POS2-12

Low-Cost Antenna Elements for Reducing Grating Lobes

M. Loifer, H. Matzner
Department of Communication Engineering, HIT – Holon Institute of Technology
Golomb 52, Holon 58702, Israel
haim@hit.ac.il

1. Introduction

Antenna arrays based on grating lobe reduction were introduced last years [1-2]. One of the main advantages of this kind of antenna arrays is that a relative sparse feeding network can be used, and moreover, a low loss waveguide feeding network can be implemented. However, one has to design a special antenna element having nulls in predefined directions in order to cancel the grating lobes. [1] proposes an antenna array based on one grating lobe reduction where the distance between elements is 1.8λ with elements having nulls at 34^o [1] by applying box horn elements. Here we deal, for simplicity, with linear arrays of H-plane coupled elements, and two kinds of elements will be discussed: an element composed of 3 rectangular microstrip patches fed by a 1:3 microstrip divider, and a wire element composed of 1:2 upper divider and two arms. The advantages of the last element are that no substrates are contained, and that the nulls of the element can easily be controlled by adjusting the distance between its arms. The structure of the paper is as follows: in section 2 the geometry of the elements is shown, simulated results are presented in section 3, and the measurements are described in section 4 for the second element. Finally section 5 is for the conclusions.

2. Geometry

2.1 The 3-Patches Element

A flat element with a radiation nulls at $\theta = 34^o$ can be designed by 3 H-plane coupled rectangular microstrip antennas fed by a 1:3 microstrip power divider. The radiation null position can be controlled by the distance between the elements. For 2.5 GHz as a center frequency, the geometry of the element and the divider are shown in figure 1

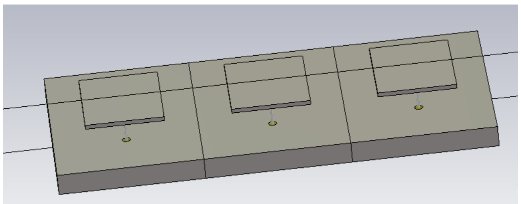
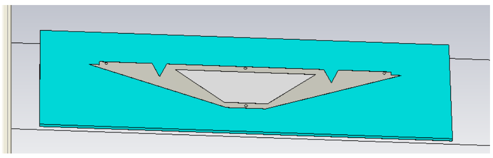



Figure 1: An element based on 3 rectangular microstrip patches (left) and the divider (right)

The length of each patch is 51.3 mm, its width is 37.8 mm, the thickness is 2 mm and the height above ground is 8 mm, on air substrate. The distance between the patches is 70 mm. The distance of the feed point from the edge of the element is 1.8 mm. The geometry of the microstrip 1:3 divider is shown in figure 2

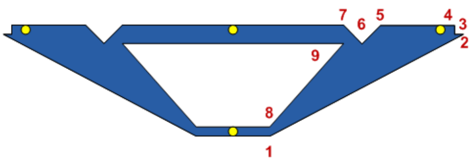


Figure 2: The microstrip 1:3 power divider for feeding the 3-patches element.

The divider is printed on a Taconic RF35 substrate. The distance between the output ports is 70 mm. The yellow circles are the ports. The relevant coordinates are (in mm): 1 (7.88, -1.43), 2 (68.8, 19.25), 3 (64, 13.25), 4 (64, 21.01), 5 (42.05, 21.01), 6 (38.83, 12.91), 7 (35.61, 21.01), 8 (9.95, 1.44), 9 (33.07, 19.57).

2.2 The 2- Patches Element

A picture of the element is shown in figure 3

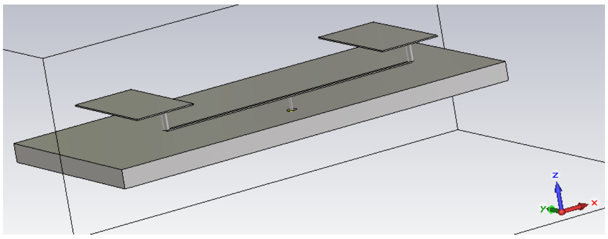


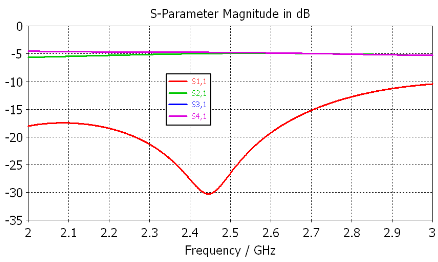
Figure 3: The two patches element.

The sizes of the element (mm): height of the connector is 5.58, the thickness of the horizontal strip and the patches is 0.5, the length and width of the horizontal strip are 115, 1.76 respectively, the diameter of the upper wires is 2.85 and their height is 7.35, and the sizes of the parallel patches are 54 x 26.

