Mixed Non-Uniform Width / Evanescent Mode Ceramic Resonator Waveguide Filter With Wide Spurious Free Bandwidth

Sharjeel Afridi, Muhammad Sandhu, Ian Hunter

Institute of Microwave & Photonics, School of Electronic and Electrical Engineering

University of Leeds

LS29JT Leeds, United Kingdom

Email: el11s2a@leeds.ac.uk

***Abstract*— This paper presents a method to improve the spurious performance of integrated ceramic waveguide filters. Non-uniform width ceramic waveguide resonator and evanescent mode ceramic resonators are employed together to the resonant frequencies of higher order modes. The proposed designs give 75% improvement in stop band response when compared to uniform width ceramic waveguide filter. Simulated results of two six pole chebyshev filters are presented here with improved stop band performance.**

Keywords— Attenuation, Ceramic, Non-Uniform Width Resonator, Spurious performance, TEM

I. INTRODUCTION

High-performance microwave filters with low loss, high selectivity and high power handling are widely used in satellite and wireless communication systems. Dielectric TEM filters offer a very good spurious performance but a high volume; whereas ceramic filled waveguide filters provide 50% miniaturization but have crowded modes in proximity with the pass band[1, 2]. Many techniques have been used to improve the stop band performance of waveguide filters. Ceramic TEM and Ceramic filled waveguide filter provided a good way of dealing with the spurious problem as well as maintaining considerable miniaturization[3]. Combline and mixed combline resonators were used to increase the stop band attenuation in [4-6]. The Non-uniform width resonators and Step impedance resonators were used to improve the stop band response of waveguide filter [7, 8]. Recently, different irises were proposed with Non-uniform widths in rectangular waveguide filter to increase the stopband region [9]. In Ceramic waveguide filter, Step impedance resonators, non-uniform width (NW) resonators and evanescent mode non-uniform width (NW) resonators were used to improve the spurious performance [2, 10].

This paper presents a new design approach to combine non-uniform width ceramic waveguide resonators with ceramic evanescent mode resonators to notably increase the spurious free region with small degradation of overall Q-factor of the Ceramic Waveguide filter.

II. CERAMIC RESONATORS TYPES

A. Non-uniform width ceramic rectangular waveguide resonator

Fundamental and higher-order mode frequencies of rectangular waveguide resonators depend on their physical dimensions (length, width and height). Higher order mode frequencies can be changed by changing its length and width ratio while keeping its fundamental frequency constant. The idea to spread higher order modes in a waveguide filter by using non-uniform width resonators was first proposed by Riblet [11]. The Q-factor and resonant frequencies of resonators are calculated by [13]. The width and length of non-uniform width resonators can be computed by following equations[8].

$$W_o = \frac{c}{2}\sqrt{\frac{3}{4(f_o)^2-(f_1)^2}} \qquad (1)$$

$$L_o = \frac{W_o}{\sqrt{(\frac{f_o}{fc})^2-1}} \qquad (2)$$

Where W_o and L_o are the different widths and lengths of resonators.

B. Evanescent mode ceramic waveguide resonator

An evanescent mode ceramic waveguide resonator consists of a rectangular ceramic block with a metal-plated hole at the centre of its broad dimension [3]. The metal-plated hole dimensions has a significant effect on fundamental and higher order modes of the resonator. Increasing the dimensions of the metallic hole moves higher order modes further away at a cost of reduced Q-factor. Fig 1. Shows the diagram of TEM and NW resonators.

III. FILTER 1

In order to improve the spurious performance of Uniform width ceramic waveguide filter, the Non-uniform width resonators, and the evanescent mode ceramic resonators are studied separately by the author [10]. Here, we propose a combined resonator approach to further increase the spurious-free window of the filter.

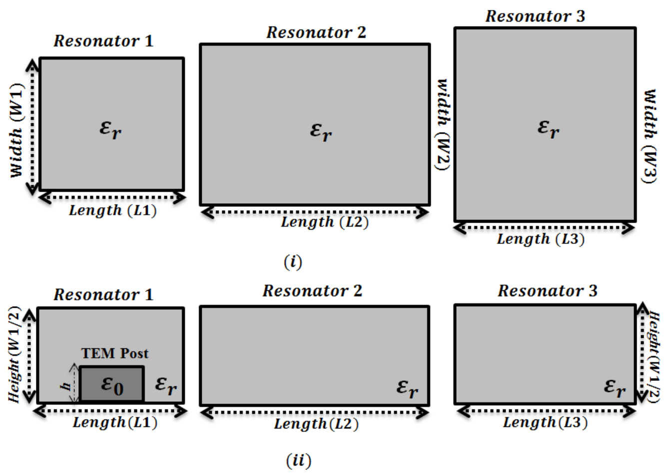

Fig 1. Non-uniform width and evanescent mode Resonators (i) Top View (ii) Front View

