A Two Dimensional Slot Array Antenna

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Abstract

The concept of a linear long slot antenna of novel structure is extended to two dimensions. Half wave slots are interconnected with a phase reversing section consisting of cross slots and cross over connections. These sections ensure that adjacent half wave sections of the slot radiator produce in-phase radiation. A two dimensional structure should have even better gain then a linear structure. The planar structure uses a reflecting plane to provide one main forward lobe and a high gain.

Keywords – 2D slot array antennas, long slots

Introduction

Slot antennas cut into a metallic conductor in free space have been extensively analyzed and used for various applications [1]-[5]. This type of antenna has numerous desirable features in terms of weight, size, cost and easy integration with planar and quasi-planar surfaces.

As the electrical length of a standing wave magnetic dipole (slot antenna) is increased beyond a half wavelength, adjacent half wave sections develop out-of-phase standing voltage waves. As a result, long slot antennas develop a multiplicity of radiation lobes. These are normally not desirable as they reduce antenna gain and send signals out in undesired directions. A method of overcoming the above problem is to make the adjacent standing voltage wave anti-nodes in a long slot have the same phase. This is achieved first by isolating adjacent half wave slot sections by orthogonal slots and then reconnecting the radiating half wave slots with cross over conductors or wires. The overall structure of the antenna is shown in Figure 1 and has been reported as per references [6,7]. A crossover structure is shown in Figure 2. The antenna can be made to have a large number of half wave sections. The antenna is fed at a single point near the center of the structure.

The purpose of this paper is to report on extending the linear slot array to a two dimensional slot array.

Two Dimensional Slot Array Antenna Development

The single long slot antenna provides a good gain of about 10dB. If one can extend the linear long slot to an array of long slots to create a planar structure one would expect that an even higher gain will be achievable.

A two dimensional array of three by three long slots is constructed as shown in Figure 3. Each elemental slot is approximately one half wavelength long. The structure is made with uniform slot and wire dimensions in the x and z directions. If the antenna functions for horizontal polarization it can be fed so as to function with vertical polarization as well. The feed point is located at the center of the antenna at the center of the cross-over wires. For the case under consideration the horizontal wires are fed by the source and the antenna will produce horizontal polarization. It is expected that the antenna will be mostly used as a unidirectional high gain beam antenna and therefore a reflecting plate is placed behind the antenna. This antenna is shown in Figure 4. The structure is analyzed using a moment method wire and plate analysis package known as WIPL-D [8]. The widths and lengths of the slots are adjusted to achieve a good combination of impedance and radiation bandwidth as well as good gain.

The input impedance as a function of frequency is shown on a Smith Chart in Figure 5 where a source impedance of 120 Ω is used. The return loss is shown in Figure 6. The horizontal polarization radiation pattern is shown in Figure 7. The gain is about 45 or 16.6 dB. The on axis (y axis) gain is shown in Figure 8. The cross polarization has been checked and the ratio of vertical to horizontal polarization is very good at all of the inband frequencies from 3.0 to 4.0 GHz.

It is useful to look at the near field of this antenna just in front of the slots to observe whether or not the outer slots are receiving energy and supporting electric fields. Figure 9 shows the strength of the electric fields in front of the slots. While we note that the electric fields at the center of the antenna are stronger than at the edges it should be noted that the fields at the center are made up of transmission energy and radiation energy while the outside slots will not be transmitting energy but only radiating it.

Conclusions

The idea of building a "two dimensional long slot array" antenna with phase reversing structures to ensure that adjacent sections of the antenna will have in-phase standing waves has been verified as being practical. This type of structure provides a high gain with minimal side lobes. The impedance bandwidth of the antenna is about 25 to 30% and the radiation bandwidth of the antenna is about 15%. It is expected that reactances can be placed in series with the cross over wires to improve the characteristics as has been proposed for electric dipole planar arrays [9]. The antenna structure is compatible with printed circuit board technology.