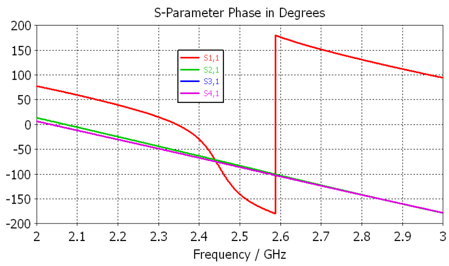
3. Simulations

3.1 The 3-Patches Element

The scattering parameters of the 1:3 power divider is shown in figure 4



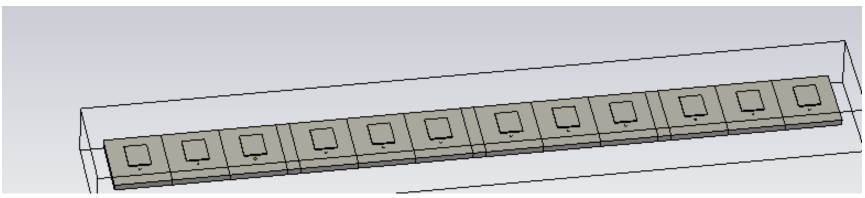
(a)



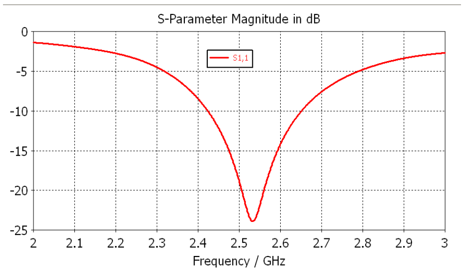
(b)

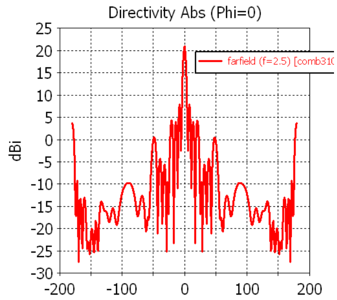
Figure 4: The scattering parameters of the 1:3 power divider. (a) Amplitudes. (b) Pahses.

It is shown that the insertion loss accuracy is less than 0.5 dB for 2.3 to 2.7 GHz, and the phase error is less than 5^{o} for the same frequency range. An array of 4 such 3-patches elementsgeometry, return loss and an H-plane radiation cut of the array are shown in figure 5



(a)





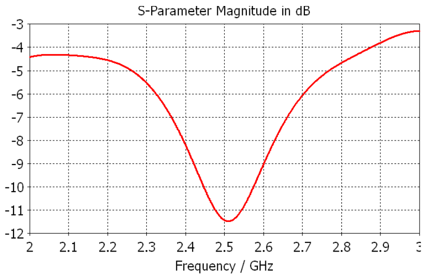
(b) (c)

Figure 5: (a) Am array of 4 3-patches elements. (b) Return loss of an element. (c) H-plane pattern.

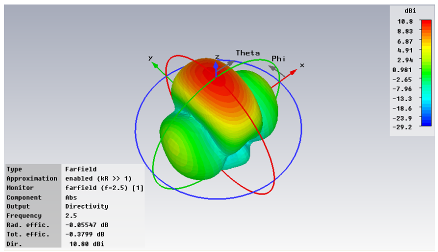
It is shown that the SWR = 2 bandwidth is 9%, the gain is 21 dBi, the H-plane beamwidth is 4.8^o and the sidelobes are 13 dB, at 2.5 GHz.

3.2 The 2-Patches Element

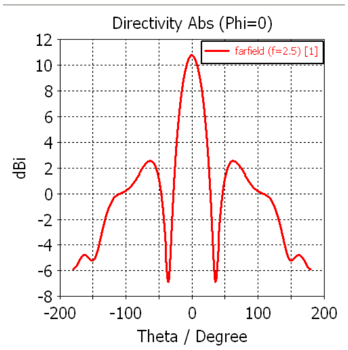
The simulation results for the 2-patches element are shown in figure 6



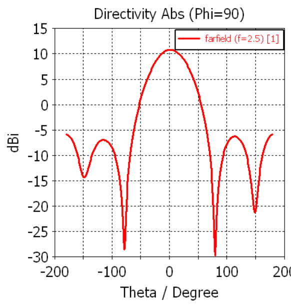
(a)



(b)

