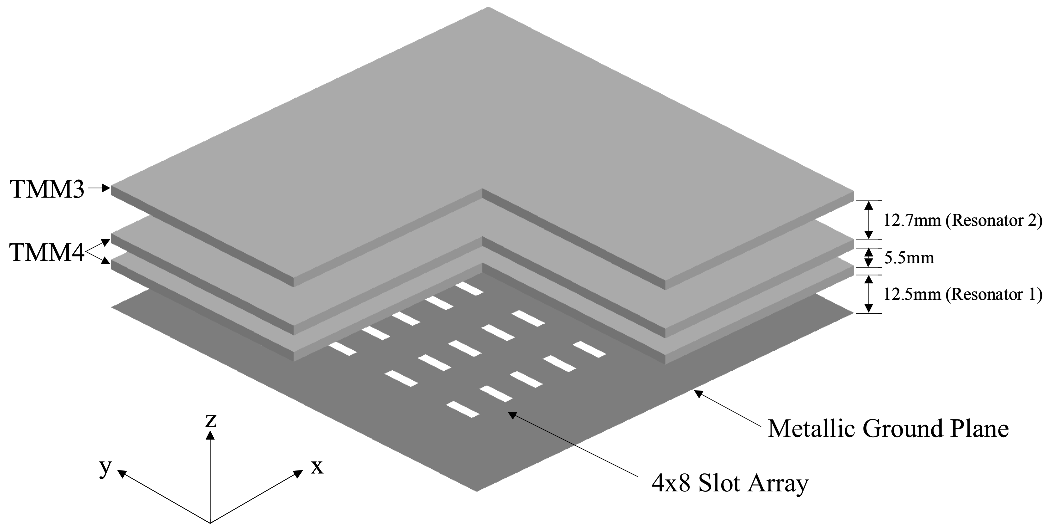

Fig. 1. Dual resonator 1-D EBG antenna with slot array feed realized using Rogers TMM dielectric sheets with dimensions 152mm x 152mm x 3.18mm. One quarter of the TMM sheets has been cut away to show the slot array more clearly.

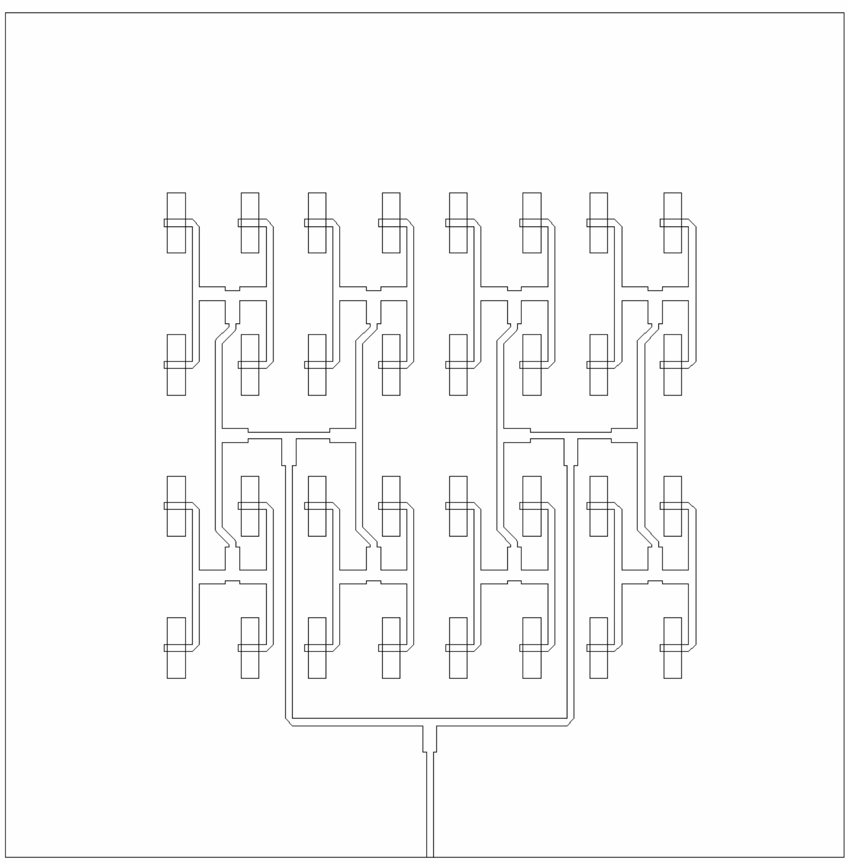

Fig. 2. Stripline feed network for the dual resonator 1-D EBG antenna consisting of a 4x8 slot array. Slots are superimposed on the stripline network to show relative position.

