Non-inclined slotted waveguide array with various shapes of Irises

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Abstract—*Non-inclined narrow wall slotted waveguide with iris reduces the cross polarization. In this paper non inclined slotted waveguide array with iris is compared with inclined narrow wall slotted waveguide array to demonstrate the huge reduction in cross polarization. Analysis of various shapes of iris is done to compare their effects on co polarization and cross polarization.*

Keywords—Inclined slots, Non inclined slot, Iris, Slotted Waveguide Array (SWA), Co polarization, Cross polarization.

I. INTRODUCTION

Slot waveguides are frequently used as linear arrays of radiating sources in antenna arrays, for example in radar, navigation, communication and high power microwave applications. Main advantages are low cost and low losses. To obtain radiation the perpendicular to the waveguide they should satisfy two conditions first, distance between successive slots should be close to $\lambda g/2$, where λg is guided wavelength, second they should have supplementary phase shift of π between two consecutive slots. These conditions can be achieved with slots positioned in the broad wall of a rectangular-section waveguide or on the narrow wall. If the slots are placed in the broad wall, it will have many disadvantages, notably a big pitch between successive waveguides. so scanning angle of the beam get restricted in a plane perpendicular to the waveguides. Hence narrow wall slotted waveguide antennas are preferred. Keeping the slots perpendicular to the axis of the waveguide, will lead to no energy coupling between the slots and the waveguide, and the radiation is zero.

There are two approach to solve In a this problem, in first approach, slots are inclined to meet the above stated necessary conditions. However, inclination of the slots, leads to cross-polarization component in radiation.

Another known approach is using slots that are not inclined (i.e. that are perpendicular to the axis of the waveguide) and in exciting them by means of an obstacle (for example, irises or rods) placed in the waveguide.

In U.S. Pat. No. 4,435,715 (Hughes Aircraft) describes a waveguide with non-inclined slots in which the excitation of a slot is obtained by placing conductive rods on either side of the slot. Each slot is positioned between an edge of the slot and on one of the broad walls of the waveguide. However, this approach costly to implement as the rods have to be fixed individually within the waveguide, for example by dip soldering. To eliminate the aforementioned disadvantages, it is desirable to design a slot with excitation structures integrated to the waveguide walls. This way manufacturing of the whole antenna can be done from single aluminum block. Therefore, the excitation structures should be different from wire or thin iris type structures.

Many non-tilted slot configurations have been used in literature [1-6].However, since all the non-tilted slot are unexcited by nature, all of the non-tilted slots in the literature needs placement of excitation structures adjacent to the slot. This is performed by first making the slots on an empty waveguide and then, carefully inserting the excitation structures and fixing them to the waveguide walls. In [2,3,4] inclined metallic wires are used for excitation purpose .In [1,5] iris structures facilitates excitation where as in [6] dielectric structures with metal parts does the job. But no work has been done till now on using different shapes of Irises with Non-inclined narrow wall slotted waveguide array to analyze its effect on Co and Cross polarization, so this work is being carried out in the present paper.

II. THEORY AND DESIGN

The Different Iris shapes can be used as an obstacle for surface currents on narrow wall in the waveguide which due to their capacitive nature will lead to generation of electric lines which otherwise is not possible in the non inclined slots. This effect can be explained with the help of the following figure.

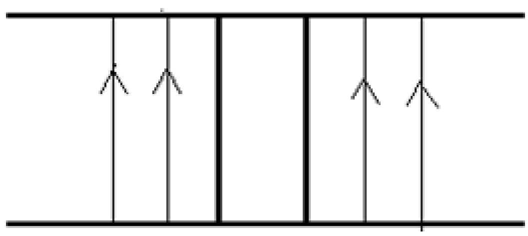

Fig.1: Surface Current on narrow wall of waveguide with Non-inclined slot (without Iris)

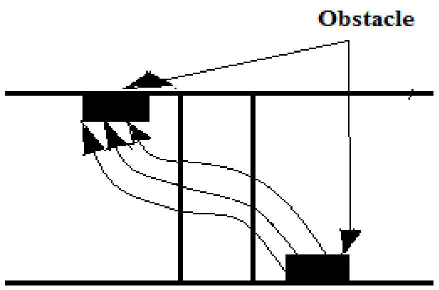

Fig.2: Surface Current on narrow wall of waveguide with Non inclined slot(with Iris)

