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Tuning error comparison analysis of two tunable edge-coupled Bandpass filters using different dielectric materials

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Abstract— In wireless communication systems, bandpass filters play a very important role. Bandpass filters need to filter signals at transmission and recieption at a definite frequency with a specific bandwidth. Tunable bandpass filters are those in which we can vary it's frequency of passband by adjusting its components. In this paper we present a comparison of tuning error of two edge-coupled microstripline bandpass filters using two different dielectric materials i.e. plastic & ceramic. The operating frequency of two filters is same as 1.5 GHz.

Index Terms— Bandpass filter, Bandwidth, Communication systems, Edge-coupled, Microstripline Banpass filter, Operating frequency, Tuning error.

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1 Introduction

When we design edge-coupled microstripline bandpass filter using chebyshev approximation we use following equation for transfer function:

$$|s_{21\,(j\Omega)}|^2 = \frac{1}{1+\mathcal{E}^2 F_n{}^2(\Omega)}$$

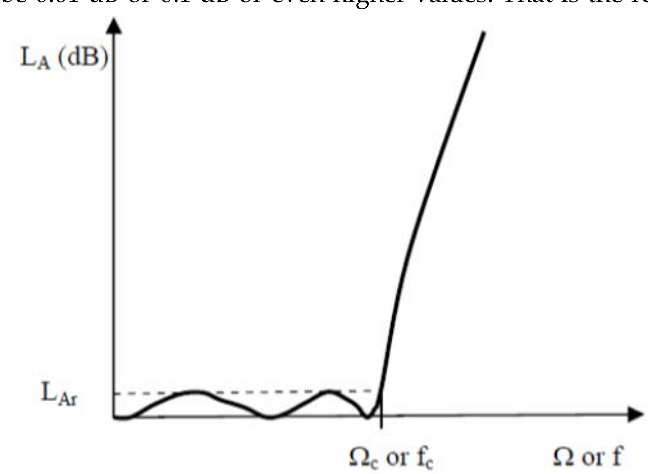
Ɛ is the ripple constant, Fn(Ω) is filter function and Ω is frequency variable. If the transfer function is given, the insertion loss response of the filter can be calculated by:

$$L_A(\Omega) = 10 \log \left[1/ \left| S_{21}(j\omega) \right|^2 \right]$$

For lossless conditions Return loss can be given by:

$$L_R(\Omega) = 10 \log \left| 1 - \left| S_{21}(j\omega) \right|^2 \right| \text{ dB}$$

Practically, the specifications for losses in pass region can normally be higher than zero. In Chebycheve approach it can be 0.01 dB or 0.1 dB or even higher values. That is the reason



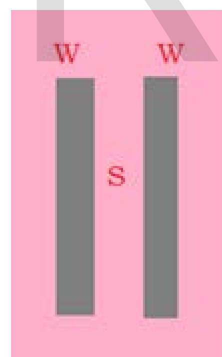
Chebychev approach shows some ripples in pass region, this can

Figure 1

lead to better (Higher) slope in the stop region. The attenuation characteristics for low pass filter based on Chebychev approach is shown in figure 1.

2. **TUNABILITY WITH TUNING CAPACITOR IN SERIES:**

The implementation and study of tunable resonators in stepped impedance resonators has been made by B. Kapilevich et al. A similar approach has been applied to edge-coupled flters. A capacitor has been inserted in series with the coupled sections as shown in fig. 3.



