

Centerline Longitudinal Shunt Slot Excitation by Elliptic shaped single Ridge Waveguide

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Abstract: The Application of elliptic shaped ridge waveguide is presented for excitation of a centreline longitudinal shunt slot antenna. The proposed method is realized by adding elliptic shaped to the ridge of the single ridge waveguide. The elliptic shaped ridge is placed exactly under the longitudinal slot and the slot placed along centreline of the waveguide. It is shown that for a typical slot, the slot normalized conductance can be increased by increasing the elliptic shaped depth. The simulation results show that the proposed structure can be considered as a proper candidate for replacing the conventional longitudinal shunt slot.

Index Terms: Slot antenna, Second order beams, HFSS, Scan Array.

1. Introduction

Longitudinal shunt slot antenna has been frequently used due to its pure linear polarization. However, despite its advantages, the conventional longitudinal slot antenna has several shortcomings. Its basic drawback is the appearance of second-order beams off the principal planes which are usually called butterfly lobes [1, 2]. These second-order beams decrease the antenna efficiency and increase the susceptibility of the radar to jamming. Thus, it is desirable to eliminate these second-order beams. The second-order beams are associated with the alternating offset of successive slots which is essential in order to avoid the grating lobe appearance. Several methods have been proposed in the literature to suppress the second-order beams [2,5]. Another disadvantage of this antenna is its long width. The width of the conventional longitudinal waveguide slot antenna is approximately $0.7\lambda_0$ at the design frequency.

Therefore, for some applications which require large scanning angle in E-plane, the conventional slotted waveguide antenna is not a good candidate. This shortcoming has been overcome by utilizing ridge waveguide fed slot antenna [6].

Application of elliptic shaped ridge waveguide fed slot arrays is presented. The proposed structure is realized by adding the elliptic shaped to the ridge of the single ridge waveguide. The elliptic shaped ridge is placed exactly under the slot. It can be shown that the radiation characteristic of the slot can be varied by changing both slot length and elliptic shaped depth. Applying the proposed method not only eliminate the required offset but also has the advantage of ridge waveguide in reducing the required waveguide width. The following sections introduce the geometry of the proposed structure and

discuss more about the radiation characteristics of the proposed slot antenna.

2. Proposed structure

Fig.(1) shows the proposed structure which is considered to be a proper candidate for replacing the conventional waveguide longitudinal slot antenna. As the figure shows, a longitudinal narrow slot is cut in the upper broad wall of a ridge waveguide. The slot is placed exactly along the centreline of the waveguide. Elliptic shaped is applied to some part of the ridge which is placed under the longitudinal slot.

The electromagnetic field of the dominant mode and further the current at the upper wall of rectangular waveguide is deviated from the center line due to the elliptic shaped ridge. Therefore, some current interrupt the slot and the displacement current in the slot is formed. The displacement current and its equivalent magnetic current sheet justify the radiation to the outer space.

Fig.(2) shows the proposed and conventional slots. As indicated by the figure, the conventional waveguide has a wider width in comparison with the width of the ridge waveguide in the proposed slot. That is due to the effect of the ridge on the characteristics of the ridge waveguide.

The proposed elliptic shaped ridge has middle symmetry and the width of the elliptic shaped ridge is equal to the width of the initial ridge. The ridge height has also some effect on the propagation characteristic of the ridge waveguide and the radiation characteristics of the slot. But in this paper, only a constant value of the ridge height is taken into account. As the height of the ridge increases the radiated power is also increases, while the power handling capability and phase velocity of the dominant mode are decreased.

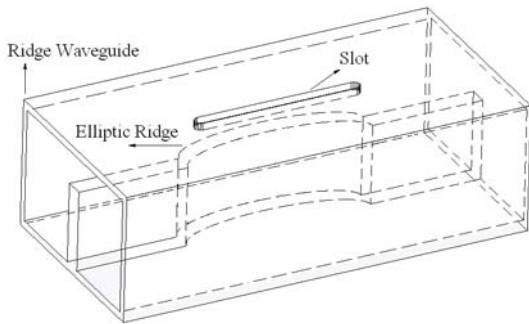


Fig. (1): Proposed structure for excitation of the centred longitudinal slot

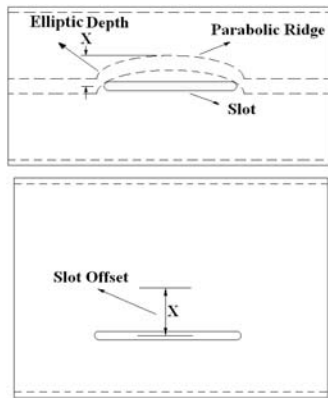


Fig. (2): Top views of the proposed and conventional slot antenna

3. Simulation results

In order to investigate the characteristics of the proposed structure, the proposed slot antenna with various elliptic shaped depths has been simulated using HFSS. The dimensions of the proposed slot antenna are shown in Table (1) The simulation of the antenna has been done for slot length equal to 45 mm and elliptic shaped depths equal to 6, 8, 12 and 17mm.

