INVESTIGATIONS ON BROADWALL SLOTS IN RECTANGULAR WAVEGUIDE FOR LONGITUDINAL POLARIZATION

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Introduction

Slotted waveguide arrays have been used in numerous radar and communication applications. Array antennas employing the conventional longitudinal offset broadwall slots are popular for producing a polarization transverse to the waveguide axis. There are excellent design and analysis techniques for such antennas. In order to produce longitudinal polarization one may use the narrow wall slots with alternating tilts. Resonant transverse slots in the broadwall are also candidates for longitudinal polarization. The level of excitation of a transverse slot is controlled by the amount of offset from the centerline. Since the amount of offset is usually limited, the dynamic range of excitations possible is inadequate for many applications. A typical transverse slot operating near resonance exhibits strong series impedance. Therefore even a small array of transverse slots will produce high input impedance with a consequent difficulty in achieving an input match. There is no simple mechanism to introduce a 180-degree phase reversal in a resonant transverse slot. Therefore, transverse slot arrays require a spacing of one guide wavelength to produce a beam in the broadside region. Josefsson [1] studied the use of baffles to suppress the grating lobes.

We investigated some broadwall slots to overcome the limitations of transverse slots and to produce longitudinal polarization. We started with an investigation of T slots. A T slot shown in Fig.1 contains both a longitudinal section that is located in the waveguide centerline and a transverse section. The motivation to study the T slot is the fact that the centered longitudinal section is not excited by the TE10 mode source but excited by the coupling to the transverse section which in turn is excited by the source. The electric field in the two halves of the longitudinal section of a symmetric T slot will exhibit odd symmetry. Thus the longitudinal section does not contribute significantly to the internal scattering or exterior radiation in the region near broadside.

Methodology

Our analysis started with the formulation of the pertinent integral equations for the slot aperture electric field [e.g., 1-2]. Only the dominant electric field across each slot section is assumed. The field equivalence principle is used to close the slot and obtain the scattered field in each region with the use of appropriate equivalent magnetic currents that are surrogates to the aperture electric field. The required Green functions for the waveguide region and the exterior half space or the parallel plate region are known [3]. We then match the tangential component of the magnetic field along each slot section. The integral equations were solved by the method of moments using global Galerkin technique with sinusoidal expansion and testing functions.

Numerical Results and Discussion

The T slot behaves primarily as series impedance. Figs. 2 and 3 show computed values of the normalized series impedance presented by the slot. The abscissa of these figures is half the length of the longitudinal section plus the length of the transverse section. The slot exhibits resonance typically when this length is between 0.5 to 0.6 of the free space wavelength. The slots were cut in standard X-band waveguide. The curves from left to right correspond to transverse section lengths of 4.7, 4.4, 4.1, 3.8, 3.5, 3.2, 2.9, and 2.6 mm respectively. Exterior region is assumed to be half space for these two figures. Figures 4 and 5 present similar impedance data for a T slot radiating in an exterior baffle region. Both the real and imaginary parts of the input impedance are found to be substantially higher when we have baffles in the exterior region.

Fig. 6 shows the far field radiation pattern in a plane containing the waveguide axis. It is seen that there is no grating lobe for the principal polarization. The principal polarization pattern is nearly constant up to some angular region and then it drops sharply. This is due to the evanescent nature of propagation in wide angular regions in the parallel plate for the horizontal polarization. However, for the vertical polarization there is no such evanescence. The cross polarization is zero in the broadside region and it increases away from broadside. The cross polarization level is greater for T slots with small excitations since each half of the longitudinal section is excited strongly in that case relative to the transverse part. In an array application, the cross polarization level may be reduced by using sub-array architecture so that not too many elements are excited weakly. In addition, the phase of the longitudinal part may be reversed by choosing the transverse part above or below the waveguide centerline. Results of array patterns employing such T slots will be presented in the symposium. In addition we shall also discuss the characteristics of a C-shaped slot in the broadwall.