References

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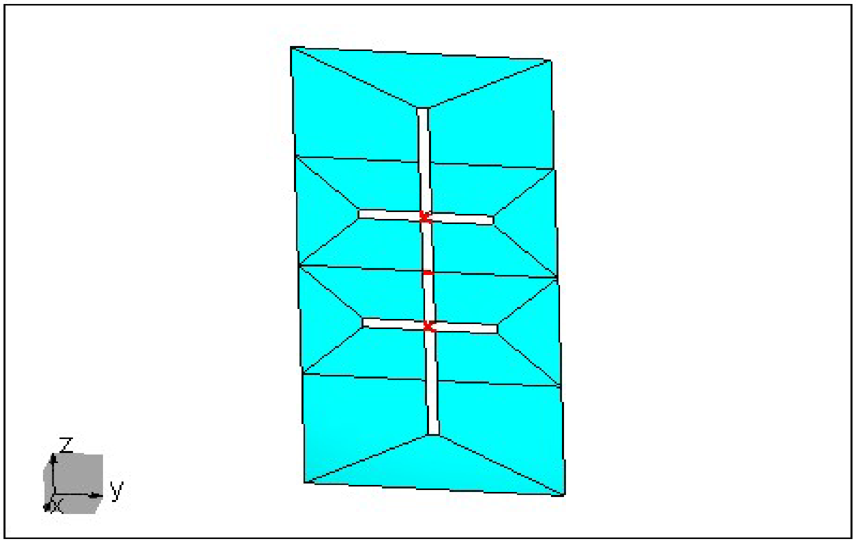

Figure 1

A long slot antenna with a phase reversing structure between half wave sections.

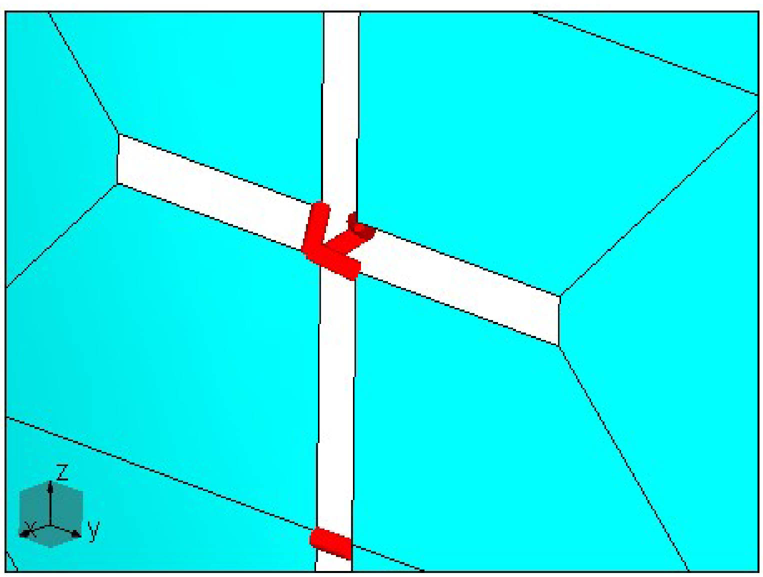

Figure 2

Detail of the cross-over (phase reversing) structure.