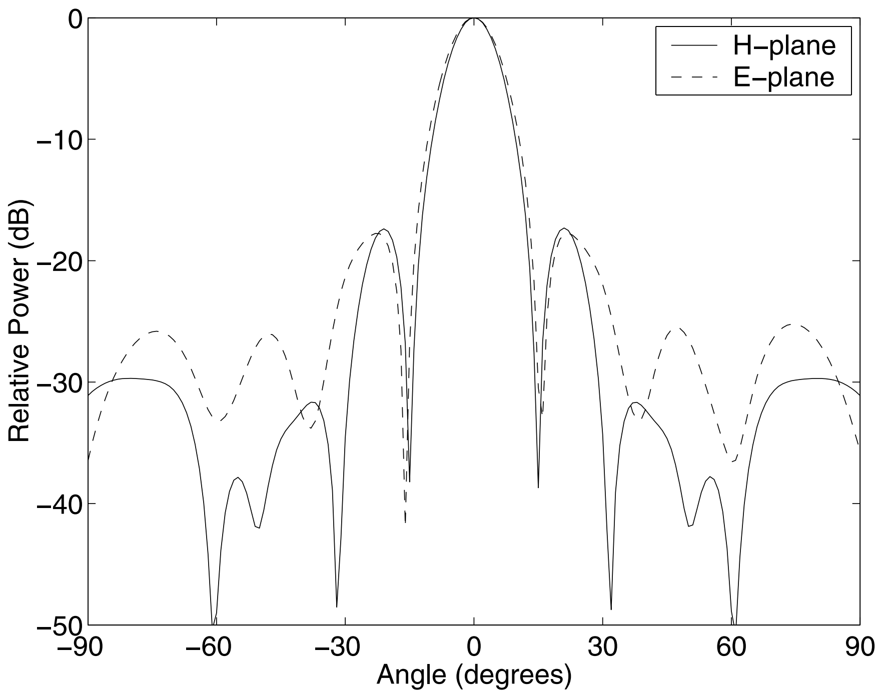

Fig. 3. Computed *H*- and *E*-plane radiation patterns at 12.1GHz.

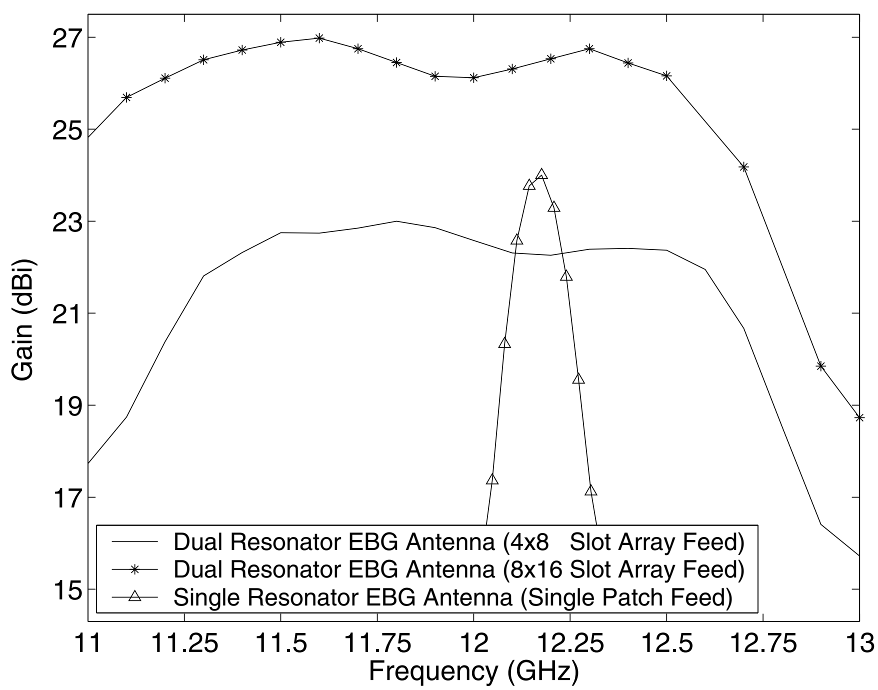

Fig. 4. Theoretical gain for dual resonator 1-D EBG antennas (4x8 slot array feed and 8x16 slot array feed) compared with a classical single resonator EBG antenna.