The proposed designs consist of a monoblock ceramic having both non-uniform width resonators and ceramic evanescent resonators. Different width resonators have different cut-offs and at the same time, evanescent mode resonator further enhances the out of band response. A six pole Chebyshev integrated ceramic waveguide filter is designed for the following specifications;

Fundamental frequency (f_o) : 1842 MHz

Bandwidth : 75 MHz

In our first design, the first and the last resonators are low Q evanescent mode resonators. The low Q-factor of the first and last TEM resonators have a negligible effect on overall insertion loss of filter[12]. The couplings are achieved as described in [3]. The filter provides the 40 dB stop band attenuation up to 3.60 GHz which is about 75 % improvement in spurious performance compared to the uniform width integrated ceramic waveguide filter [2]. Fig 2. Show the physical layout of the proposed ceramic waveguide filter1.

A comparison of proposed filter1 and integrated ceramic waveguide filter is given in Fig 3 which clearly demonstrates the improvement in spurious performance.

IV. FILTER 2

Besides improving spurious performance evanescent mode resonator offers the merit of miniaturization. Therefore, a second design is simulated with all resonators consisting of different width evanescent mode resonators. The frequency spread is achieved by changing the height of the metal plated blind holes.

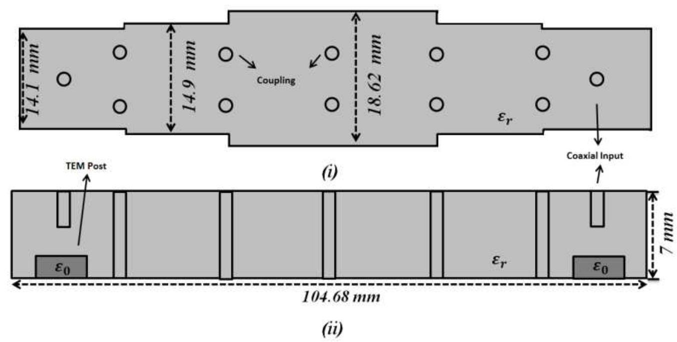

Fig 2. Physical layout of Filter1 (i) Top View (ii) Front View

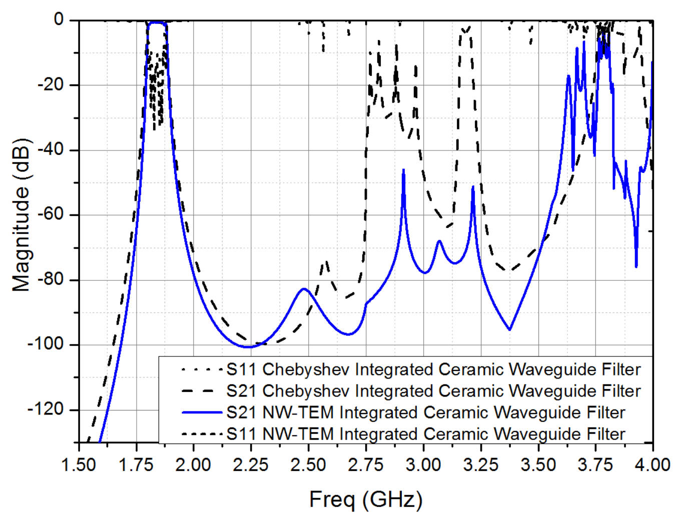

Fig 3. Spurious Performance comparison of Ceramic waveguide filter and NW-TEM Ceramic Filter

Different hole height results in different widths and heights of resonators which also spread out the higher resonance of the resonator. This filter gives 40 dB attenuation up to 3.55 GHz. TEM resonators allow considerable size reduction without affecting the overall selectivity of the filter. The external and internal coupling would follow the same procedure as in [3]. Fig 5 gives the physical layout of the filter. The simulated results in fig 6 show the comparison of integrated ceramic waveguide filters, filter1 and filter2. Both of the proposed filters show a considerable amount of improvement in spurious performance up to 75-80%. Table 1 Shows the comparative data of volume and quality factor of evanescent mode and non-uniform width resonators used in both filters.

Table 1. Quality factor and Volume of Resonators

	Resonator Type	Volume (Cm3)	Unloaded Q factor
Filter 1	Evanescent Resonator 1 &6	1.391	1568
	Non-uniform width Resonator 2&5	2.33	1978
	Non-uniform width Resonator 3 &4	2.17	2012
Filter 2	Evanescent Resonator 1 &6	1.372	1559
	Evanescent Resonator 2&5	1.638	1732
	Evanescent Resonator3 &4	1.837	1859

