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A Modified Sierpinski Pattern Thinned Planar Array of Rectangular Microstrip Antenna with Reduced SLL

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Abstract: A novel technique to achieve reduced side lobe level by sequential modification of Sierpinski carpet patterned array is presented in this paper. A 9×9 planar array is reduced to a Sierpinski carpet shaped array and after final modification it exhibits a peak SLL of -21dB and about 40% reduction in the number of elements. **Keywords**: **Microstrip patch antenna, antenna array, Sierpinski carpet**

1. Introduction

Design and synthesis techniques in antenna array are based on two different types of non-uniform arrays. One is accomplished with the non-uniformly spaced antenna elements and the other is realized using non-uniform excitation in which the elements of the antenna array are selectively turned on and off. This later category is classified as antenna array thinning. In cases of large antenna arrays, array thinning is an efficient technique to reduce number of elements, power consumption, complexity of feed network and overall weight. However, this also increases the side lobe level (SLL) so with reducing number of elements the SLL must be also kept low. With the use of fractals in electromagnetics, symmetric finite iteration self similar geometry was used in designing fractal elements as well as arrays. One such attempt to develop Cantor fractal ring arrays became prominent as a definite technique for antenna array thinning [5]. In 1999 Werner et al. [6] put

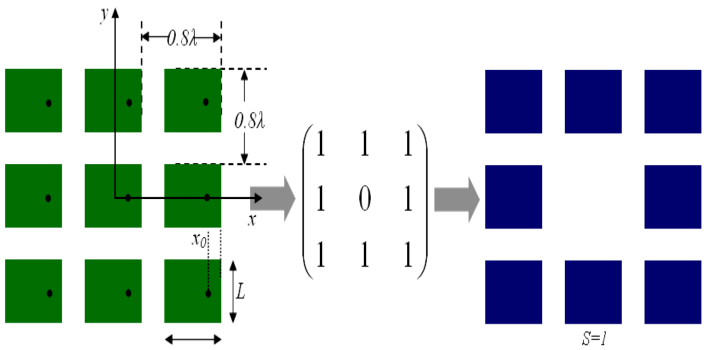

Fig.1 Illustration of the procedure for converting a 3×3 rectangular microstrip planar array in to a first stage (*S*=1) of Sierpinski carpet based thinned array by removing

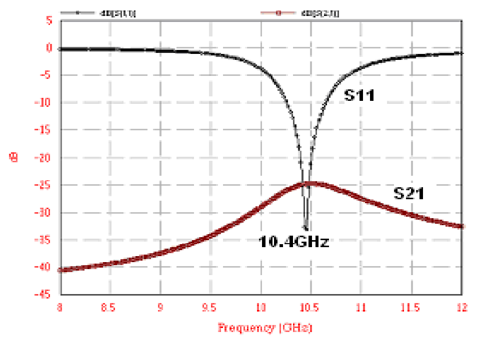

Fig.2 Return loss of two element rectangular microstrip antenna array and the corresponding mutual coupling given by S21.

forward some

generalized array factor expressions for creating thinned arrays using fractal geometries. Later Hebib et al. [7] reported a Cantor spiral array for designing thinned array antenna. One of the most important considerations of antenna array thinning is to address the issue of side lobe level. Jianfeng *et al.* [8] developed an immune algorithm to bring about side lobe reduction in thinned antenna arrays. In [9] an iterative FFT technique was used to realize thinned antenna array with low side lobe level (SLL). In this work it is shown that if a fractal route to array thinning is taken it is comfortable enough to achieve low SLL. We choose to call it a fractal route as in the present paper the process begins by sequentially turning OFF the microstrip patch antenna elements as illustrated for a 3×3 planar antenna array in Fig 1. This is however; applied on a 9×9 planar array of rectangular microstrip antenna and directly a 21% reduction in number of elements is achieved as explained in detail in next section.

Once this is achieved the array geometry is modified to obtain thinning as well as maintaining low SLL. Rest of the paper is divided in to two broad sections namely that of synthesis of the modified Sierpinski carpet patterned rectangular microstrip antenna based planar antenna array along with discussion on array patterns in Section II and concluding remarks in Section III.

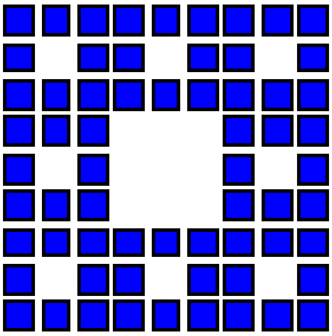

Fig. 3 Second stage of Sierpinski carpet based thinned rectangular microstrip antenna array. Lines show the central axis.