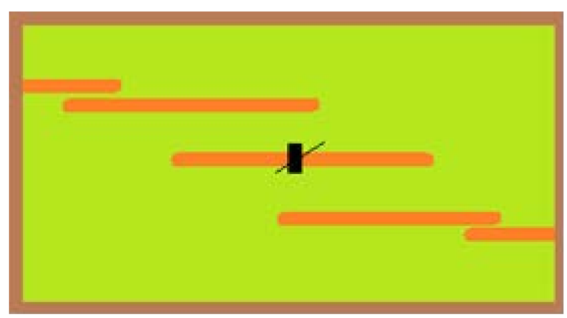


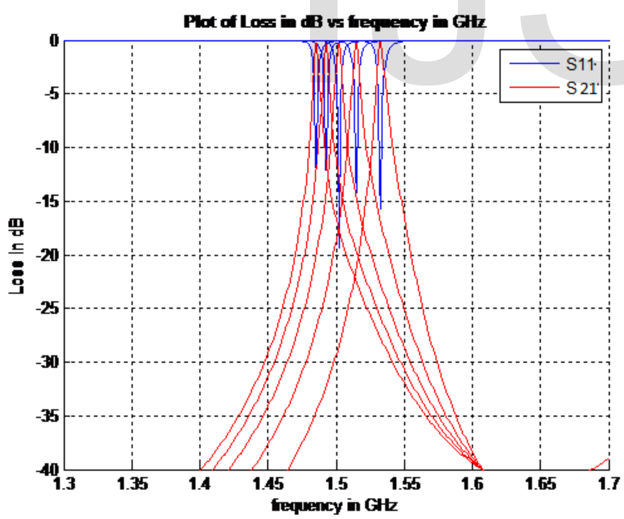
Figure 2 Edge-coupled filter geometry

Figure 3 Tuning capacitor in series

The symmetry of filter has not been affected. No bandwidth compensation scheme has been adopted which would require tunable input and output matching sections.

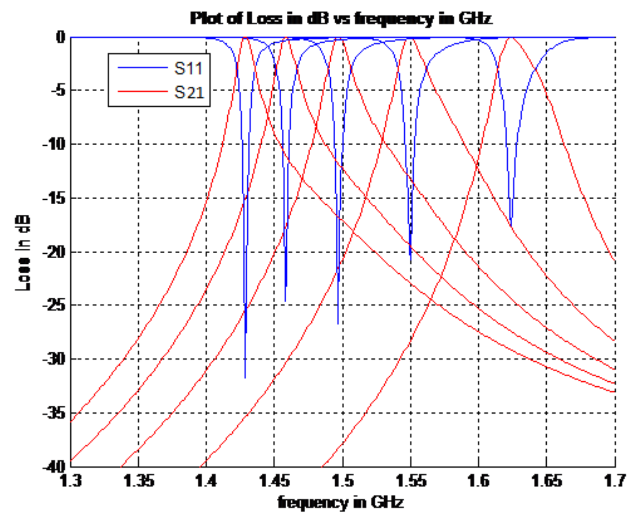
The two parameters (Insertion loss & Return loss) are crucial to analyse to obtain good performance of any filter. A good filter will have high return loss and low insertion loss. The performance of any tunable filter is measured in terms of quality factor or Q factor, Where Q is the ratio of center frequency to the bandwidth of any filter. Higher the value of Q the better is the tunable filter.

3. RESULTS, DISCUSSION & TUNING ERROR COMPARISON OF TWO FILTERS:



The tunable filter model consists of four equally spaced stripline sections each having impedance of 50Ω. Only the external capacitance is changed to find the optimum Q factor, while the filter geometry and elements remain constant. A continuous tuning of external capacitor is done and corresponding change in Q factor & center frequency is observed using MATLAB and best result was found for each capacitance value for both the dielectric materials. Figure 4 & Figure 5 show the Insertion loss & Return loss characteristic for Ceramic & Plastic Material respectively.

