

WestminsterResearch

http://www.wmin.ac.uk/westminsterresearch

Rectangular waveguide resonators in planar form for filter applications.

Alexander B. Shelkovnikov Djuradj Budimir

School of Informatics, University of Westminster

Copyright © [2004] IEEE. Reprinted from the proceedings of the IEEE Antennas and Propagation Society International Symposium, 2004, pp. 2167-2170.

This material is posted here with permission of the IEEE. Such permission of the IEEE does not in any way imply IEEE endorsement of any of the University of Westminster's products or services. Internal or personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution must be obtained from the IEEE by writing to pubs-permissions@ieee.org. By choosing to view this document, you agree to all provisions of the copyright laws protecting it.

The WestminsterResearch online digital archive at the University of Westminster aims to make the research output of the University available to a wider audience. Copyright and Moral Rights remain with the authors and/or copyright owners. Users are permitted to download and/or print one copy for non-commercial private study or research. Further distribution and any use of material from within this archive for profit-making enterprises or for commercial gain is strictly forbidden.

Whilst further distribution of specific materials from within this archive is forbidden, you may freely distribute the URL of the University of Westminster Eprints (<u>http://www.wmin.ac.uk/westminsterresearch</u>).

In case of abuse or copyright appearing without permission e-mail <u>wattsn@wmin.ac.uk.</u>

RECTANGULAR WAVEGUIDE RESONATORS IN PLANAR FORM FOR FILTER APPLICATIONS

A. Shelkovnikov and D. Budimir*

Abstract – This paper observes microwave waveguide resonators in planar form and proposes design for obtaining low-cost devices in planar form that are suitable for mass fabrication. Periodic resonators at 3.6 GHz are designed and simulated using this technique, which represents advantages of this technology, resulting the reduced size, cost and compactness of these components, while maintaining easy fabrication process. This is achieved due to the configuration that holds both the microstrip and the rectangular waveguide interconnected by a simple taper on the same substrate.

I. INTRODUCTION

The increasing introduction of microwave and millimeter-wave applications in communication systems has created new challenges for different technologies in design of passive devices. The demand for low-profile, lightweight and high-performance circuits of compact design is growing rapidly. High-Q resonators are required in microwave and millimeter-wave applications such as LANs and point-to-point communications.

Classical waveguide theory can still be used in order to meet the modern requirements of component parts for communication systems. Rectangular waveguide filters are well-known to be of highly-rated performance due to higher resonator Q values [1]; however their difficulty in integration and high cost makes them improbable for utilization in low-cost high volume applications. This can be solved by implementing design technique where rectangular waveguide is integrated with planar circuits on the same substrate. Moreover, introduction of a dielectric substrate results in significant size reduction without considerably diminishing its performance [2], [3].

In this paper, the conventional rectangular waveguide is modified to implement the dielectric substrate and to achieve planar structure of resonators and filters for microwave and millimeter-wave applications. Within the substrate the sidewalls can be realized either using metallized posts (metallic vias), metallized groove or paste sidewalls. The ground plane at the bottom and the tapered microstrip line on top both provide the metallic walls effect for the structure.

II. RECTANGULAR WAVEGUIDE RESONATORS IN PLANAR FORM

Fig.1 shows the structure of a $\lambda/2$ TEM-mode planar-rectangular dielectric waveguide resonator. The dielectric material has the following properties: dielectric constant $\mathcal{E}_r = 2.2$ and thickness h = 1.52 mm. The substrate is Rogers RT/Duroid 5880, cladding with copper and a dielectric loss tangent of 0.0007, according to manufacturer data sheet.

0-7803-8302-8/04/\$20.00 ©2004 IEEE 2167

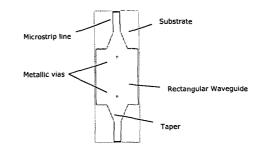


Fig. 1. Configuration of a waveguide resonator in planar form

The resonant frequency (f) of the dominant mode of $\lambda/2$ TEM-mode planar waveguide resonators can be calculated using the following relation:

$$f = \frac{c}{2 \cdot l \sqrt{\varepsilon_{eff}}}$$

where c is the velocity of light in free space, l is length of the resonator along the direction of propagation and \mathcal{E}_{eff} is the effective dielectric constant, which is defined as

$$\mathcal{E}_{eff} = \frac{\mathcal{E}_r + 1}{2} + \frac{\mathcal{E}_r - 1}{2} \left(1 + \frac{10h}{w}\right)^{-1/2}$$

where ε_r is the relative permittivity of the dielectric material, h is the thickness and w is the width of the resonator.