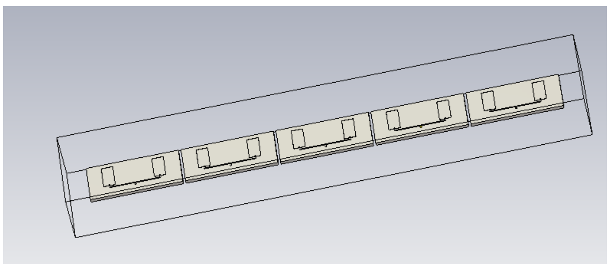


(c)

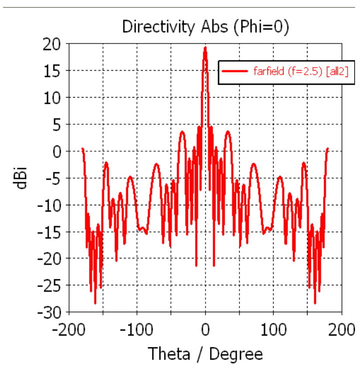


(d)

Figure 6: Simulation results of the 2 patches element: (a) Return loss. (b) 3D radiation pattern. (c) H-plane radiation cut. (d) E-plane radiation cut.



(a)



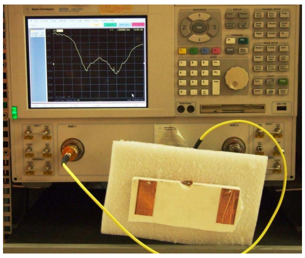
(b)

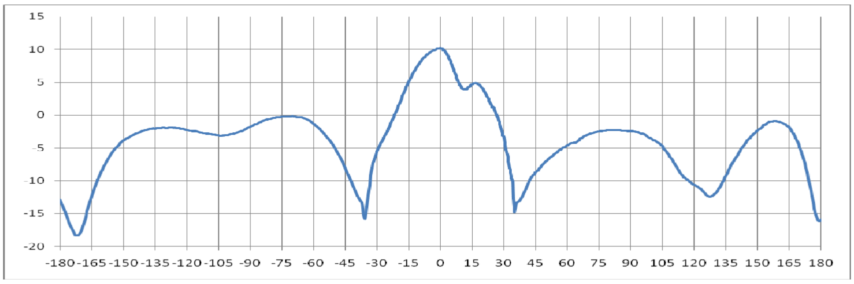
Figure 7: (a) The geometry of the array. (b) An H-plane radiation cut of the array.

It is shown that the SWR = 2 bandwidth of the element is 6%, the gain is 10.5 dBi, the H-plane beamwidth is 32^{o} with nulls at 34^{o} and the E-plane beamwidth is 58^{o}. The geometry and simulated H-plane radiation cut of an array of 5 H-plane coupled elements with distance of 1.8λ are shown in figure 7. It is seen that the grating lobes were cancelled. The gain is 19 dBi, the H-plane beamwidth is 5.8^{o} and the sidelobe level is -14.7 dB at 2.5 GHz.

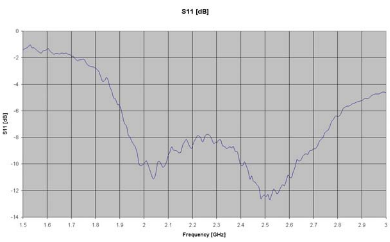
4. Measurements

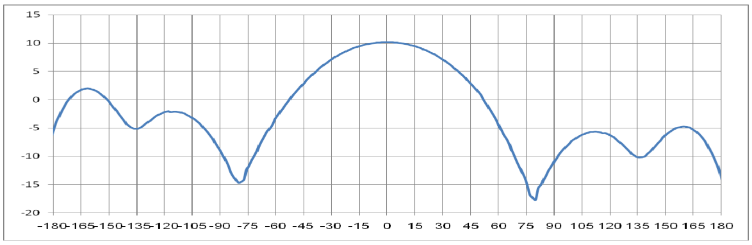
A picture of the element, measured return loss and radiation patterns of the 2-patches element are shown in figure 8





(a) (b)





(c) (d)

Figure 8: (a) A picture of the 2-patches element, (b) H-pane radiation cut. (c) Return loss of the element. (d) E-plane radiation cut.

It is shown that a very good agreement between simulations and measurements was achieved.

5. Conclusions

Simple and relatively flat elements for reducing grating lobes were introduced. The agreement between simulation and measurements was very good. More research has to be done in order to increase the bandwidth of these elements, and to find elements for two dimensions grating lobe reduction.

References

[1] T. Sehm,, A. Lehto and A.V. Raisanen, "A 38 GHz Horn antenna Array", EuCAP 1998, Amsterdam, Vol. 1, pp. 184-189,1998.

[2] Dau-Chyrh Chang , Ji-Chyun Liu, Kai-Yuen Cheng , Bing-Hao Zeng, " UWB Antenna Array for Grating Lobe Reduction", Isap 2006, Singapore, 2006.