N-4

ANALYSIS OF ANTIPODAL RIDGE WAVEGUIDE STRUCTURE AND APPLICATION ON EXTREMELY WIDE STOPBAND LOWPASS FILTER

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ABSTRACT

This paper presents an accurate analysis of antipodal ridge W/G structure. Design parameters like the cut-off frequencies of TE_{10} and TE_{20} modes, characteristic impedance and gap impedance have been calculated. Comparison with exact analysis of such structure reported in Literature, shows very good agreement. Using the fact that antipodal ridge structures provide very large bandwidth (about twice that of double ridge W/G structures), a lowpass filter with extremely wide stopband using evanescent mode-antipodal ridge W/G techniques has been developed and tested. Spurious free response up to at least the sixth harmonic has been achieved.

INTRODUCTION

Antipodal ridge waveguide structure is very useful for both active and passive microwave components. In [1] exact analysis using Ritz-Galerkin technique has been performed to calculate the eigenvalue problem of a general structure having two arbitrary double ridges in a rectangular waveguide. Numerical results for two symmetrically placed identical double ridges and that for the case when the two identical double ridges are inverted with respect to each other (antipodal) have been reported. As an example of the applications of such antipodal ridge waveguide structure, two varactor-tuned Gunn Oscillators are briefly described. In [2] mode matching technique has been applied to calculate the eigenvalue problem of generalized finline structure (similar to ridge structure) with arbitrary slot width located on both sides of the dielectric substrate.

Using exact methods to generate design tables which cover a wide range of parameter variation would be cumbersome and time consuming. Instead an approximate method, which provide accurate results would be preferable. Exact results have been used for comparison to check the validity of the approximation.

This paper presents an approximate but accurate analysis of antipodal ridge W/G structure. The overlapped ridges form with the top and bottom wall of the rectangular waveguide an E-bend on each side of the ridges. Replacing the physical structure by its equivalent circuit using [3] and applying the transverse resonance technique at cut-off frequency [4, 5] makes it possible to calculate the required design parameters. Comparison with published results, which have been calculated using exact methods, shows very good agreement.

The calculated results show that such structures can provide a bandwidth up to twice that of the double ridge structure. Using this fact, a lowpass filter using evanescent mode-antipodal ridge waveguide technique has been developed and tested. Spurious-free response up to at least the sixth harmonic has been achieved.

ANTIPODAL RIDGE WAVEGUIDE ANALYSIS

Figure 1 - (a) shows the antipodal ridge waveguide structure, while Figure 1 - (b) shows its equivalent circuit at cut-off frequency. Region (3) in Figure 1 - (a) is considered as an E-bend and replaced by its equivalent circuit L_3, C_{31} and C_{32} [3]. C_1, Y_{01}, Y_{02} and Y_{04} are as defined in Fig. 1 -(b) and [4]. Applying the transverse reasonance technique as mentioned in [4, 5] and solving the resultant transendental equation numerically, it becomes possible to calculate the cut-off freqencies of TE_{10} and TE_{20} modes of the structure and the characteristic impedance and the gap impedance based on power voltage definition. Table 1 shows comparison between the results from this analysis and that given [1] which shows very good agreement.

TABLE 1

$b/a = 0.5$, $d/b = 0.1$, $c/a = 0.125$

	λ_{c10}/a		λ_{c20}/a	
t/a	From [1]	This paper	From [1]	This paper
0.125	6.244	6.26	2.315	2.30
0.250	5.340	5.34	2.901	2.89
0.375	4.534	4.59	3.110	3.09
0.5	3.693	3.76	3.030	2.95

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It is important to mention that the present analysis is valid only for $d/b \leqslant 0.5$. For $d/b > 0.5$ the antipodal ridge structure has been analyzed using the conventional methods mentioned in [4, 5] taking into account the proximity effect between the ridges when t/a becomes small.

Complete design tables for the different parameters have been generated. Examples of these results are shown in Figure 2.

The bandwidth could reach up to 12 with realizable dimension. The slight decrease in BW for $d/b < 0.1$ is due to slight increase in $\lambda_{c_{20}/a}$.

