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Spurious Suppression of Ceramic loaded filter with different Ceramic Permittivity

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Abstract: This work presents the 3rd order ceramic waveguide filters with improved stopband performance. The idea utilizes ceramic loaded resonators with different permittivity's and TEM loading. The overall response spreads out the higher order resonances by integrating the effects of different ε_r and TEM without affecting the overall performance of a filter. The simulated results of a 3rd order ceramic loaded waveguide filter is presented, which is in good agreement with the idea.

Keywords: Ceramic, TEM, Filters, Permittivity, Stop band

1. INTRODUCTION

Over the couple of years rectangular waveguide filters have been an ideal and suitable candidate for low loss, cheap and high power filters for different microwave applications(Hunter, *et al.*, 2002). The current advances in cellular communication pose new challenges for miniaturized and low cost microwave waveguide filters. Dielectric filled resonators used extensively in microwave filters which offers considerable size reduction by a factor of $\frac{1}{\varepsilon_r}$with good performance(Konishi,1991). The dielectric loaded band pass filters are also offers miniaturized volume with high Q, but they suffer from crowded mode chart near pass band. Different ceramic loaded filters with same ceramic or different ceramic slabs were implemented in (Şimşek, *et al.*, 2012) (Aydoğan,*et al.*, 2016) (Walker and Hunter,2001)with in-line and cross coupled resonators. Different width ceramic loaded slabs with ridge improves the spurious performance of the filter without affecting the selectivity of a filter(Afridi, *et al.*, 2018).

In this paper we used different ε_r slabs in three different resonators. The change in ceramic slabs width makes them resonate at the same fundamental frequency, but with different spurious frequencies. This difference in frequency spreads out the spurious resonances as they will not contribute strongly to make a pass band near fundamental frequency. The TEM loading in one ceramic slab also allows to push the spurious resonance on higher side which improves the overall spurious of a filter.

2. CERAMIC LOADED RESONATOR

Three different ε_r ceramic slabs resonators were used to implement a 3 pole ceramic loaded waveguide filter. Three different permittivities of 36, 40 and 43 were used to design the resonators. The resonator with $\varepsilon_r = 36$ is designed with TEM loading which push its first spurious resonance upto 4.89 GHz but with degradation in Q factor as shown in **(Fig. 1).** The lower Q factor can be improved by increasing the height of the resonator, but it can also increases the overall volume of a filter. The ceramic slabs is metallized with the silver paint with the conductivity of $4x10^7$.The ceramic slabs placed at the center of metallized housing touched from top and bottom. All three resonators are designed for the fundamental frequency of 1842 MHz. Other details of ceramic loaded resonators like permittivity, Q factor and spurious performance is also given in **(Table 1).**