Figure 4: Insertion loss & Return loss characteristic of Band-pass filter using Ceramic as substrate material



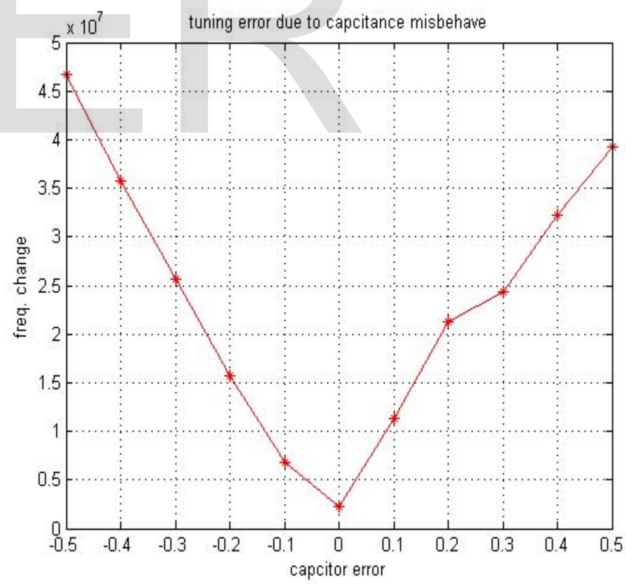


Figure 5: Insertion loss & Return loss characteristic of band-pass filter using Plastic as substrate material

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Figure 6: Tuning error due to capacitance misbehave for Plastic substrate.

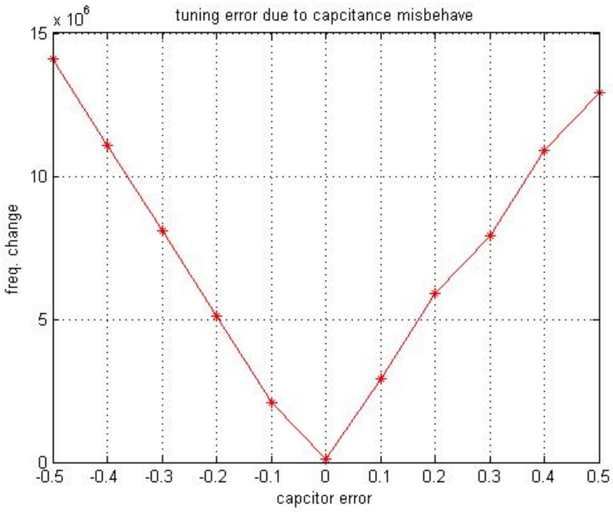

Figure 7: Tuning error due to capacitance misbehave for Ceramic substrate.

Figure 6 & figure 7 show the tuning error due to capacitance misbehave. These graphs show the value of frequency change for every incorrect 0.1pF of capacitance value. And we can see the difference between two graphs for Plastic & Ceramic materials.

4. COMPARISON WITH PREVIOUS WORK

The bandpass filter presented here is same as in [1] in terms of operating frequency but this is a tunable filter and [1] had a fixed passband. Other parameters are compared in table 1. The proposed filter shows better tunability than other basic tunable filters. We further examined its tuning error behavior for both the materials, which was not done in [1].

Parameters	Previous work	For Plastic Material	For ceramic Material
1.Operating Frequency	1.5 GHz	1.5 GHz	1.5 GHz
2.Tuning Range	Fixed band	1.3GHz-1.7GHz	1.4 GHz-1.6 GHz
3.Substrate used	Rogers R04003	Plastic	Ceramic
4.Relative Dielectric Constant	3.38	2.3	7.55
5.Q factor	7.875	>150	>150
6.Attenuation at centre frequency	>20dB	>20dB	>20dB

5. CONCLUSION & FUTURE WORK

In this paper MATLAB is used to obtain maximum possible Q factor. Filter is tuned to various frequencies and it is found that the changes made in this design gives better values of Q, it is maintained above 150 and it is acceptable for any edge-coupled stripline filter and it is better than previous work. Further we examined the tuning error comparison for two materials i.e. plastic and ceramic, and from the results we can say that ceramic based filter shows less error with compare to plastic based filter.

As a compromise in bandwidth is observed the work can be extended to improve the bandwidth while maintaining the Q factor. Same experiment can be done for wide pass band and wide tuning range.

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