These electric lines while travelling from Iris at the bottom wall of the waveguide to the Iris to the upper wall will modify the surface current near narrow wall in such a way that slot will intercept some of the surface current and will lead to radiation from the slot. Number of electric lines travelling from Iris at the bottom surface to the Iris at the upper surface of waveguide will be proportional to the charge stored in each of these Iris that is more the charges stored in the Iris more the electric lines travelling between the two Iris. Hence the number of electric lines travelling will depend on the shapes of the Iris which stores the charges. Hence it is expected that different shapes of Iris will lead to different Co polarization. The Iris shape which can store more charges will lead to more co polarization and vice versa. To achieve high gain and directivity array of such structure is used. In array of such structure, successive slots are spaced at distance of $\lambda g/2$ as in case inclined narrow wall slot and pair of Iris are placed near to each slot in such a way that it leads to phase shift of π at each slot. This condition can be satisfied by placing the iris as shown in structure in Fig 3.

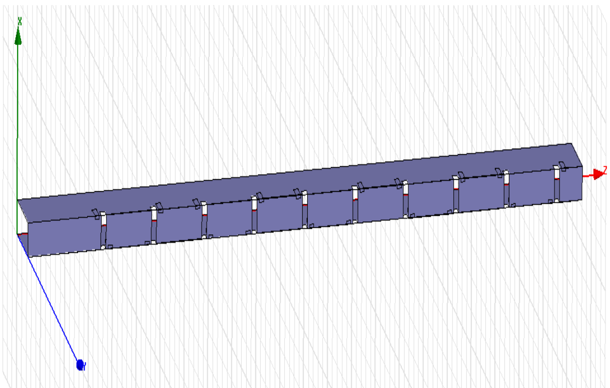

Fig.3: Non inclined Narrow wall slotted waveguide array structure with Iris.

As it is already stated that Iris of different shapes will lead to different level of co polarization hence in this paper Iris of different shapes are used to compare its effect on co polarization. Different Iris shapes used here are Iris with

a. Rectangular face
b. Semi circular face
c. Pentagonal face
d. Triangular face

Table 1 below is to mention dimension of slot and Iris

Table 1: Various Parameters and their dimension for given structure

Parameters	Dimensions
Slot width(w)	2.44 mm
Iris width(l)	2 mm
Iris-slot distance(c)	3.22 mm
Iris height(b)	1 mm
Iris depth(h)	6mm

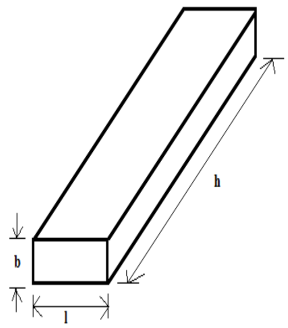

Fig.4: Iris with Rectangular face depicting its various parameters

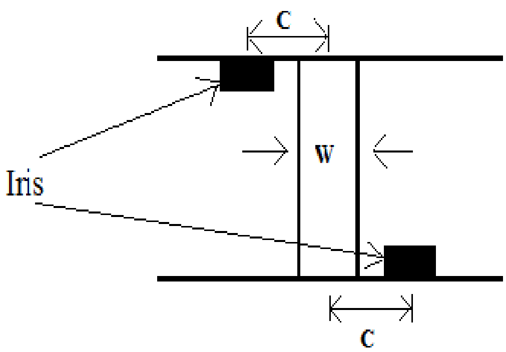

Fig.5: Placement of Iris near Non inclined Narrow wall slot

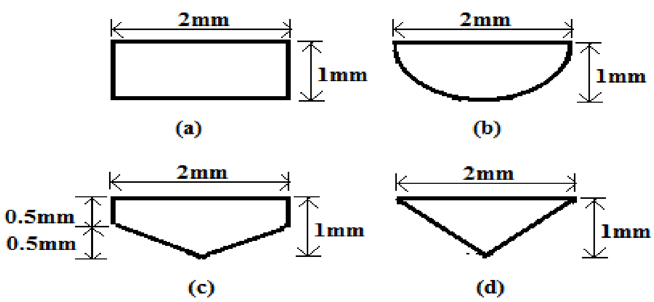

Fig.6 : Different Iris shapes and their dimensions (a) Iris with Rectangular face(b)Iris with Semi ellipsoidal face (c) Iris with Pentagonal face(d) Iris with Triangular face.