The modal energy transformation from waveguide, supporting the TE10 mode, to microstrip and vice versa is performed by tapers acting as mode converters on input and output ports of the structure. The integrated microstrip with a rectangular waveguide structure preserves the guided wave properties of the corresponding conventional rectangular waveguide with equivalent width. This allows for the analysis and design of these structures using the well-known techniques for a conventional waveguide [4].

The structure integrates the resonator, microstrip and taper on the same substrate. The discontinuity of resonator is presented by metallic holes [5], [6], transversely inserted inside the waveguide.

The resonator is constructed on a 1.52 mm thick dielectric substrate with $\varepsilon_r = 2.2$. The waveguide has a width w = 30 mm and length 40 mm. Both metallic cylinder holes are 0.7 mm in diameter and of 1.52 mm height. The length of the resonator *l* is 28 mm, which is chosen to be approximately half the guide wavelength ($\lambda g / 2$).

2168

Simulated and experimental results of the proposed resonator are shown on Fig.2 and Fig.3.

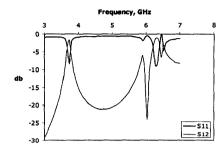


Fig. 2. Simulated response of the rectangular waveguide resonator in planar form

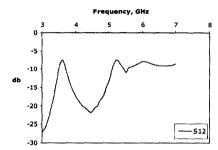


Fig. 3. Experimental response of the rectangular waveguide resonator in planar form

III. APPLICATIÔN

To verify the feasibility of the proposed structure, the two resonator filter was simulated. E-plane bandpass filter, designed with its center frequency at 5.15 GHz and bandwidth of 300 MHz integrating rectangular waveguide and the planar circuit on MIC technology is with the response presented at Fig.5.

The three-dimensional (3-D) EM simulator package HFSS [7] was used for simulation of presented structures.

2169

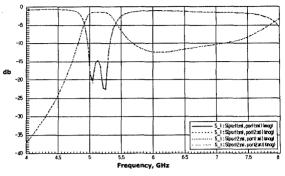


Fig. 4. Simulated response of the two resonator filter

IV. CONCLUSION

To meet the modern requirements for wireless communication devices, we have designed the low-cost, small-sized and suitable for mass fabrication passive structures integrating rectangular waveguide and planar circuits on the same substrate. Resonators structure design concepts have been investigated and obtained. The rectangular waveguide planar resonator has been simulated and measured. The feasibility of the proposed structure has been shown by simulated two resonator bandpass filter.

REFERENCES

- D. Budimir and C. Turner, "Novel high-Q waveguide E-plane resonators using periodic metallic septa", Microwave and Optical Technology Letters, vol.23, no.5, December 1999, pp. 311-312
- [2] D. Deslandes and K. Wu, "Integrated microstrip and rectangular waveguide in planar form" IEEE Microwave and wireless component Letters, vol.11, no.2, February 2001
- [3] A. Shelkovnikov, D.Budimir, "Novel waveguide E-plane bandpass filters in planar form", Seoul, Asia-Pacific Microwave Conference (APMC '03), 2003
- [4] D.M. Pozar, Microwave Engineering, New-York, John Wiley and Sons, 1998
 [5] Y. Cassivi, L. Perregrini, P. Arcioni, M. Bressan, K. Wu, and G. Conciauro,
- "Dispersion characteristics of substrate integrated rectangular waveguide" IEEE Microwave and wireless component Letters, vol.12, no.9, September 2002
- [6] C.-Y. Chang, W.-C. Hsu, "Novel planar, square-shaped, dielectric-waveguide, single-, and dual-mode filters", IEEE Transactions on Microwave Theory and Techniques, vol.50, no.11, November 2002
- [7] Ansoft HFSS V 8.5, 2003

2170