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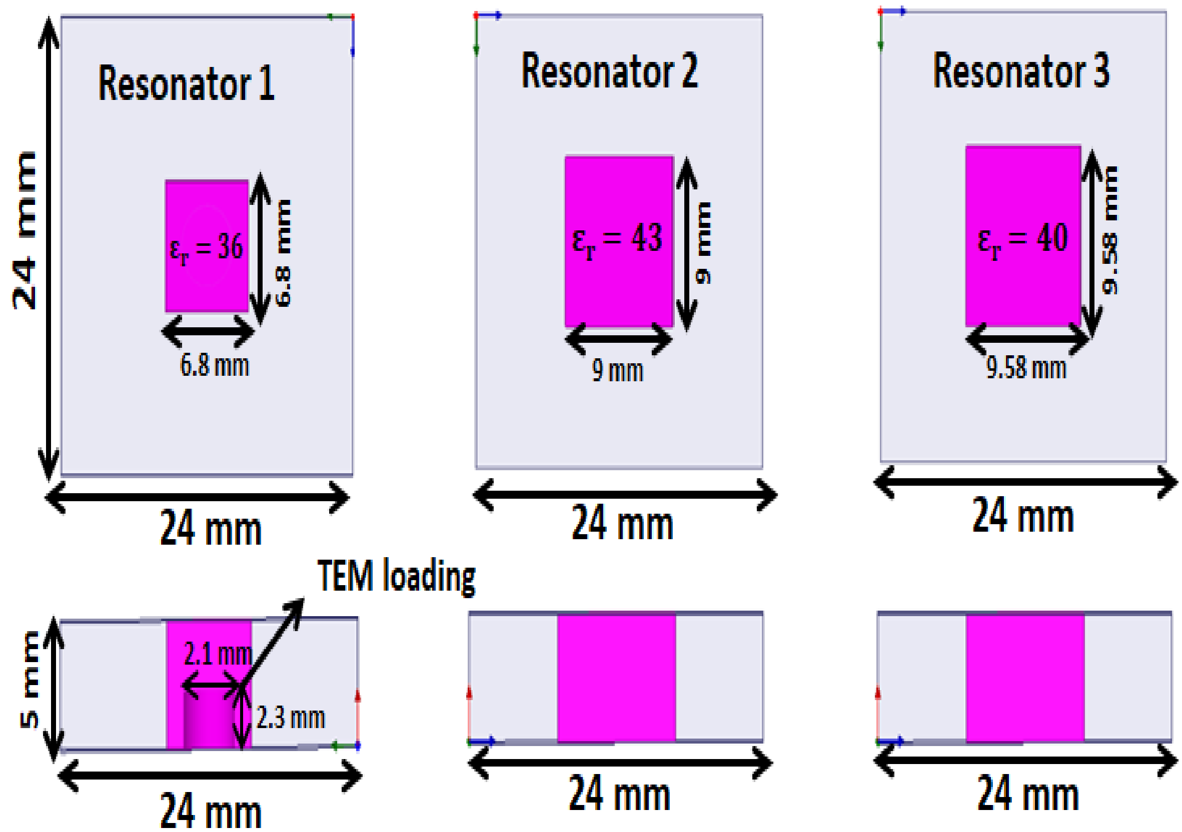

Fig.1. Three different ε_r resonators with TEM loading (a) Top view (b) Side view

Table 1. Details of all three resonators

Resonator #	ε_r	1st Spurious Frequency (in GHz)	Q Factor
1	36	4.89	1756
2	43	3.62	2100
3	40	3.55	2087

3. DESIGN METHODOLOGY

A 3rd order ceramic loaded waveguide filter with TEM loading is designed for the following specification;

- Fundamental frequency 1842 MHz
- Bandwidth 80 MHz

Three different ceramic slabs with different ε_r were used to design a 3 pole chebyshev ceramic loaded waveguide filter. The TEM loading is introduced in one of the resonator to increase the stop band rejection of the filter. The input/output coupling is realized by the coaxial probe placed in first and last resonator. The coaxial cable is touched the top and bottom surface of resonator to fully couple the magnetic field around the ceramic slabs of resonators as shown in **(Fig. 2).** Metallized iris windows is used to couple the energy from one resonator to another resonator as explained in (Afridi, *et al.*, 2018).

4. RESULTS AND DISCUSSION

The simulated response of 3rd order ceramic loaded waveguide filter in **(Fig. 3-4).**shows the insertion of a filter is around 0.6 dB and return loss of 13 dB. The stop band rejection of a ceramic loaded filter is improved to $f_o x$ 3.1, which shows 13 dB rejection upto 5.7 GHz. This spike in stop band response around 3.6 GHz is appeared due to the spurious response of non TEM resonators, which can be reduced if we increase the order of a filter and introduction of TEM loading in more resonators. This improved performance can eliminate the use of low pass filter with the band pass filter to improve the stop band rejection. The group delay of filter is also shown in **(Fig. 5).**