Table (1): Dimensions of the proposed slot antenna

| | |
|-------------------------|---------|
| Inner waveguide width: | 50.4 mm |
| Inner waveguide height: | 31 mm |
| Wall thickness: | 2 mm |
| Ridge height: | 22 mm |
| Ridge width: | 5 mm |
| Slot width: | 3 mm |

Table(2): Dimensions of the conventional antenna

| | |
|------------------------|----------|
| Inner waveguide width: | 72.14 mm |
| Inner waveguide width: | 34 mm |
| Wall thickness: | 2 mm |
| Slot width: | 3 mm |

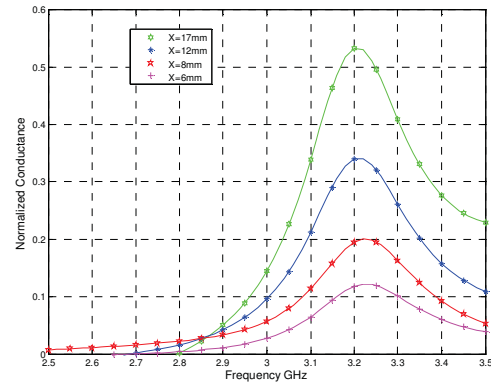


Fig. (3): Normalized conductance variation of the proposed slot versus elliptic shaped depth and frequency for slot length equal to 45 mm.

For comparative reasons, a conventional longitudinal slot with the same specification is also simulated. The slot offsets are selected to be equal to the elliptic shaped depths, i.e. X=6, 8, 12 and 17 mm. The various dimensions of the conventional longitudinal slot are shown in Table (2).

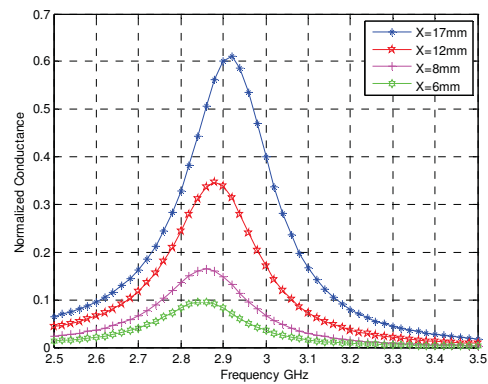


Fig. (4): Normalized conductance variation of the conventional longitudinal slot versus slot offset and frequency for slot length equal to 45 mm.

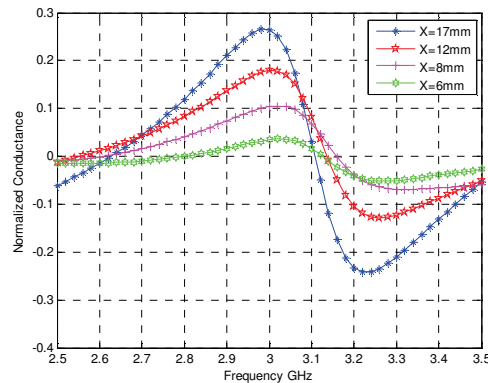


Fig. (5): Normalized susceptance variation of the proposed slot versus slot offset and frequency for slot length equal to 45 mm.

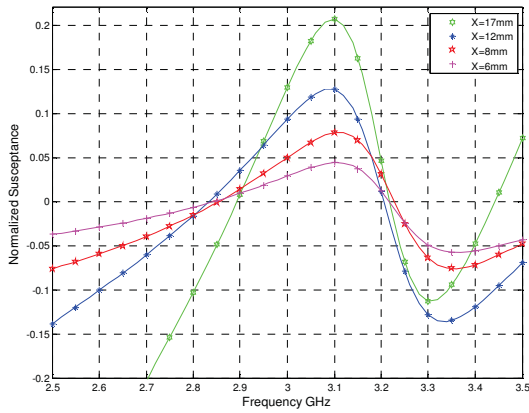


Fig. (6): Normalized susceptance variation of the conventional longitudinal slot versus elliptic shaped depth and frequency for slot length equal to 45 mm.