III. RESULTS

Standard WR 90 waveguide is used here for simulation purpose which has cross sectional dimension of 10.16 mm x22.86 mm and its length depends on number of slots present. For this analysis 10 slots are used and corresponding length of waveguide is 5.5 λg.

A. Comparison of co and cross polarization of Inclined and Non inclined slotted waveguide array:

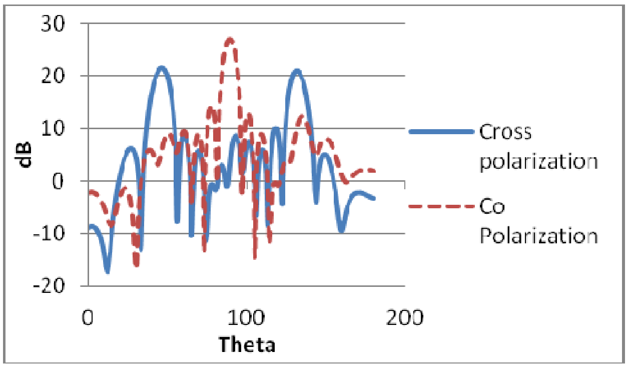

Fig.7: Co and cross polarization due to Inclined Narrow wall slotted waveguide array

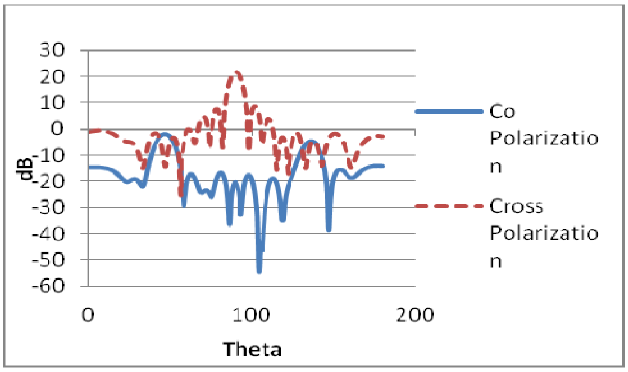

Fig.8: Co and cross polarization due to Non Inclined Narrow wall slotted waveguide array with rectangular Irises.

B. Comparison of co and cross polarization due to various shapes of Irises:

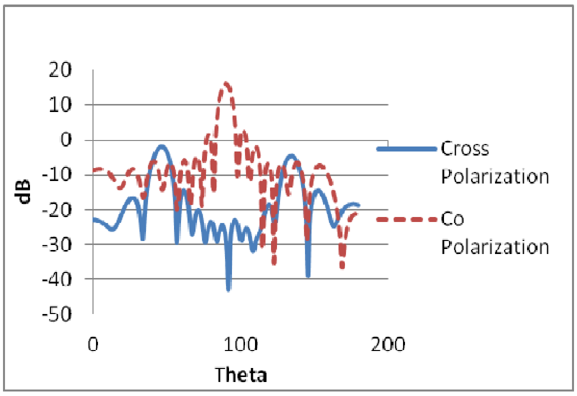

Fig.9: Co and cross polarization due to Non Inclined Narrow wall slotted waveguide array with Triangular face Irises.

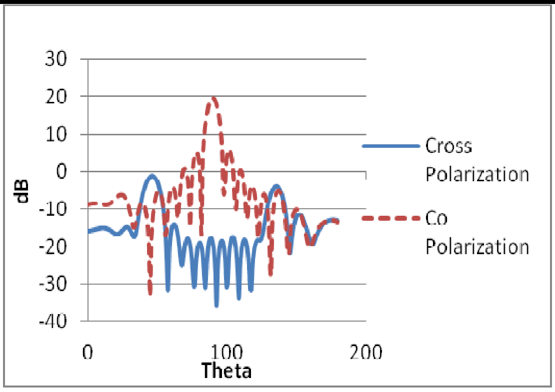

Fig.11: Co and cross polarization due to Non Inclined Narrow wall slotted waveguide array with Semi ellipsoidal face Irises.