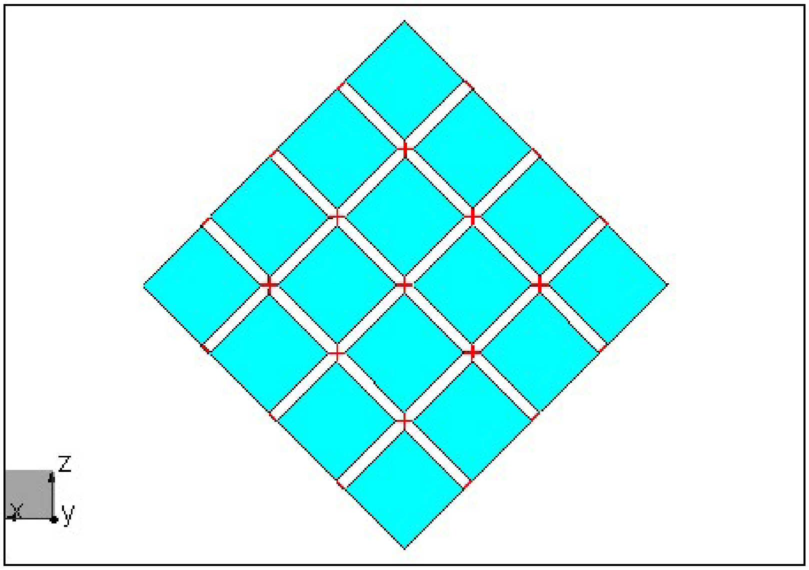

Figure 3

Basic 3 x 3 long slot array antenna. Note the cross-over wires and the outer edge shorting wires. The feed point is at the centre of the antenna.

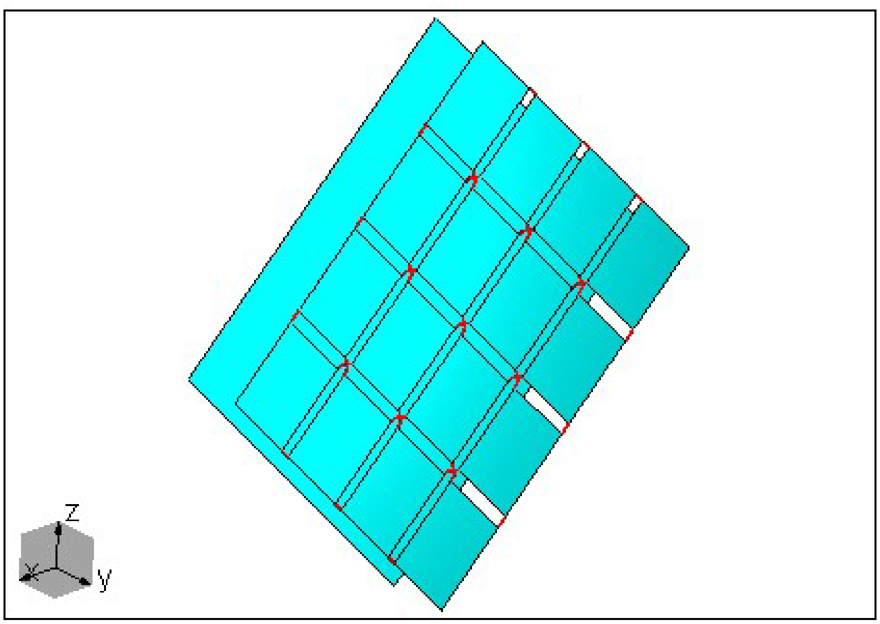

Figure 4

Basic 3 x 3 long slot array antenna with the reflecting plate.