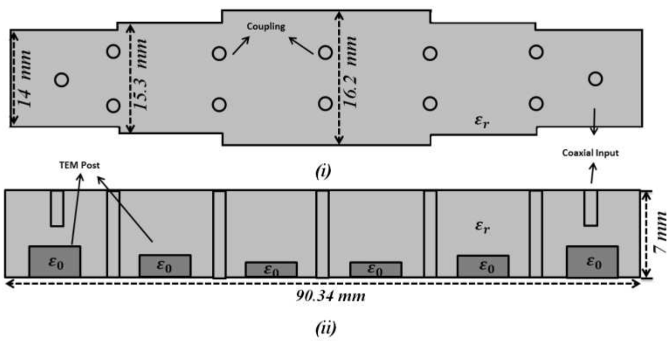

Fig 5. Filter2 (i) Top View (ii) Front View

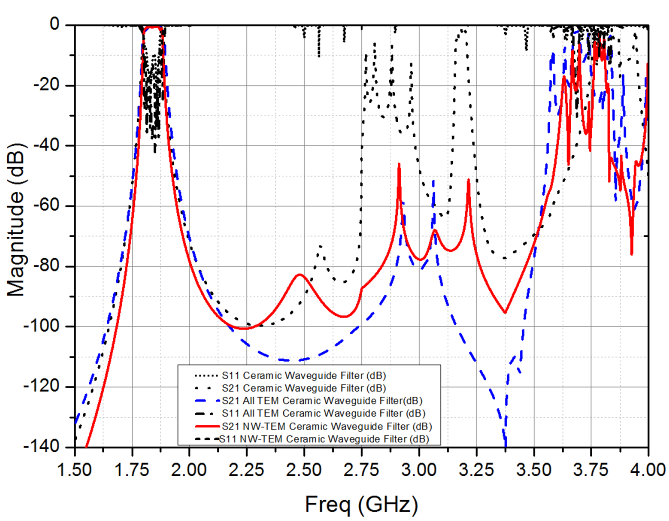

Fig 6. Spurious Performance comparison of Ceramic waveguide Filter, Filter1 and Filter2

V. CONCLUSION

A new design approach using evanescent ceramic resonator and non-uniform width ceramic waveguide resonator is proposed to improve the spurious performance of integrated ceramic waveguide filter. The simulated results are in good accordance with the theoretical concepts. This work will be extended to include the measured results and deal with other design details including manufacture tolerances, tuning, interfaces, power handling and temperature performance etc.

ACKNOWLEDGEMENT

The authors would like to thanks the Royal Academy of Engineering and Radio design Ltd. for sponsoring Prof. Ian Hunter and Sukkur Institute of Business Administration, Pakistan for sponsorship of Sharjeel Afridi and Muhammad Y Sandhu.

REFERENCES

[1] Chi, W., et al., Dielectric combline resonators and filters. IEEE Transactions on Microwave Theory and Techniques, 1998. 46(12): p. 2501-2506.

[2] Hunter, I.C. and M.Y. Sandhu. Monolithic integrated ceramic waveguide filters. in Microwave Symposium (IMS), 2014 IEEE MTT-S International. 2014.

[3] Hunter, I., S. Afridi, and M. Sandhu. Integrated ceramic waveguide filters with improved spurious performance. in Microwave Conference (EuMC), 2015 European. 2015.

[4] Hui-Wen, Y., et al. Improvement of spurious performance of combline filters. in Microwave Symposium Digest, 1997., IEEE MTT-S International. 1997.

[5] Weily, A.R. and A.S. Mohan. Mixed combline and He₁₁ mode dielectric resonator filter with improved spurious performance. in Microwave Conference Proceedings, 1997. APMC '97, 1997 Asia-Pacific. 1997.

[6] Hee-Yong, H., et al. The design of band-pass filters made of both dielectric and coaxial resonators. in Microwave Symposium Digest, 1997., IEEE MTT-S International. 1997.

[7] Morelli, M., et al., Stopband performance improvement of rectangular waveguide filters using stepped-impedance resonators. IEEE Transactions on Microwave Theory and Techniques, 2002. 50(7): p. 1657-1664.

[8] Morelli, M., et al. Stop-band improvement of rectangular waveguide filters using different width resonators: selection of resonator widths. in Microwave Symposium Digest, 2001 IEEE MTT-S International. 2001.

[9] Escudero, J.M.P., et al. Enhancing the spurious free range in inductive rectangular waveguide filters. in Microwave Conference (EuMC), 2015 European. 2015.

[10] Sharjeel Afridi, M.Sandhu., Nutapong Somjit, Ian Hunter, Monolithic Ceramic Waveguide Filter with Wide Spurious Free Bandwidth, accepted in European Microwave 20162016: London, United Kingdom.

[11] Riblet, H.J., Waveguide filter having non identical section resonant at same fundamental frequency and different harmonic frequency, Oct 13. 1964: US.

[12] Iglesias, P.M. and I.C. Hunter. Non-uniform Q-factor distribution in microwave filters. in Microwave Conference (EuMC), 2012 42nd European. 2012.

[13] Matthaei, G.L., Microwave Filters, Impedance Matching Networks And Coupling Structure. 1964: Mc Graw Hill.