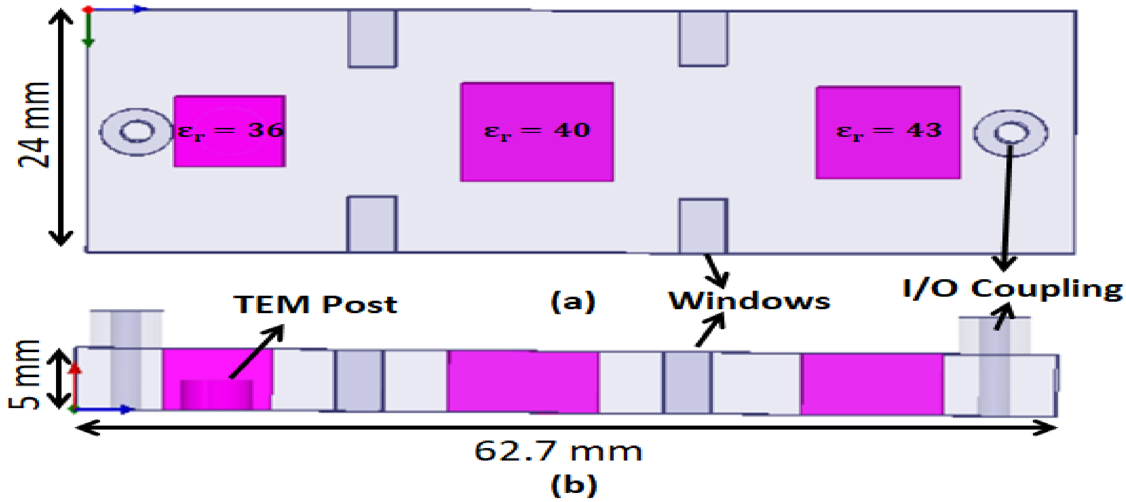

Fig.2. 3rd order ceramic loaded filter with different $\varepsilon_r$slabs (a) Top view (b) Side view

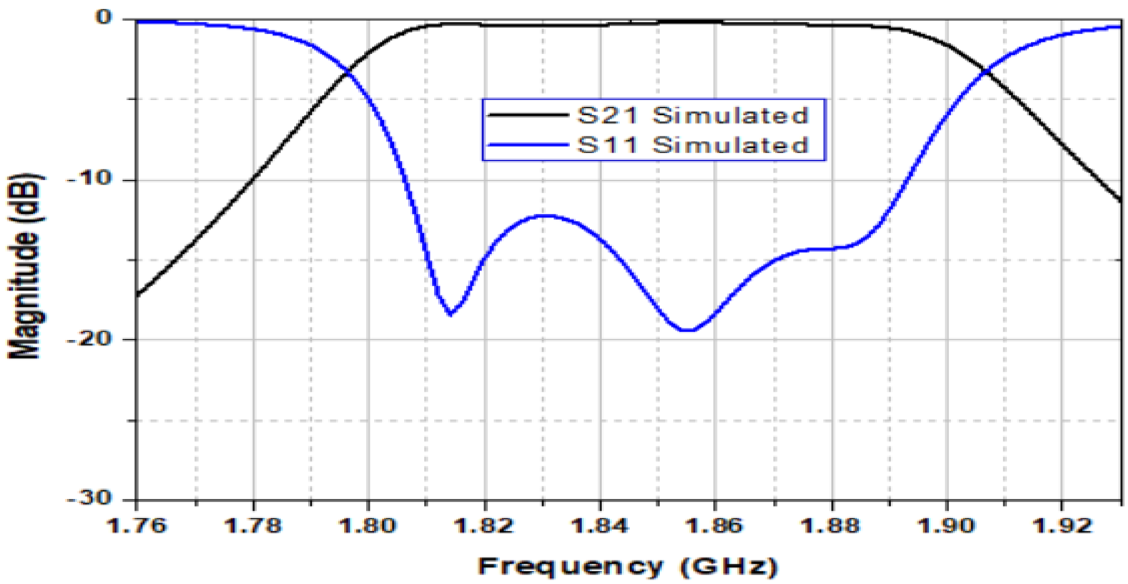

Fig. 3. Passband response of a 3rd order ceramic loaded filter with different ε_r

