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Design of Narrowband Microstrip Impedance Resonator BPF for EMI & Noise Suppression

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ABSTRACT

In this paper, a narrowband band pass filter for EMI suppression & noise cancelation is presented. The proposed filter is based on parallel microstrip coupled line which is spaced apart by half wavelength from each successive line resonators. This provides a very strong capacitive coupling effect between all the resonators to achieve a band pass response. The band pass filter operates from 2.54GHz to 2.66GHz, voltage standing wave ratio of between one to two. It is found that the proposed filter gives remarkable size reduction than other conventional filters. The simulation is carried on HFSS EM simulation Software. The result gives a return loss and insertion loss parameters. The impedance is adjusted to 50 ohm exactly.

Keywords: *HFSS, FBW, parallel lines, Resonators, Mode Coupling, EMI etc*

I. INTRODUCTION

The band pass filter is a two port passive device which is used to adjust the bandwidth at a limited point in a broadcast system by providing transmission at passband frequencies and attenuation in the stopband of a filter. Among many years back at World War II, band pass filter theory and design methods began by investicators such as Mason, Sykes, Darlington, Fano, Lawson and Richards [1]. Now, many microwave filter designs are done with computer-aided design (CAD) package based on the transmission loss method. The 2.45 GHz Industrial, Scientific and Medical (ISM) band filter is used in various many RF wireless communications as Wireless Local Area Network (WLAN) for limited distance communication where the RF wireless communication system uses filters as frequency selective device, limiting EMI, noise and adjusting output signal characteristic [2]. A bandpass filter allows the frequencies within a pass band and limits all others signals whose frequencies are either below a low cutoff frequency or above an upper cut-off frequency. The band of frequencies that a bandpass filter able to pass through is referred as passband of that filter. A general bandpass filter can be achived by adding a low-pass filter and a high-pass filter or using conventional low pass filter to bandpass filter transformation prototype [3]. The ideal bandpass filter having a clear flat passband in which no gain or no attenuation and completely reject allother frequencies outside the pass band.In general situations, there is no ideal band pass filter exists.There is a frequency which is to be attenuated in the pass band region. Though, it can be mentioned that the filter do not attenuate or blocks all frequencies outside the desired frequency range. This phenomena called as filter rolls off factors and mostly expressed in dB of attenuation per octave or decade of frequency. The transmission loss method provides a high degree of control over the passband amplitude and phase characteristic to synthesize a desired band pass response [4]. The parallel coupling methods have certain benefits over the end coupling such as the length is reduced approximately by half, a identical insertion loss versus frequency band response obtained with the first spurious response which occurred at three times center frequency, the higher gap between microstrips allows for higher power rating filter and allows a broad bandwidth for a given tolerance [7]. There are three major existing atopologies to design a bandpass filter. The first is microstrip or coplanar

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waveguide (CPW), multiple-mode resonator (MMR) with the assistance of a coupling mode mechanism. Secondly, a Broadside coupled micro strip line filter with a CPW at the back side. Lastly, a direct or indirect combination of a low pass and high pass filter. However, there are many major developments in material and fabrication mode technologies. For example, high-temperature superconductors (HTS), low-temperature cofired ceramics (LTCC), monolithic microwave integrated circuits (MMIC), microelectromechanic system (MEMS), and micromachining technology [8].

II. THEORY DISCUSSION: THE MICROSTRIP

The microstrip belongs to the group of parallel-plate transmission lines and having a single ground plane and an open microstrip conductor separated by a dielectric substrate. Microstrip lines are the most general used type of transmission lines for microwave integrated circuits. Also, microstrips are used as circuit components for filters, phase shifters, couplers, resonators and antennas. [10]

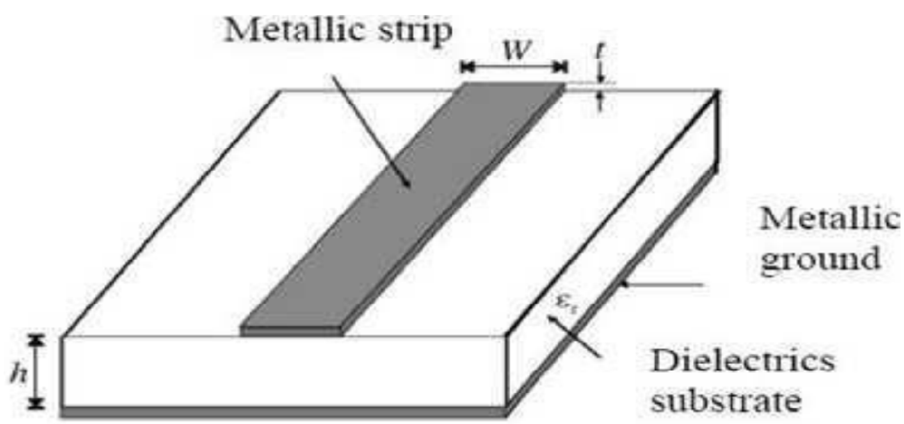

Figure 1: Diagram of a microstrip transmission line

The electromagnetic field in the microstrip line is not confined only to the dielectric and because of the electric fringing; the effective relative permittivity (eff) is less than the relative permittivity of the substrate. The electromagnetic waves in microstrip propagate in TEM (transverse electric magnetic) mode, which is characterized by electric and magnetic fields that exist only in the plane perpendicular to the axis of the wave propagation.