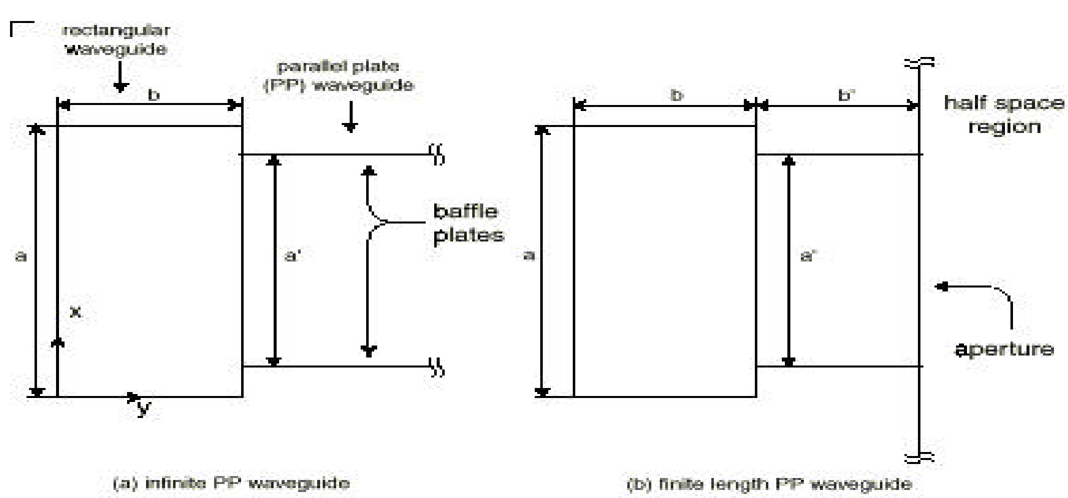
References

[1] L.G. Josefsson, “A Waveguide transverse slot for array applications,” IEEE Transactions on Antennas and Propagation, vol. AP-41, no. 7, pp. 845-850, 1993.

[2] L.G. Josefsson, “Analysis of longitudinal slots in rectangular waveguides,” IEEE Transactions on Antennas and Propagation, vol. AP-35, no. 12, pp. 1351-1357, 1987.

[3] C.-T. Tai, Dyadic Green Functions in Electromagnetic Theory, IEEE Press, 1993.

[4] J. R. Mosig and F. E. Gardiol, “A dynamic radiation model for microstrip structures,” Advances in Electronics and Electron Physics, vol. 59, pp. 139-237, 1982.



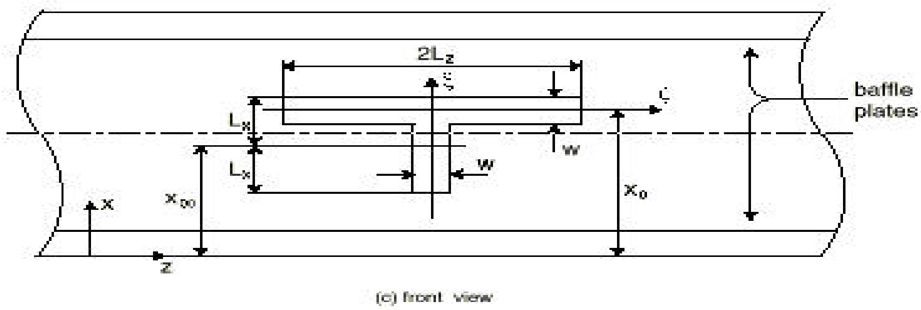


Fig. 1 T slot in the broad wall of a rectangular waveguide radiating between baffles