LOWPASS FILTER WITH EXTREMELY WIDE STOPBAND AND RESULT

Using the same design concept as in [6], which is based on using evanescent mode waveguide sections to realize series inductances, while antipodal ridge waveguide sections are used to construct distributed shunt capacitances, a lowpass filter with passband 3.8-4.2GHz and stopband from 6-26.5GHz has been developed and tested to demonstrate the applicability of the analysis. Filter construction is shown in Figure 3, while the results achieved is demonstrated in Figure 4.

Figure 4 - (a) shows the inband return loss of 20dB and insertion loss of 0.3dB in the frequency band 3.8-4.2GHz. The insertion loss of this type of filters is about three times that of single ridge structure [6]. It is expected to reduce the insertion loss by optimizing the design approach than that used before [6]. Spurious free out-of-band response in the frequency band 6-26.5GHz has been achieved and is shown in Figure 4-(b).

CONCLUSIONS

An accurate analysis of antipodal ridge waveguide structure has been presented. The electrical performance of such a structure has been calculated and compared to exact analysis reported in literature. The calculated results show that such structures can provide a bandwidth up to twice that of the double ridge structure. Using this fact, a lowpass filter using evanescent mode-antipodal ridge waveguide technique has been designed and test results have been presented. Spurious-free response up to at least the sixth harmonic has been achieved.

ACKNOWLEDGEMENT

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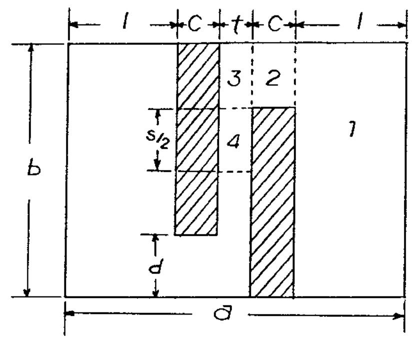
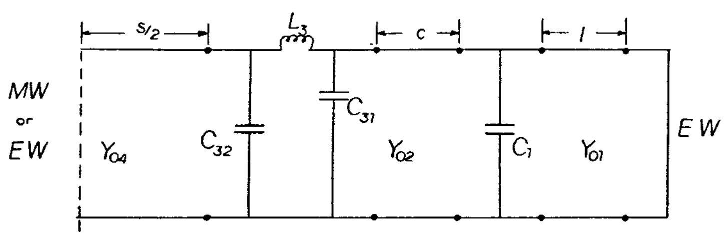


Figure 1-(a)



C_1 is the step capacitance between regions (1) and (2). Y_{01} Y_{02} and Y_{04} are the characteristic admittances of regions (1), (2) and (4).

Figure 1-(b)