Parallel Couple Microstrip Lines

As in the case of a single microstrip line, a parallel-coupled line microstrip arrangement is also a TEM-mode system. The relative directions of the voltages on the coupled microstrip lines at any specific plane

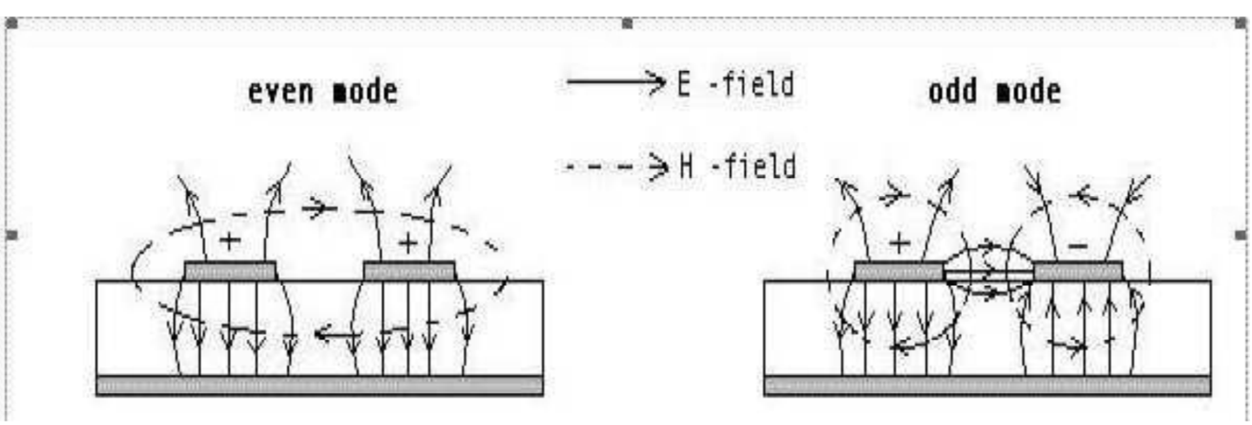

Figure 2: Even and Odd modes for the microstrip line

along the structure and at any specific time will be the same or opposite resulting in two different modes of field distribution, namely the even-mode and the odd mode. These modes are illustrated in the figures below[10].

The even and odd mode coupling gives result in EM distributions denoted by Zoe and Zoo.These are the two major parameters in designing filters. The overall behaviour of filter is depend on these two mode coupling parameters.

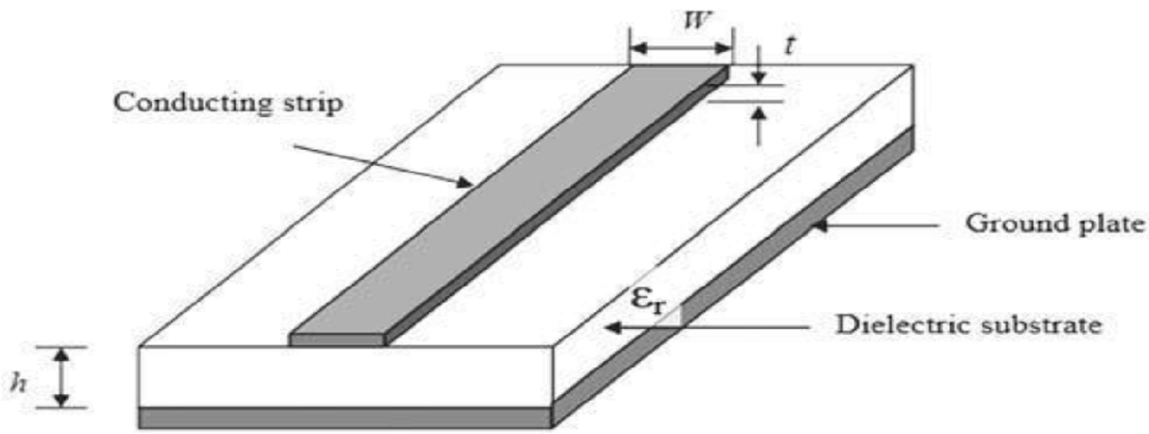

Figure 3: Basic Microstrip Structure

III. DESIGNING OF BAND PASS FILTER

Step 1: Calculation of the Resonator length (RL1)

First we have to calculate lambda

$$\lambda = \frac{c}{f} = \frac{3\times10^{8}}{2.4\times10\wedge 9} = 125mm$$

Resonator length,

$$RL1 = \frac{\lambda}{2\times\sqrt{4.4}} = 31mm$$

Similarly we have calculate for RL2 and RL3.

