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E-Plane Band pass Filter With Resonators of Different Cutoff Frequencies

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Abstract

An E- plane bandpass filter with metal insert when mounted introduces ridges in the resonators which achieves improved stop band performance is considered. Higher modes interaction between E-plane discontinuities is included in the design. The predicted filter performance shows improved stop band performance and reduced filter dimensions compared with conventional E-plane bandpass filters.

الملخص

يتضمن البحث الى تحسين عمل مرشحات عرض الحزمة المايكروية في نطاق القطع بواسطة ادخال قطع معدنيةعلى محور موجه الموجات حيث اتضح ان المرشح المقترح يؤدي الى تحسين في العمل ضمن نطاق القطع اضافة الى تقليل ابعاد المرشح مقارنة بمرشحات عرض الحزمة المألوفة.

1. Introduction

All- metal insert placed in the E-plane of a rectangular waveguide along the waveguide axis offer the potential of realizing low cost and low dissipation loss millimeter wave filters [1]. Also the attenuation in the second stop band (i.e where the resonators are about one millimeter wavelength long)may often be too low and too narrow for many applications ,such as diplexers, when frequency selectivity and high stop band attenuation are considered to be important filtering properties. In recent years, much effort has been devoted to the study of E-plane bandpass filters with improved stop band performance. Several different solutions have been proposed to improve the stop band performance[2-].Although most of these solutions lead to a higher passband insertion loss , this is at the expense of increased manufacturing complexity. In this research paper an E-plane filter with resonators of different cutoff frequencies and characteristic impedances is investigated.

2.Proposed configuration

The proposed configurations are constructed of direct coupled ridged waveguide sections which, in general, have different cutoff frequencies and characteristic impedances (i.e non-uniform ridged waveguide) and reactive elements (metal septa) arranged in the sections in a manner such that each section is resonant at the same fundamental frequency. As the guide wavelengths differ in the different sections, the sections are not all simultaneously resonant at any higher frequency. The main features of the new structures are the use of conventional rectangular waveguide housing and the use of a metal insert which when mounted introduces ridges in the resonators. This improvement in the upper stop band associated with superior electrical performance of ridged waveguide, such as cutoff frequency reduction, provides a convenient way to realize E-plane bandpass filters with stop band performance. The structure is simple and compatible with the E-plane manufacturing process.

2.1 Design procedure

The common approach to the design of the conventional E-plane bandpass filters described by V.Postoyalko [1] can be used with minor modifications ,for filter structures with different impedances and cutoff frequencies such as E-plane bandpass filters with improved stop band performance. The most important steps in this design procedure , which include the concept of impedance inverters and impedance scaling of the impedance levels of the prototype filter have been presented by Budimir [7]. The main limitations of this approach are the frequency dependence of the guide impedances and the frequency dependence of the impedance inverters .Once the dimensions of the filter have been found , the frequency response of the overall filter at each frequency can be simulated by cascading the ABCD matrices of the resonators and the septa.

3.Numerical Results

In order to denomostrate the advantages of the new E-plane bandpass filter over the conventional E-plane bandpass filter, a five resonator X-band conventional E- plane bandpass filter and E-plane ridged waveguide bandpass filter (in which the width of ridges are arbitrary chosen)with the following specifications
Passband : 9.25-9.75 GHz ,Bandwidth: 0.5 GHz ,Number of resonators: 5 ,Passband return loss: 20 dB
have been designed. The parameters of for these filters are given in Table 1.The overall filter response (i.e insertion loss (Li) and return loss(L_R)) can be expressed in terms of elements of the total ABCD matrix of the filter at each frequency (by directly combining the ABCD matrices of the individual filter sections) as

$$Li = 20 \log_{10} ((A+B+C+D)/2) \qquad \ldots\ldots\ldots\ldots(1)$$

$$L_R = 20 \log_{10} ((A+B+C+D)/(A+B-C-D)) \qquad \ldots\ldots\ldots(2)$$

Figure 2 shows the relation between the calculated insertion loss and frequency of the conventional E-plane filter with ideal impedance inverters designed to pass a band of frequencies (0.5 GHz) in the vicinity of 9.5 GHz, The element of the ABCD matrices of the individual filter sections are calculated using the mode-matching method. The dotted line (3) shows a minimum stop band attenuation of 50 dB between 10.27 and 14.25 GHz and the location of the second passband at 14.88 GHz.
The solid line (4) shows the calculated insertion losses of the corresponding ridged waveguide E-plane filter with ideal impedance inverters (with rwg.gap=9/1/8/2/7 mm)with a minimum stop band attenuation of 50dB between 10.27 and 14.25 GHz and the location of the second passband at 14.88 GHz. The dashed-dotted line (2) represents the calculated insertion loss of the ridged waveguide E-plane bandpass filter when the frequency dependence of discontinuities is included in the model and it shows a minimum stop band attenuation of 50dB between 10.80 and 12.60 GHz and the location of the second passband is at 14.80 GHz.
The dashed line (1) shows the calculated insertion losses of the corresponding conventional E-plane bandpass filter with real impedance inverters when frequency dependence of discontinuities is included in the model with a minimum stop band attenuation of 50dB between 10.66 and 12.13 GHz and the location of the second passband at 13.95 GHz.
The dotted line (3) represents the performance of conventional E-plane bandpass filter with ideal impedance inverters.