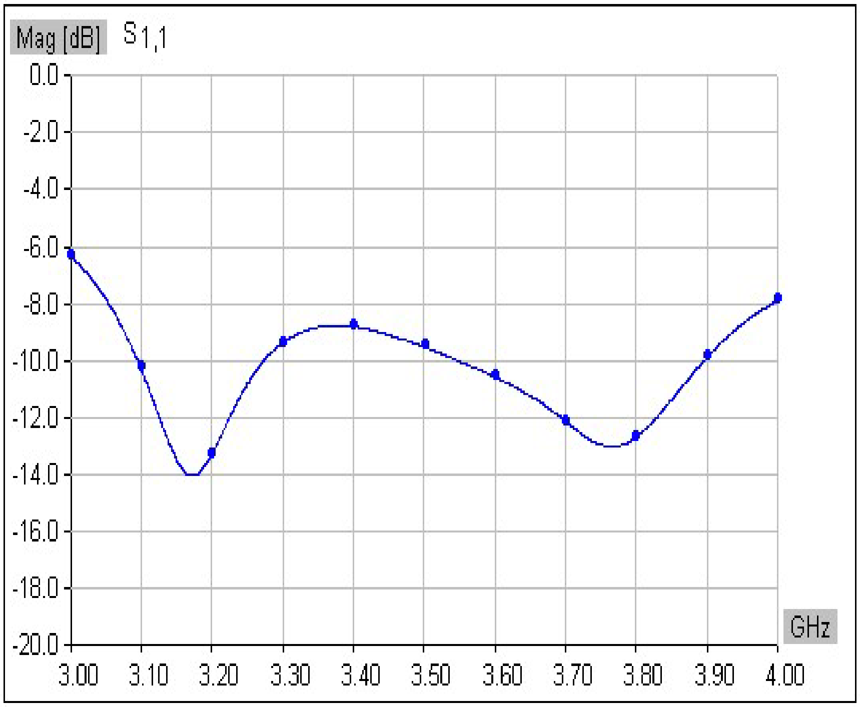

Figure 5

Return loss of the antenna when fed by a 120 Ω source.

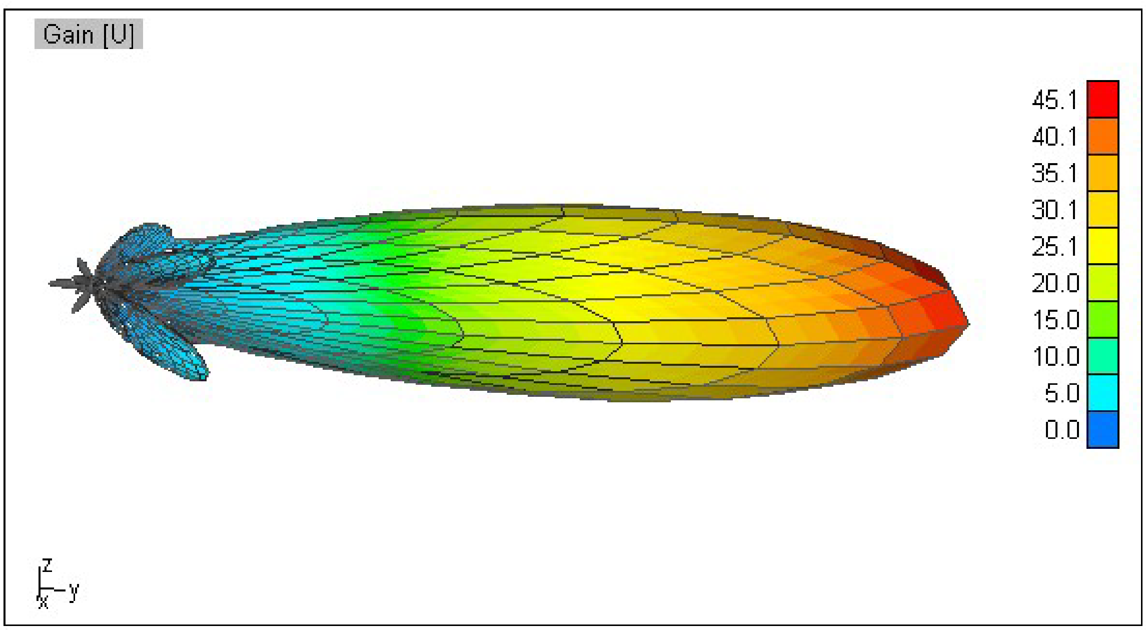

Figure 7

Radiation pattern of the antenna at 3.3 GHz.