RL2=31mm and RL3=31mm

Step 2: Calculation of the feed length (Fl):-

$$FL = \frac{\lambda}{4\times\sqrt{4.4}} = 14.5mm$$

Step 3: Calculation of the feed width (wf)-

A simple but accurate equation for Microstrip *Charateristic Impedance* is:

$$Z_0 = \frac{60}{\sqrt{\epsilon}} \ln\left(\frac{8h}{W} + \frac{W}{4h}\right) \; for \; \frac{W}{h} \le 1$$

$$Z_0 = \frac{120\pi}{\sqrt{\epsilon}\left[\frac{W}{h}\right] + 1.393 + 0.667 \ln\left(\frac{W}{h} + 1.444\right)} \; for \; \frac{W}{h} \ge 1$$

Where Z0=impedance

H=height of substrate

W=width of strip=?

Generally, feed width=2.7mm for 50ohm impedance

Feed width=1.4mm for 70 ohm impedance.

Feed width=0.7mm for 100 ohm impedance

Step 4*: Calculation of the substrate length (Ls)-*

$$Ls = \frac{\lambda}{4} = 31mm$$

Ls=31mm

*Step 5***:** Calculation of the gap between resonators (Rg)-

Gap (Rg) =0.02*lam to 0.05*lam

$$\boldsymbol{Rg = 0.02 * \lambda = 2.5mm}$$

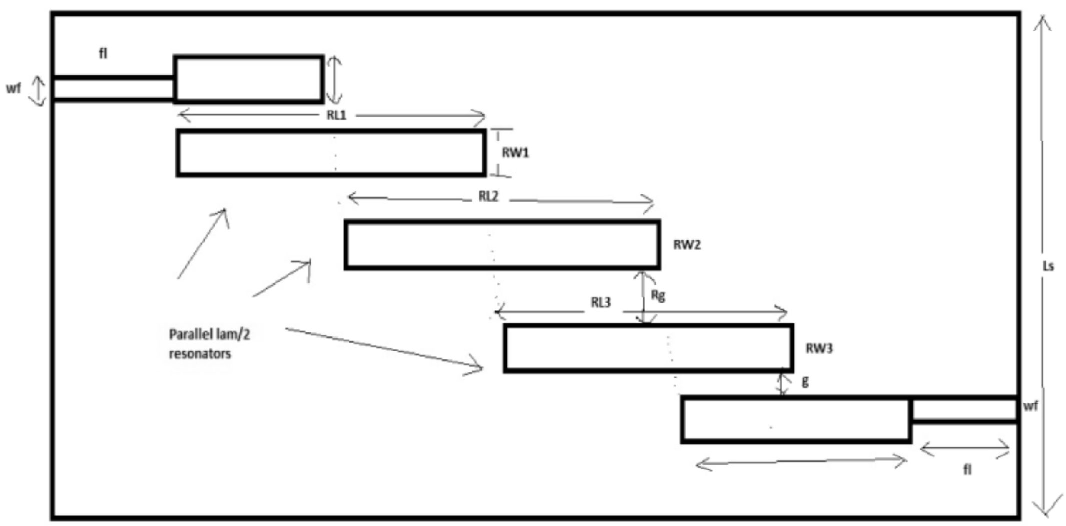

Figure 4: Top view of parallel coupled band pass filter (BPF)

IV. RESULT AND DISCUSSION

The filter is realized with FR4 substrate having dielectric constant 4.4 and tangent loss of 0.027. The ISM band such as 2.45GHz frequency is taken as centre frequency**.**

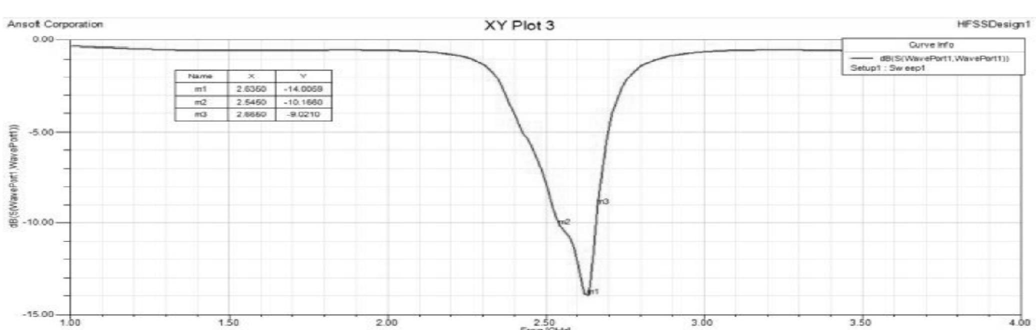

Figure 5: Return Loss (S11)