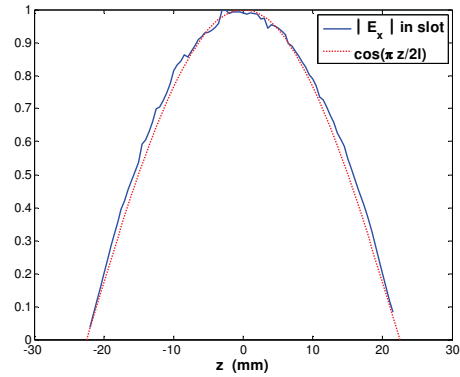


Fig. (9): magnitude distribution of x-directed electric field in the slot ((thick solid line) and half-cosinusoid (thick dotted line))

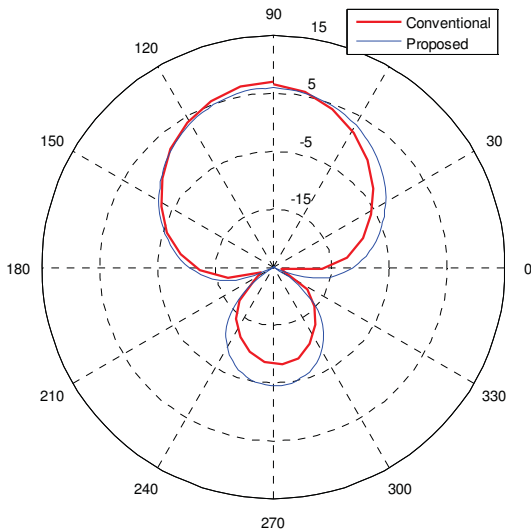


Fig. (7): E-plane radiation pattern of the proposed (solid line) and conventional slots (thick solid line)

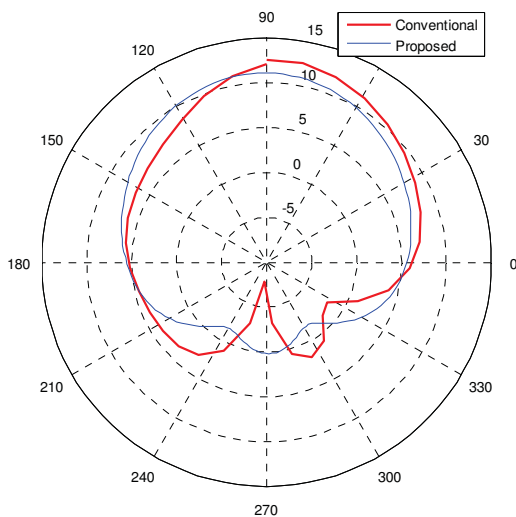


Fig. (8): H-plane radiation pattern of the proposed (solid line) and conventional slots (thick solid line)

The normalized conductance and susceptance variation of the conventional and proposed slot versus slot offsets and elliptic shaped depths are shown in Fig. (3) to Fig. (6). It is indicated from the figures that the shift of the resonance frequency versus slot offsets in the conventional slot is larger than the shift of the resonance frequency in the proposed slot, while the variation of the magnitudes and the shapes of the normalized conductances are comparable.

For better comparison, the radiation pattern of the proposed and conventional slot in E- and H-plane are shown in Fig. (7) and Fig. (8), respectively.

It is confirmed from the figures that the radiation pattern of the proposed slot has better symmetry in comparison to the conventional slot, while the front to back ratio of the proposed slot is reduced. That is, due to the reduction of the ground plane width of the slot (The width of the waveguide).

The distribution x-directed electric field is shown in Fig. (9) and is compared with half-cosinusoid function. As the figure shows, the electric field distribution is similar to half-cosinusoid. So, the proposed slot can be replaced with shunt admittance in equivalent circuit.

The simulation results show the effectiveness of the proposed slot and its ability for replacing the conventional longitudinal slot.

4. Conclusions

A modified configuration has been proposed for replacing conventional longitudinal slot. The slot was cut exactly along the centerline of a typical single ridge waveguide. The ellipticshaped was added to the ridge part of the ridge waveguide just under the slot position. The density of electromagnetic field was deviated from the centerline by the ellipticshaped part of the ridge waveguide as some surface current was interrupted by the slot and the radiation occurs. Comparison of the simulated parameters of the conventional and proposed topology indicates the efficacy of the proposed structure and its capability for replacing the conventional longitudinal slot.

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