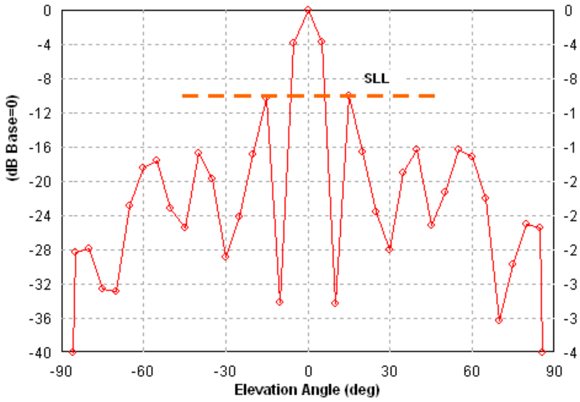

Fig. 4 Array pattern of a uniform feed 9×9 Sierpinski carpet based rectangular planar antenna array.

2. Modified Sierpinski Carpet Based Rectangular Microstrip Antenna Array

The rectangular microstrip antenna element that is used to construct the planar array is designed at 10.4 GHz. The rectangular microstrip antenna element consist of width W of 11.9 mm and length L of 9.17mm with probe feed at a distance 'x_0' of 2.4 mm from edge of the patch. The single element as well as the antenna arrays is simulated using IE3D™. The mutual coupling between two element arrays using such antenna element is shown in Fig 2. It is seen that the mutual coupling is less than -20dB as well as gain is maximum for a separation of 0.8λ. Most of the array thinning using fractal geometries assumes isotropic point sources with spacing of 0.5λ [6]. This is however ideal and in microstrip antenna array a spacing of 0.5λ can not be maintained due to mutual coupling issues. A second stage of growth of such array is shown in Fig. 3.

For second stage antenna array the number of elements due to Sierpinski carpet based array thinning procedure is 64 instead of 81 for the planar Euclidian array. This provides for a 21 % reduction in number of elements.

At the first instance it is observed that the side lobe level increases upon implementing the array thinning technique with uniform excitation of the elements. This is shown in Fig 4.A peak SLL of -11 dB is observed. Sierpinski carpet array can be modified for greater reduction of side lobe level .It is observed that the peak SLL falls to -14 dB for a distribution as shown in Fig. 5 along with the array pattern because deleting some elements from the corners [10] can provide a greater reduction of SLL. In this modified Sierpinski carpet based array, the number of elements is 52 instead of 64 for the normal Sierpinski carpet array. This provides further 18% reduction in the number of elements. Again shifting some elements along central axis of array brings about further reduction of SLL to -16dB which is shown in Fig.6

Now the question is how to reduce the no of elements further as well as keep SLL as low as possible. Without shifting the center elements if all the corner elements are removed then the array assumes a circular pattern which is shown in Fig.7. This results in 44 elements with 45% reduction also with -15.5dB SLL. Retaining the previous elements we can again shift the centered elements and get -17dB SLL which is better than the previous one but with same no of elements as shown in the Fig.8. Finally adding some of the corner elements the side lobe can be effectively reduced to -21dB with 48 elements with 40% reduction which can shown in Fig.9

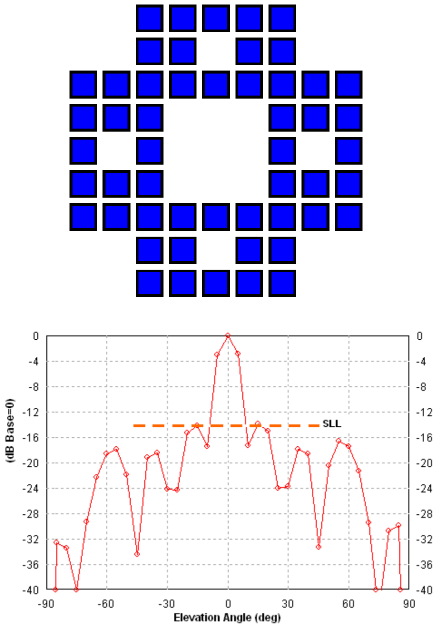

Fig. 5 Planar array layout after deleting corner elements and corresponding array pattern. A peak SLL of -14 dB is observed.