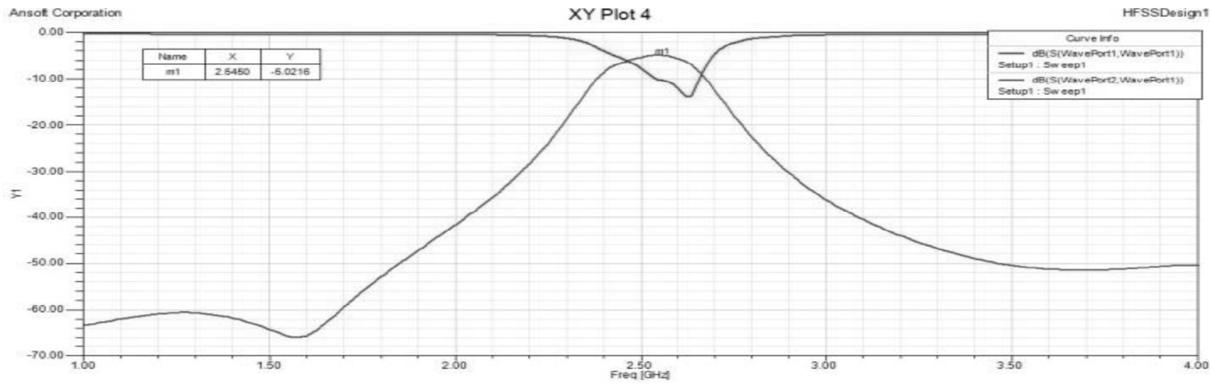

Figure 6: Insertion loss (S21) & return loss (S11)

The fig. 5 and 6 gives a simulated result ensuring the red is return loss (S11) and blue is insertion loss (S21) obtained for band pass filter. Figure 6 gives the reflection and transmission losses measured for port 1 and port 2 in the range 1GHz to 4GHz. With the 3 dB level, we got about 120 MHz of fractional bandwidth, and insertion loss of -5.2 dB. So, to designed parallel end coupled band pass filter we have taken the centre frequency of 2.45 GHz. The order of filter used is n = 3.

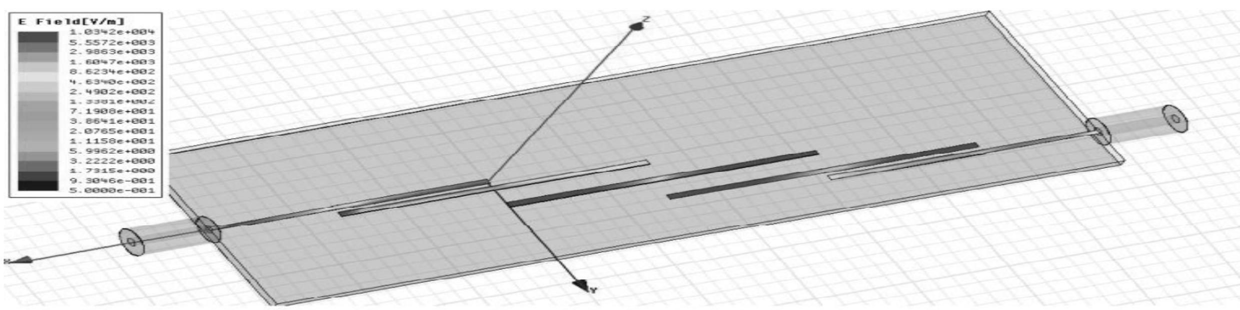

Figure 7: Current distribution of BPF filter

As shown in Fig. 7 the current distribution of BPF. It shows that where the current is minimum & maximum. The red colors indicates current is maximum along the all resonators.

V. CONCLUSION

A narrowband microstrip band pass filter having centre frequency of 2.45GHz for EMI suppression is presented. The good insertion loss & return loss coefficients of filter is obtained.By optimizing on the length and width of the resonators offsetting from frequency is eliminated.The resonator gap is adjusted such that narrowband response is achieved. The length is adjusted to 32 mm and width is also varied by length and adjusted to 0.8mm. If the coupling gap between the resonators is too small then effective coupling between the resonators are reduced resulting narrowband response. The clear pass band region is achieved ie. the Pass band is fully protected from EMI and Noise. The proposed system is effective, reliable & compact filter design obtained.

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