4. Conclusion

The design of a prototype consisting of ideal impedance inverters separated by rectangular waveguide resonators, and a prototype consisting of ideal impedance inverters separated by ridged waveguide resonators was presented The broadband high attenuation behavior in the second stop band was achieved by E-plane bandpass with unequal ridges introduced in resonator sections. The predicted filter performance showed improved stop band performance and reduced filter dimensions compared with conventional E-plane bandpass filters.

5.References

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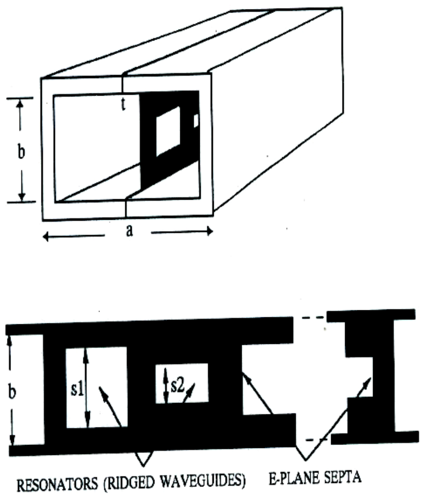
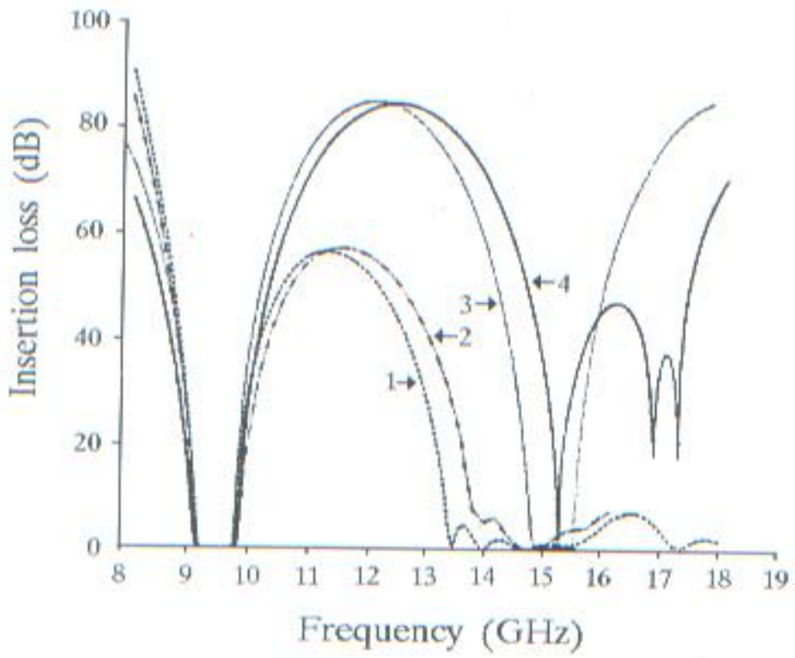


Figure (1) The proposed E-plane filter structures



Figure(2) Comparison of calculated insertion loss of X-band five resonator E-plane bandpass filters

Table -1-
Parameters of X-band five resonator ridged waveguide E-plane bandpass filters
Ridged waveguide gaps =9/1/8/2/7,insert thickness =0.10 mm

Figure	2			
	dotted line	dashed line	solid line	dash–dotted line
Normalized element value of ideal impedance inverters ($K's$) and septum lengths ($d's$ in mm)	$K_1 = 0.3964$ $K_2 = 0.1350$ $K_3 = 0.1005$ $K_4 = 0.1005$ $K_5 = 0.1350$ $K_6 = 0.3964$	$d_1 = 1.3334$ $d_2 = 6.2502$ $d_3 = 7.6076$ $d_4 = 7.6076$ $d_5 = 6.2502$ $d_6 = 1.3334$	$K_1 = 0.3937$ $K_2 = 0.0994$ $K_3 = 0.0734$ $K_4 = 0.0814$ $K_5 = 0.1095$ $K_6 = 0.3863$	$d_1 = 1.4294$ $d_2 = 5.0914$ $d_3 = 6.4568$ $d_4 = 6.4374$ $d_5 = 4.7229$ $d_6 = 1.1115$
Resonator dimensions (mm)	$l_1 = 21.8748$ $l_2 = 21.8748$ $l_3 = 21.8748$ $l_4 = 21.8748$ $l_5 = 21.8748$	$l_1 = 15.8258$ $l_2 = 16.1814$ $l_3 = 16.2054$ $l_3 = 16.1814$ $l_5 = 15.8258$	$l_1 = 21.7926$ $l_2 = 17.9614$ $l_3 = 21.5551$ $l_4 = 18.6711$ $l_5 = 21.1974$	$l_1 = 15.813$ $l_2 = 13.8175$ $l_3 = 16.1633$ $l_4 = 14.5730$ $l_5 = 15.6943$
Ridged waveguide gap dimensions (mm)	10.16 10.16 10.16 10.16 10.16		9.00 1.00 8.00 2.00 7.00	