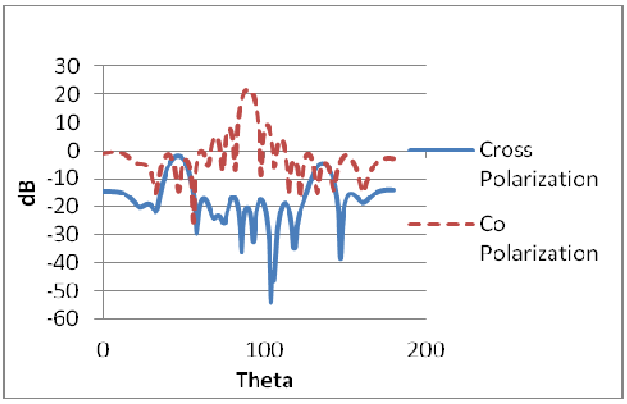

Fig.12: Co and cross polarization due to Non Inclined Narrow wall slotted waveguide array with Rectangular face Irises.

From all the co and cross polarization curves it can be seen that cross polarization is below 0 dB for all the shapes of Irises. Also it can be seen that co polarization is least for Iris with triangular face and maximum for Iris with rectangular face, i.e. as surface area of the face of the Iris increases co polarization increases.

C. Gain, Radiation pattern and Return Loss:

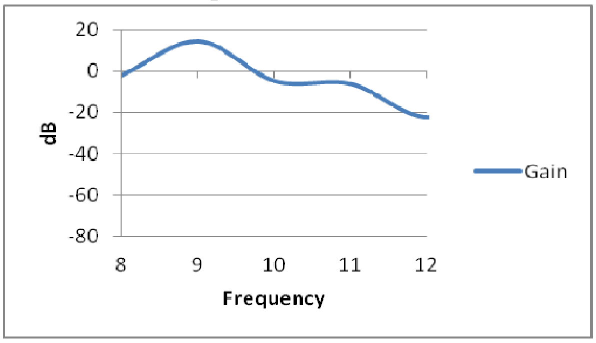

Fig.9: Typical Gain Characteristics of Non Inclined Narrow wall slotted waveguide array with Irises.

From the gain characteristics it can be seen that gain at operating frequency of 9 GHz is 14.5 dB.

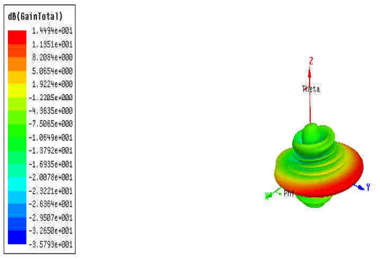

Fig.10: Typical 3-D Radiation pattern of Non Inclined Narrow wall slotted waveguide array with Irises.

3-D radiation pattern shows that antenna has very high directivity in desired direction of radiation.

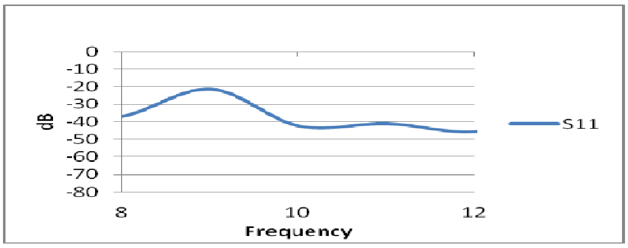

Fig.11: Typical Return Loss of Non Inclined Narrow wall slotted waveguide array with Irises.

Return loss is well below -20 dB for complete X-band frequencies.

1. Fig 7 and 8 shows that cross polarization got reduced by 20 dB in case of non-inclined slotted waveguide array with Irises as compared to Inclined slotted waveguide array.
2. It is also observed that co polarization due to non-inclined narrow wall slotted waveguide array is also reduced by 5dB as compared to inclined slotted waveguide array, this is mainly because of less coupling when iris is used as compared to when the slot is inclined.
3. Comparison of co polarization due to different shapes of Irises is shown in Table 2.

Table 2: Comparison of co polarization for various shapes of Irises

Sr.No	Shape of Irises	Co polarization (in dB)
1.	With triangular face	16.05
2.	With pentagonal face	19.64
3.	With semi cylindrical face	19.67
4.	With rectangular face	21.98

IV. CONCLUSION

The Non-inclined slotted waveguide array is designed for different optimized iris shapes for achieving reduced cross polarization. The results are found to be satisfactory when compared with narrow wall inclined slotted waveguide array with respect to cross polarization levels. Hence, these designs find many applications in radar applications where less cross polarization is required.

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