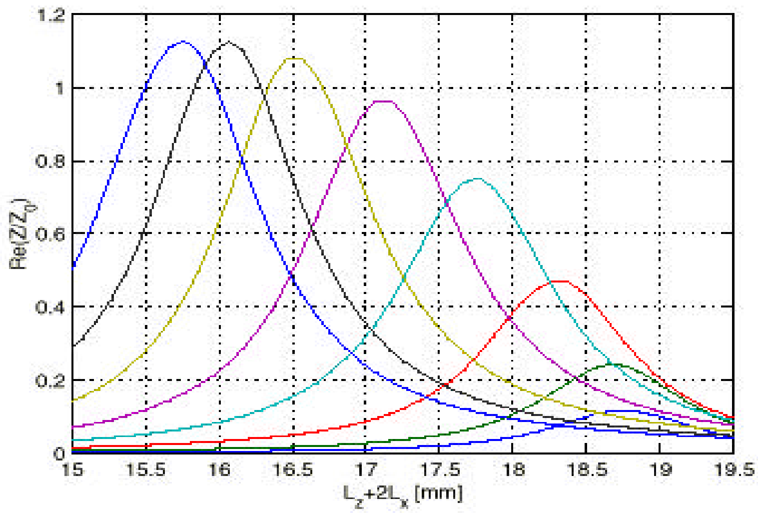


Fig. 2 Normalized resistance of the T slot radiating in a half space

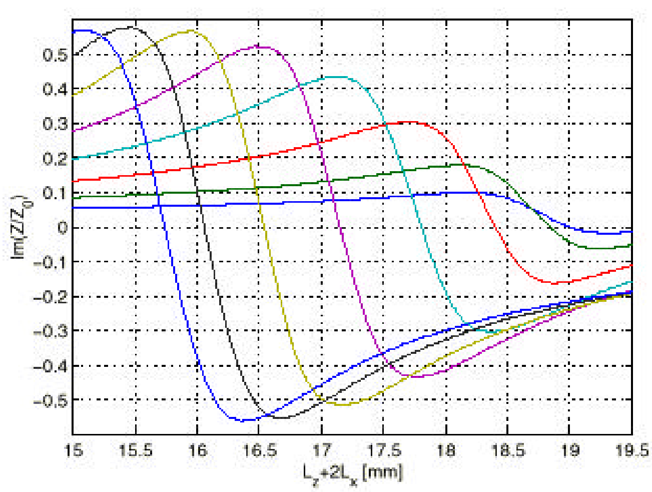


Fig. 3 Normalized reactance of the T slot radiating in a half space

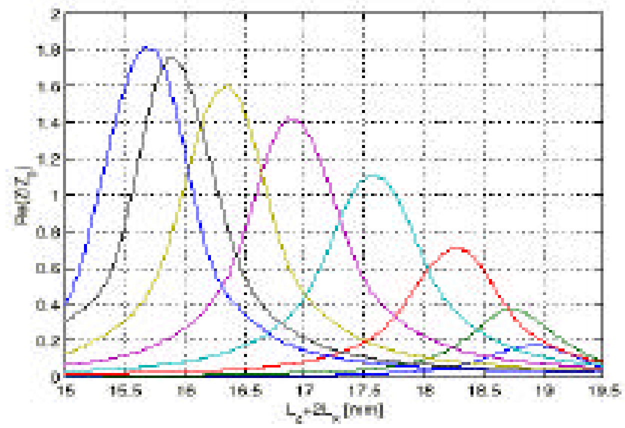


Fig. 4 Normalized resistance of the T slot radiating in a baffle region

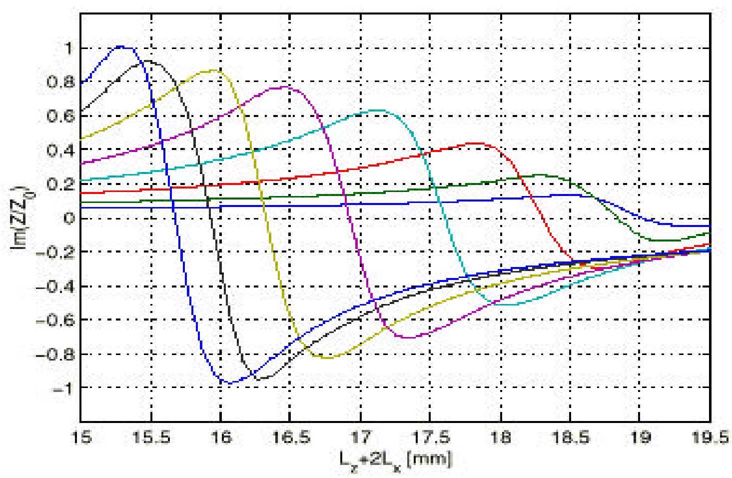


Fig. 5 Normalized reactance of the T slot radiating in a baffle region

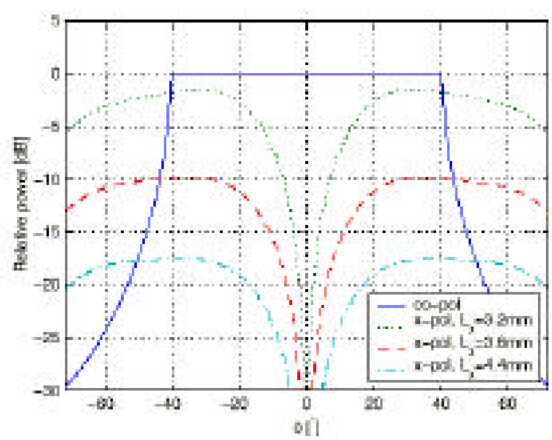


Fig. 6 E-plane radiation pattern of a T-slot