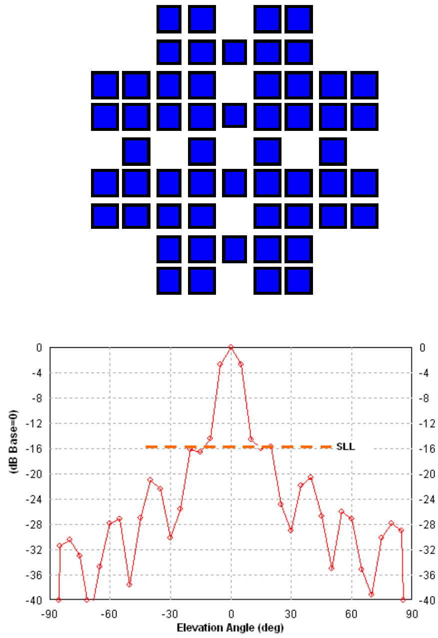

Fig. 6 Array layout after shifting elements along the central axis. A peak SLL of -16 dB is observed.

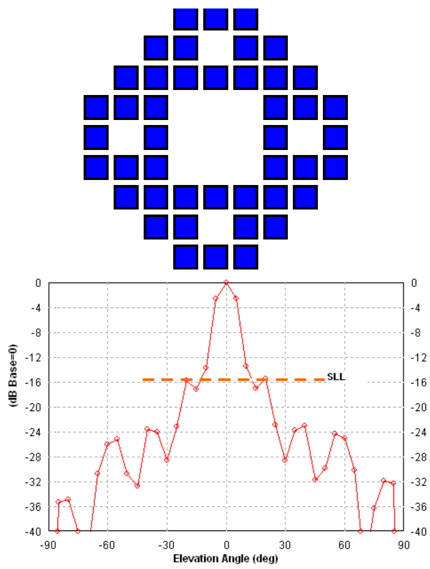

Fig. 7 Circular pattern of a uniformly fed modified Sierpinski carpet based rectangular planar antenna array with -15.5dB SLL

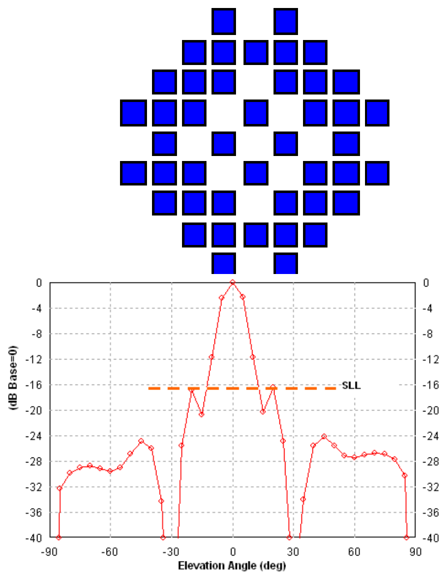

Fig. 8 Array pattern of a uniformly fed modified Sierpinski carpet based planar antenna array with shifted center elements. A peak SLL of -17 dB is observed

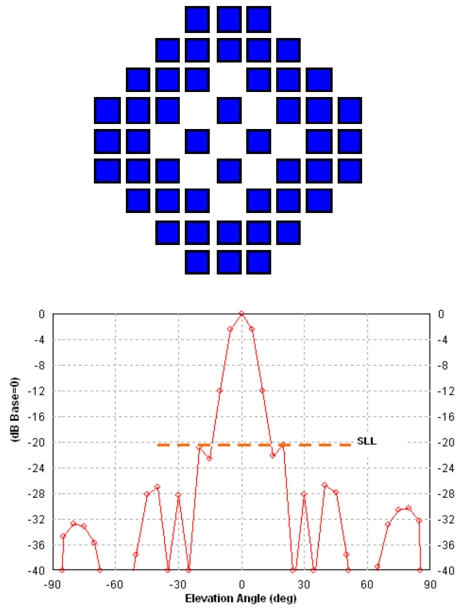

Fig. 9 Array pattern of a uniformly fed modified Sierpinski carpet based rectangular planar antenna array with shifted center elements. A peak SLL of -21dB is obtained

3. Conclusions

In this work we have achieved a SLL of -21 dB by sequentially modifying a Sierpinski carpet patterned planar Microstrip array. So incorporating fractal pattern in antenna array thinning enhanced the step towards achieving low SLL and optimum reduction in the number of elements. An improvement in peak SLL of about -21dB with 40% reduction is achieved.

4. Acknowledgment

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