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Ultra-Improved Stop band Rejection of an Ceramic Filter Using Ridge Resonators

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Abstract: This paper proposes improved design techniques for microwave filters to aid spurious performances of an monolithic ceramic waveguide resonator filter, with low insertion loss and good quality factor.The improved spurious performance of a filter is due to introduction of ridge in first and last resonator. The proposed filter design provide good miniaturization and with improved spurious performance up to 30%. Simulated result of the filteris in a good agreement with the theoretical concept which further confirms the validity and accuracy of designs without compromising the merits like Quality factor, return losses etc.

Keywords: Ceramic Waveguide Resonator, Quality Factor, Spurious performance, Miniaturization, Ridge, Return

1. INTRODUCTION

Phenomenal progress in the telecommunication industry over the decades incited significant advances in the microwave filters miniaturization. Microwave filters are mainstay pillars of radars, satellite and cellular communication systems. Cellular communication base stations usually employed coaxial cavity resonator and dielectric resonator (DR) filters (Hee-Yong, *et al.,* 1997) (Cruickshank 2016). Generally cellular base stations demands the following requirements: small physical size, low loss, reasonable cost and high-power handling capability. Coaxial cavity resonators have limited Q values, they are capable of Q's in excess of 10000, when due attention is paid to metallization (thick film or plated) conductivity, skin depth and surface finish. The size of such high Q structures, where each resonator has a cross section of 25 x 25 mm or more, give them limited scope for application in small base stations (Cruickshank 2016) (Cohn, 1957) “Direct-coupled resonator filters,” Proc. IRE, vol. 45,187–196. A related approach namely dielectric waveguide topology proves to have 20% less insertion losses in comparison to coaxial filters for small BS(Levy and Cohn 1984). These are still very large when high Qs are required. Same applies to DR filters. But recently the concerning problem of the DR filters is their crowded spectrum (Wiley and Mohan, 2000) causing poor band rejection though providing high Qs. The TEM resonator filters (Hunter and Sandhu 2014) can be added to both sides of DR filters, hence transforming transversal dimensions but providing same fundamental frequency and varied band frequencies. An integrated ceramic resonator with high permittivity of 45 offers considerable volume reduction in comparison with other standard coaxial TEM mode filters (Alseyab, and Rhodes, 1980) (Hunterand Sandhu 2014) (Afridi, *et al.*, 2018). The stop band performance of that integrated ceramic waveguide filters still offers the spurious modes in very close proximity of passband. Different techniques like blind hole in first and last resonator, non-uniform width ceramic resonators and step impedance resonators are introduced to improve the stop band performance of these ceramic waveguide integrated filters (Afridi, *et al.*, 2018). Afridi, *et al.*, 2019). In this paper, we are proposing a new approach to introduce the full half ridge across the width of resonators to improve the spurious performance of the filters without compromising their insertion loss and selectivity of the filters.

2. MATERIAL AND METHODS

CERAMIC RIDGE RESONATOR

A metal coated integrated ceramic waveguide resonator is designed with high permittivity material of rectangular ceramic block. The outer layer of the cavity is coated with metallized paint usually silver. The quality factor and center frequency can be computed by (Mitthaei,1964). The metal coated ridge across the width of the resonator helps to improve the stop band rejection of the filter and further reduce the size as in comparison with the integrated ceramic waveguide resonator(Hunterand Sandhu 2014). Ceramic cavity resonator consists of a rectangular type block enclosed with a metal ink exteriorly to provide the better conductivity to the resonator. A ceramic waveguide filters used the combination of these ceramic waveguide resonators and ceramic ridge resonators to realize the filter in waveguide technology. A ridge ceramic waveguide resonator is also given in **(Fig. 1).**

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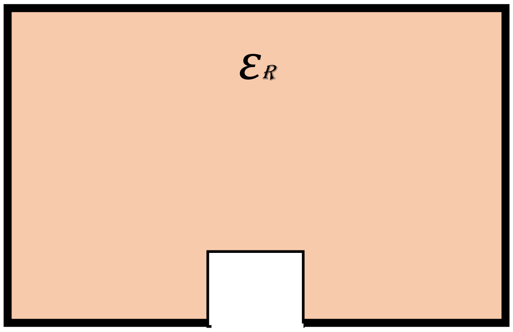

Fig.1. TEM Resonator with Ridge

Ceramic Ridge Waveguide Filter

A six pole chebyshev ceramic waveguide filters is realized using a ceramic waveguide resonators with the introduction of ridge in first and last resonators.The remaining four resonator will be the integrated ceramic waveguide resonators as in (Hunterand Sandhu 2014). The inter-resonator coupling the filters is realized by using a technique as described in (Hunterand Sandhu 2014). Coaxial probes were used to realize the input/output coupling for the filter, where the height and radius of the coaxial inside the cavity determines the bandwidth, coupling and resonant frequency. The integrated ceramic ridge waveguide filter improve the overall stop band performance by keeping the spurious resonances around 1.69 * for without affecting the overall selectivity of the filter. **(Fig. 2)** shows out the overall layout of the filter having the ridge in first and last resonators, input and output coupling and inter-resonator coupling.

