Gain Enhancement of A Microstrip Array Inserted Inside a Pyramidal Horn

A. Goldenberg and H. Matzner
Department of Communication Engineering
HIT – Holon Institute of Technology
52 Golomb st. Holon, 58102, Israel
haim@hit.ac.il

E. Levine
Electrical Engineering Department
AFEKA Academic College of Engineering
38 Mivtza Kadesh st Tel Aviv 69107 Israel
ElyL@afeka.ac.il

Abstract—Enhancement the gain of a planar microstrip array by inserting the antenna into a short horn is discussed. It is shown that an asymmetric horn surface should be used in case of unbalanced-fed elements and a symmetric horn surface is suitable for balanced-fed elements. In both cases the gain is increased and the sidelobe level is decreased. An array of 2 x 2 elements is discussed, showing gain enhancement of 2-3 dB and sidelobe reduction of 5-8 dB.

Keywords—gain enhancement of planar arrays inside a horn, gain and sidelobes of microstrip arrays.

I. INTRODUCTION

Improving the gain or the bandwidth of antennas by external devices in the near field is a common practice. For example [1-2] proposed to add dielectric layers for gain enhancement, and [3] proposed meta-material layers as external devices for improving the bandwidth.

In this paper, gain enhancement and sidelobe reduction of a microstrip array are performed by inserting the array into a suitable short horn. The structure of the paper is as follows: in section II the geometry of the original array and the horn surfaces, both for the balanced and for the unbalanced cases are presented. In section III simulation results are shown and in section IV some measurements are shown. Finally, section V concludes the work.

II. GEOMETRY

The geometry of a single microstrip element is shown in Figure 1. The sizes of the element are W = 25 mm and L = 24 mm. The substrate is TACONIC RF-35 with thickness of 1.5 mm and dielectric constant of 3.5, mounted above a foam layer with thickness 2.8 mm. The geometry of the 2 x 2 microstrip array is shown in Figure 2. The distance between elements in the H-plane (x-axis) and in the E-plane (y-axis) is 55 mm. The geometry of the horn surface for the unbalanced case is shown in Figure 3 and the side views of the horn are shown in Figure 4.

![Figure 1: A single microstrip element.](image1)

![Figure 2: Geometry of microstrip array for unbalanced excitation.](image2)

![Figure 3: A view of the array for the unbalanced case.](image3)
As shown in Figure 3, the horn surface touches the dielectric substrate just above. The horn surface is symmetric in the H-plane and asymmetric in the E-plane. The dimensions of the horn aperture are 260 mm x 240 mm and the height of the horn surface is 80 mm.

The geometry of the horn surface in the balanced case is shown in Figure 5. The horn dimensions are 260 x 150 mm.

III. SIMULATIONS

A. Original Array

The return loss of the single element in the original array is shown in Figure 6. It is shown that the center frequency is 4.5 GHz and the fractional bandwidth for VSWR = 2 is 8.5%. Radiation patterns of the original un-balanced fed array are shown in figure 7. The simulated gain is 15.1 dBi and the first sidelobe levels are -12 dB in the H-plane and -14 dB in the E-plane.
B. Unbalanced Case

After the addition of the horn surface in the un-balanced fed elements, the return loss was not changed but the radiation properties were significantly improved as shown in Figure 8. The gain was increased by 1.9 dB to 17.0 dB. The H-plane first sidelobe level was decreased from -12 dB to -18 dB and the E-plane first sidelobe was decreased from -14 dB to -19 dB.

C. Balanced Case

After the addition of the horn surface in the balanced fed elements, the return loss was not changed but the radiation properties were even better as shown in Figure 9. The gain was increased by 2.7 dB to 17.8 dB. The H-plane first sidelobe level disappeared and the E-plane first sidelobe was decreased from -14 dB to -21 dB. The balanced case shows better improvement both in the gain and in the sidelobes.
IV. Measurements

The unbalanced fed array was measured with and without the horn surface. A picture of the antenna with the horn is shown in Figure 10. It is shown that the bandwidth for VSWR=2 is 9.1% around 4.49 GHz without the horn and 8.8% around 4.54 GHz with the horn surface.

The return loss of a single element measured without the horn surface and with the horn surface is shown in Figure 11.

The H-plane radiation patterns in three frequencies are shown in Figure 12. It is shown that the half-power beamwidth in the center frequency was reduced from 31° to 22° and the first sidelobe was decreased by 4 dB due to the horn surface included.

The E-plane patterns in three frequencies are shown in Figure 13. It is shown that the half-power beamwidth in the center frequency was reduced from 30° to 25° and the first sidelobe was decreased by more than 4 dB. The measured gain without the horn surface was 13 dBi and the measured gain with the horn surface was 16 dBi.

It is obvious that the addition of the horn enlarges the aperture from 120 x 120 mm to 240 x 260 mm, or by a factor of 4.3 (6.3 dB) while the enhancement of the gain was only by a factor of 2 (3.0 dB). However, we have to remember that the aperture efficiency of a short horn is much lower than the aperture efficiency of a planar array.
V. CONCLUSION

A short horn was used as an external device in close proximity, to enhance the gain and to reduce the sidelobes of a microstrip array antenna. It was shown that for the unbalanced case, the horn increased the gain by 3.0 dB, while the aperture area had been enlarged by 6 dB. The first sidelobe was decreased by 4-5 dB. Also it was shown by simulation that for the balanced case, the horn increased the gain by 2.7 dB, while the aperture area had been enlarged by 3.6 dB. The first sidelobe was decreased by 8-10 dB. It is concluded that the balanced case is significantly more efficient and enjoys far better aperture efficiency then the unbalanced case. The insertion of the microstrip array into the envelope of a short horn can be used as an add-on accessory to existing designs.

REFERENCES