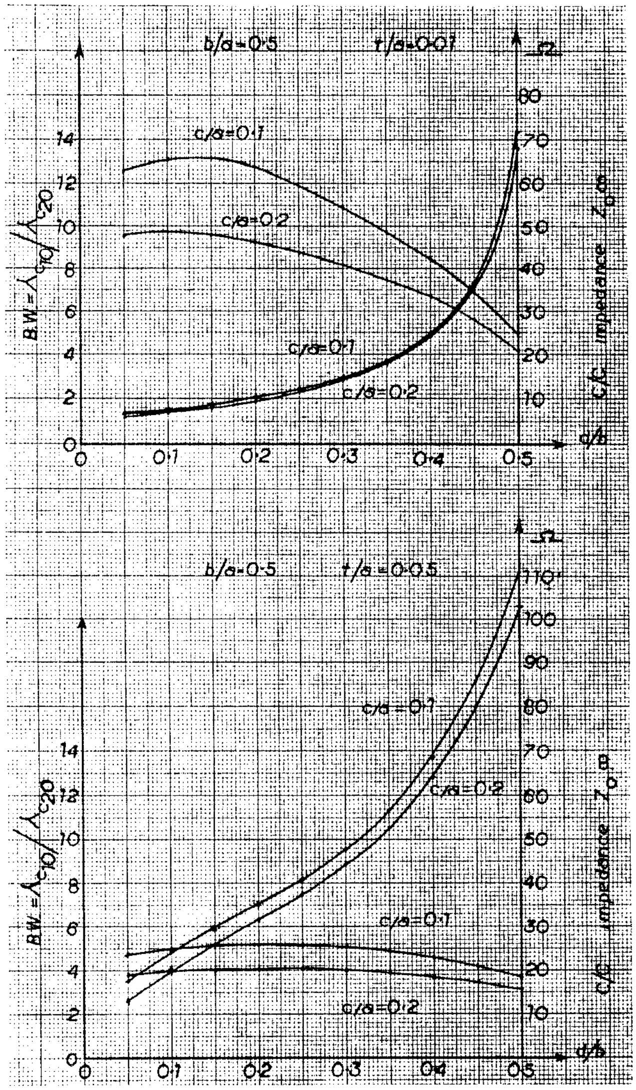


Figure 2

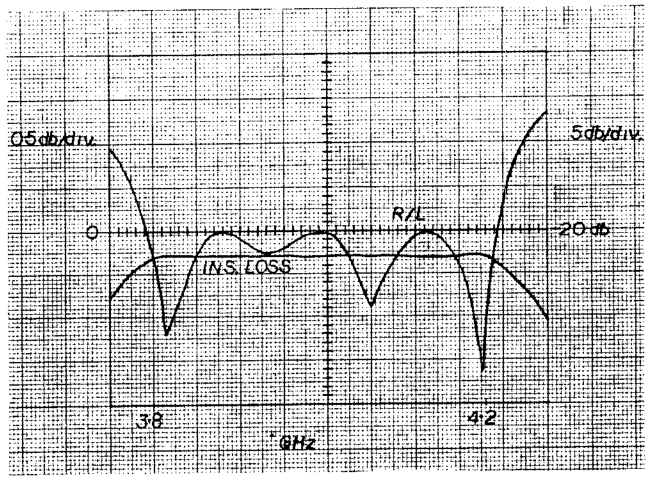


Figure 4-(a)

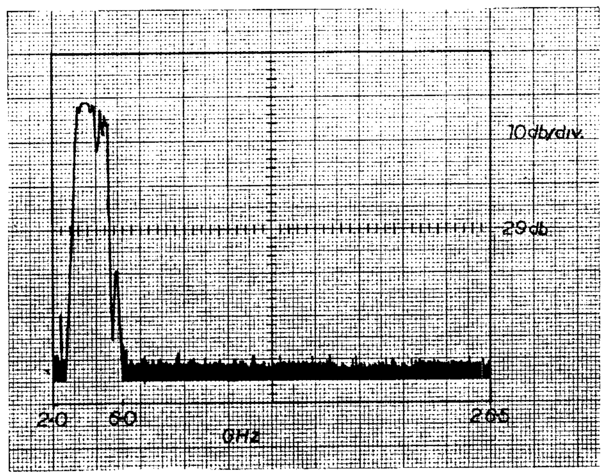


Figure 4-(b)

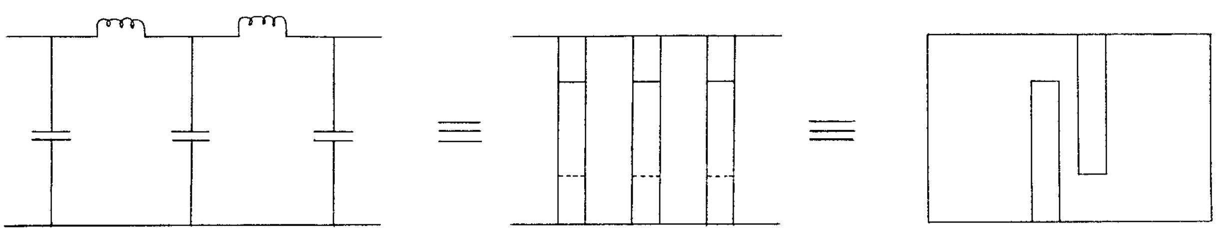


Figure 3