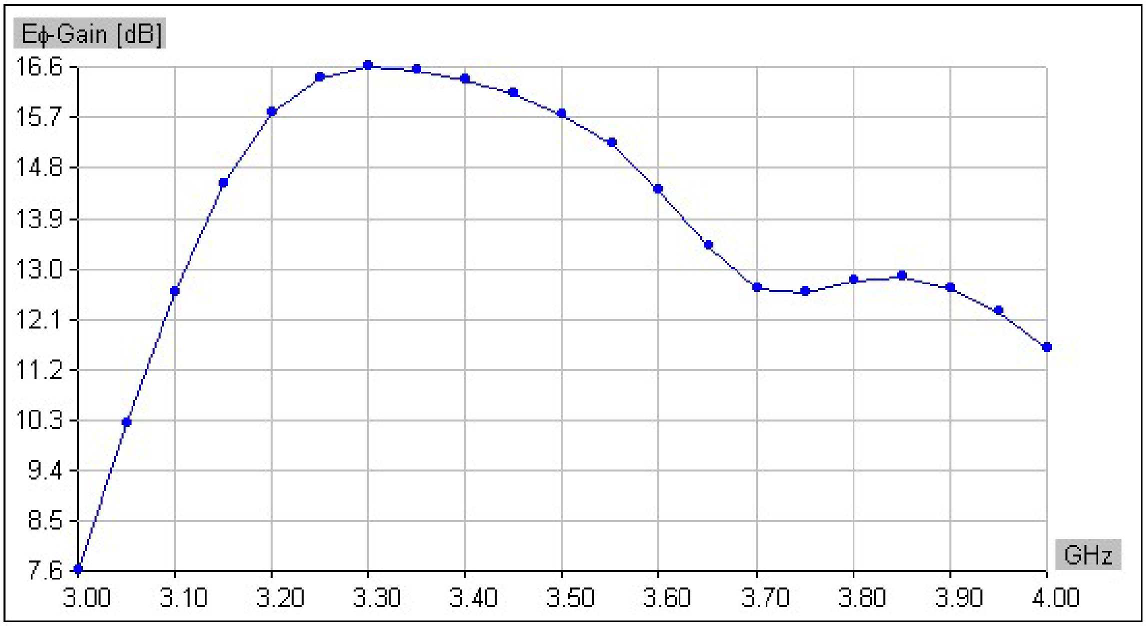

Figure 8

Antenna gain as a function of frequency.

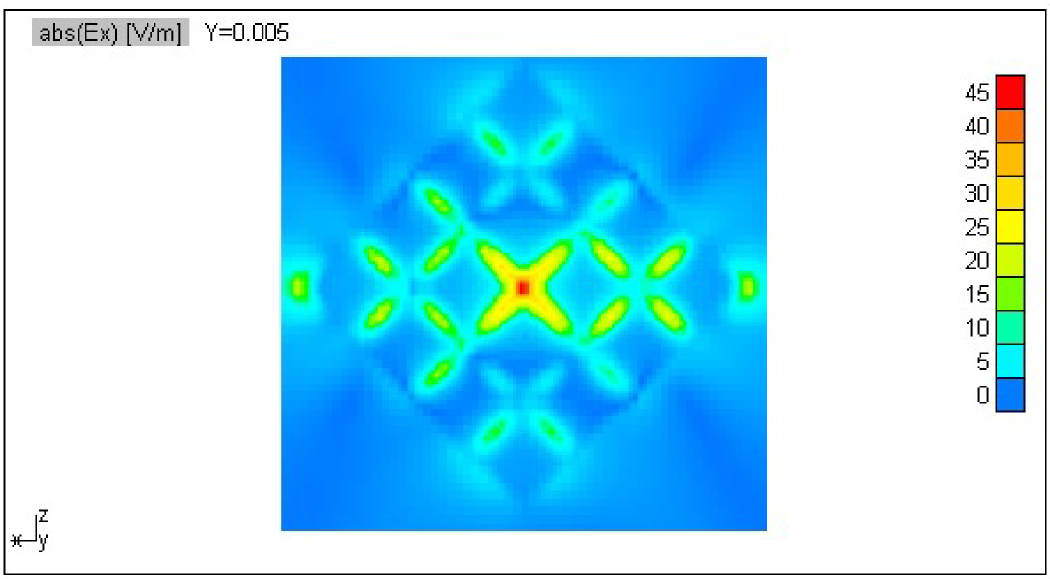

Figure 9

Near electric field pattern 5mm in front of the antenna. The electric field is in the direction of the far field electric field.