Sidelobe Reduction in Uniformly-Fed Arrays by Applying Parasitic Elements

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***Abstract* - In this paper we show that significant sidelobe reduction can be achieved in uniformly-fed arrays by combining space taper (ST), beamwidth taper (BT) and direction taper (DT). A uniformly-fed 4 rectangular microstrip element array is presented as an example. The beamwidth and the beam direction of the elements are controlled by adding parasitic elements above. It is shown that the obtained sidelobe level is 22 dB and that the gain is 14 dBi at 4 GHz.**

***Index Terms* — Sidelobe reduction, Space taper, Beamwidth taper, Direction taper.**

1. Introduction

Sidelobe reduction is important in many antenna applications. Generally, sidelobe reduction is achieved by controlling the power delivered to each element in the array. Some researchers are trying to reduce sidelobe level in uniformly-fed arrays, with the advantage of applying a relatively cheaper feeding network. For example, the idea of unequal space between elements was applied, that is, the spaces between the elements in the array increase towards the edges of the array. In other cases, different elements were used in the array, where the beamwidths of the elements become narrower towards the edges. In this paper we show that one can use also a squint control to each element in the array in order to further reduce the sidelobe level of the array.

The structure of the work is as follows: In section II we present the ST, BT and DT ideas. In section III we show the geometry of the proposed antenna and simulation results.

2. ST, BT and DT Sidelobe Reduction Performance

(1) Sidelobe Reduction by Applying Space Taper

When using space tapering such that the distance between elements in the array is increased towards the ends of the array a slight reduction of the sidelobes is achieved [1]. Figure 1 demonstrates an 8 element array with Space Taper, where the first sidelobe is -14.5 dB, compared to -13 dB in the uniform spacing case.

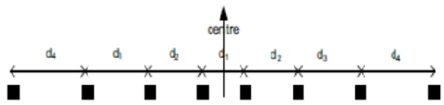

Fig. 1. Space Taper example.

(2) Sidelobe Reduction by Applying Beamwidth Taper

When the beamwidths of the elements become narrower towards the ends of the array, sidelobe reduction is obtained [2]. An example is shown in Figures 2 and 3

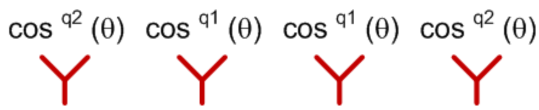

Fig. 2. An example of Beamwidth Taper geometry

As q increases, the beamwidth of the element becomes narrower. In case that $q_1 = q_2$ we have a conventional array. When $q_2 > q_1$, sidelobe reduction is achieved, and when $q_1 < q_2$ the sidelobes are going up, as shown in Figure 3

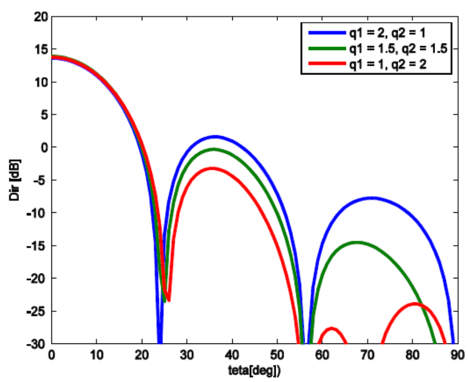

Fig. 3. An example of Beamwidth Taper pattern

(3) Sidelobe Reduction by Applying Direction Taper

When increasing the squint of the elements towards the end of the array, sidelobe level is also reduced [3]. The amount of reduction is increased as the number of elements in the array is increased, as seen in Figure 4. In this case, of 30 element array, the space between elements is 0.6λ, and the difference of the beam direction between neighbour elements is 4 degrees. The first sidelobe is 28 dB.

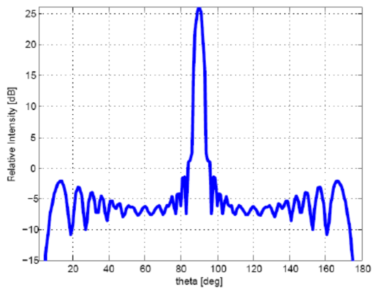

Fig. 4. Sidelobe Reduction by Direction Taper

(4) Sidelobe Reduction by a Combination of ST, BT, DT

Sidelobe level reduction can be achieved also by a combination of ST, BT and DT, as shown in the pattern of Figure 5

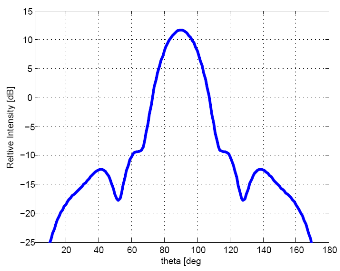

Fig. 5. Sidelobe reduction by combination of ST, BT and DT.

In this case the number of elements is 4, the distance between the center elements is 0.6λ, the distance between a center element and side element is 0.75λ, the q values are 2.4 and 4, and the directions of the beams are (left to right): -11, -7, 7, 11 deg. The sidelobe level obtained is 25 dB.

3 Simulation Results

The geometry of a 4 element antenna is shown in Figure 6.

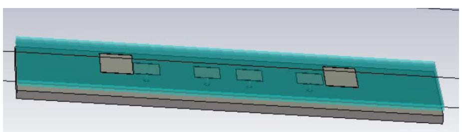

Fig. 6. Geometry of the antenna.

The antenna contains 4 fed elements and two parasitic elements printed on the upper substrate. The sizes of the fed elements are 24.5 x 18.5 mm. The sizes of the parasitic elements are 43 x 23 mm. The height of the lower substrate is 5.15 mm and the height of the upper substrate is 7.7 mm. The substrates are made of Taconic RF-35 with thickness 1.52 mm and relative dielectric constant 3.5 mm. The scattering parameters are shown in Figure 7

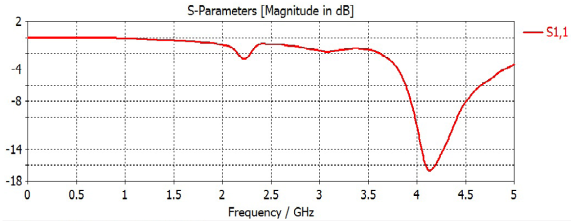

Fig. 7. Scattering parameters of the antenna

As shown in Figure 7, the center frequency is 4.2 GHz and the bandwidth is 9%. The H-plane pattern is shown in Figure 8 where the sidelobe level is lower than 22 dB and the gain is 14.2 dB.

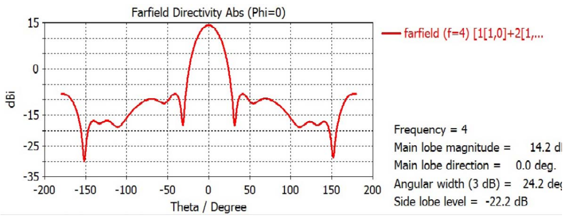

Fig. 8. Simulated pattern of the proposed array.

References

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