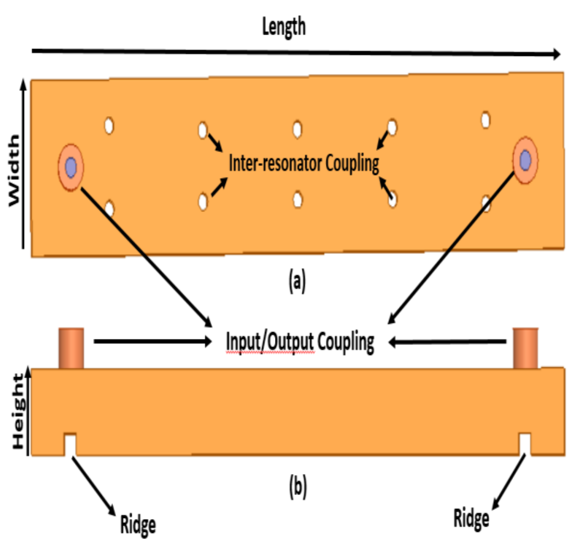

Fig.1. Layout of the Filter (a) Top view (b) Side View

The inter-resonator coupling is achieved using the metallic coated blind hole in the broad wall of the filter (Hunterand Sandhu 2014). The size of the ridge is optimized by keeping in view the improved stop band performance and good quality factor. Different parameters like center frequency, permittivity and bandwidth of the filter is mentioned in table 1 below. While the resonator type comparison in terms of size and spurious is also given in **(Table 2).**

3. RESULTS

The HFSS simulated response of the integrated ceramic waveguide filters is shown in (**figure 3 and 4)**. The simulated passband response shows the insertion loss around 0.75 dB and return loss of more than 22 dB of the filter. The simulated broadband response of the filter shows the20 dB stop band attenuation upto 3.2 GHz with few ripples around 2.9 and 3 GHz. These ripples may goes down if we optimized the size of ridge but would be at the cost of lower Quality factor. The group delay performance of the filter is also shown in **(Fig. 5).**

Table 1. Design Parameters

S. No	Parameters	Magnitudes
1	Centre frequency	1842 MHz
2	Bandwidth	75 MHz
3	Ceramic permittivity	43

Table 2. Resonator details

Resonator Type	Volume (cm^3)	First Spurious in GHz	Quality Factor
Ceramic Waveguide Resonator	2.529	2.9 GHz	2268
Ceramic Ridge Resonator	2.03	3.07 GHz	1930

4. Discussion

The unloaded Q-values of ceramic waveguide resonators and ceramic ridge resonator are 2268 and 1930 respectively. The first and last resonator have the minimum effect on the overall quality factor of a filter (Iglesias, and Hunter 2012), that's the reason we introduced low q factor resonators as first and last resonators of a filter as they are not contribute as significantly as other resonators in overall filter quality factor.

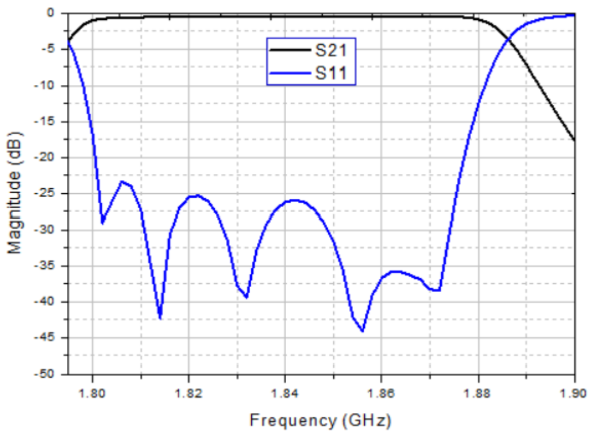

Fig.2. Passband Response of the Filter

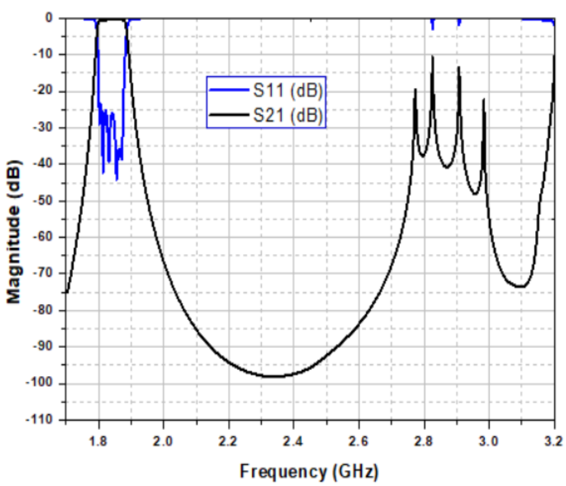

Fig.3. Broadband Response of the filter

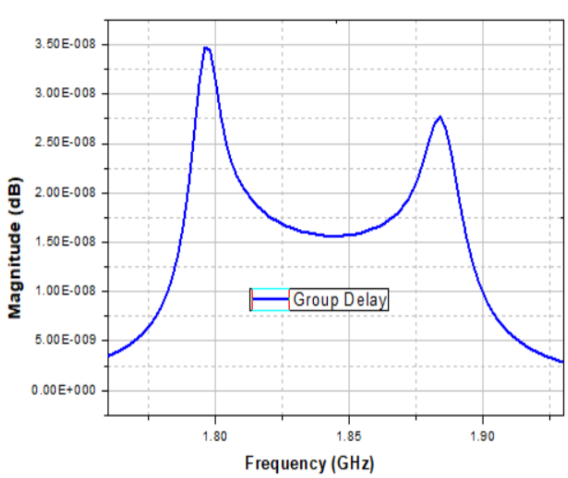

Fig.4. Group Delay of the Filter

5. CONCLUSION

The monolithic integrated ceramic ridge waveguide filter is designed with metallized ridge resonators to improve the stop band rejection of the monolithic ceramic waveguide filter. A six order chebyshev ceramic filter is realized to improve the stop band rejection and offers miniaturization without effecting the selectivity of a filter. Simulated response and results were also in agreement with the theoretical concept. Future publications will include the other data like experimental results, tuning interfaces, temperature performance, power handling and manufacture tolerances etc.

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