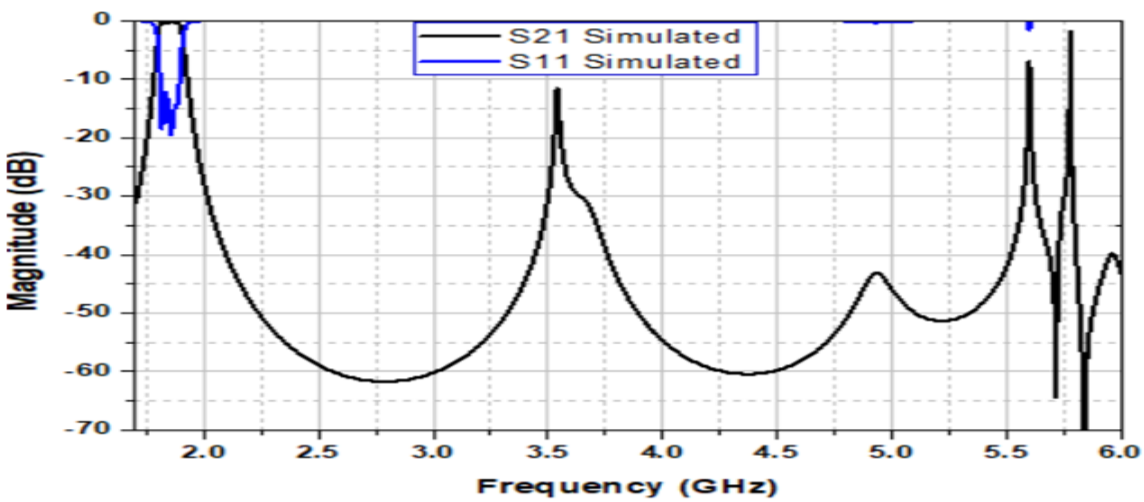

Fig. 4. broadband response of a 3rd order ceramic loaded filter with different ε_r

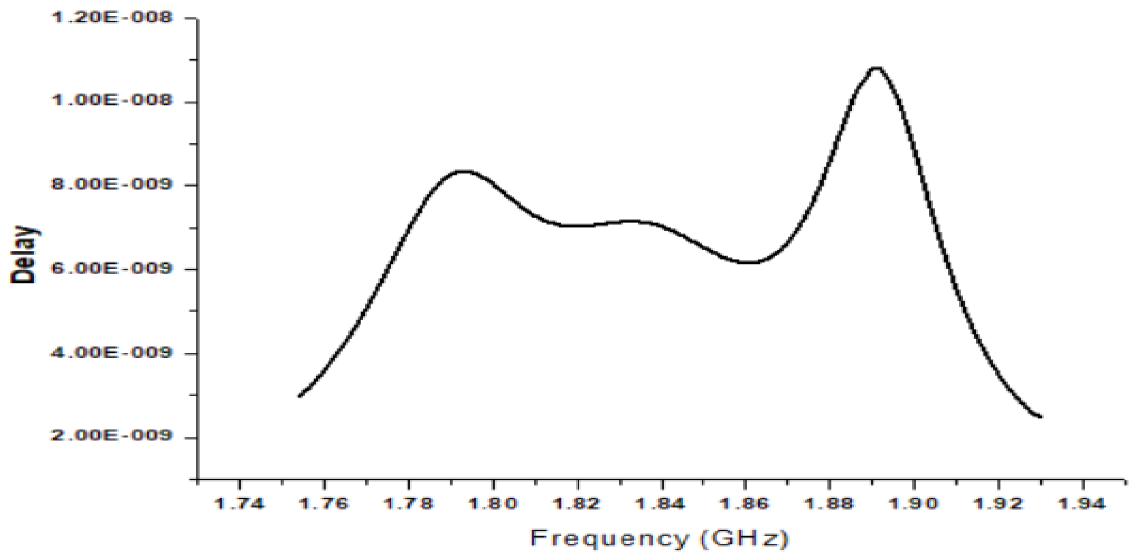

Fig. 5. Group delay of 3rd order ceramic loaded filter

5. CONCLUSION

In this paper, a new technique is introduced to design a ceramic loaded waveguide filters with different $\boldsymbol{\varepsilon_r}$andwith the integration of TEM loading. Different $\boldsymbol{\varepsilon_r}$slabs were used to design a resonators with same fundamental frequency but with different spurious resonances. Electromagnetic simulation results show good agreement with the theoretical concepts. This work will be extended to include the measured results, manufacturing tolerances, temperature and tuning interfaces.

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