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Symmetrical Compact Microstrip Band Pass Filter using Short Circuited λ/4 stubs for WLAN Applications

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ABSTRACT

In this letter, a compact micro strip Band pass filter has been proposed to work for the resonant frequency of 5.5GHz. The filter has an effective role in WLAN applications. The designed filter has -1.5dB insertion loss in the pass band at 5.5GHz and -11dB return loss in same frequency. The short circuited λ/4 is used to make the anti resonance at center frequency. The designed filter has the 50% of fractional bandwidth, flat group delay in pass band with the dimensions of 27.68x23m.

INTRODUCTION

In wireless communication receivers, the filter is an important key component to allow desired frequency bands and to reject remaining. The WLAN filter has designed in order to reject all the signals like Wi-Fi and Bluetooth which is considered as noise and to allow only the required range of frequencies of WLAN. The filters at (Wong, W.T., 2005) distinct frequencies in the pass band consists of several resonator modes with broadband characteristics. A single multimode resonator and an excitation structure and strong coupling is used to build up the broadband response. For low frequency applications, the size of these filters is not small.

The proposed second order band pass filter consists of four short circuited stubs to control the lower and upper attenuation characteristics with the lengths of lesser than λg/4 and two λg/4 short circuited stubs to resonate at 5.5GHz.

Design:

First the Prototype L-C band pass T section was developed for the center frequency of 5.5GHz as shown in fig.1. The series resonant circuit of the series arm produces equivalent zero impedance for the centre frequency and the parallel resonant circuit of shunt arm produces the infinite impedance. In order to achieve the WLAN pass band the lower and upper cut off frequencies were chosen as 5 and 6 GHz. At the input and output terminals of the filter, the characteristic impedance 50Ω will be maintained.

By following equations the inductance and capacitance values are calculated.

$$L_1 = L_2 = \frac{Z_0}{\pi(f_2 - f_1)} \tag{1}$$

$$C_1 = C_2 = \frac{f_2 - f_1}{4\pi Z_0 (f_2\ f_1)} \tag{2}$$

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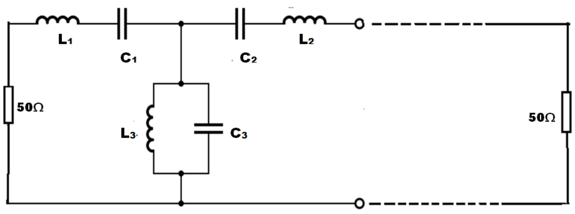

Fig. 1: Prototype L-C band pass T section.

$$L_3 = \frac{Z_0(f_2 - f_1)}{4\pi(f_2\ f_1)} \tag{3}$$

$$C_3 = \frac{1}{4\pi Z_0(f_2 - f_1)} \tag{4}$$

The calculated inductance and capacitance values are $L_1=L_2=16nH$, $C_1=C_2=0.53pF$, $L_3=0.13nH$ and $C_3=1.5pF$.

The micro strip equivalent of designed prototype filter has been developed on FR4 substrate with dielectric constant, height and loss tangent of 4.3, 1.6mm and 0.025. The width of the 50Ω I/O matching line for FR4 substrate is 3.13mm. A 90Ω high impedance line for inductive response and 20Ω low impedance line for capacitive response were used. The length of the inductors for prototype values has been calculated from following equation 5.

$$l_{L_i} = \frac{\lambda_{g1}}{2\pi} \sin^{-1}\left[2\pi f_c \frac{L_i}{Z_{oL}}\right] \tag{5}$$

To realize the micro strip equivalent for series capacitance in fig.1, short circuited stubs will have the lengths lesser than λg/4 are used to avoid the unwanted coupling effects. The micro strip equivalent of parallel resonant circuit in the shunt arm is a short circuited quarter wave resonator for the frequency of 5.5GHz.

To achieve the sharp attenuation in the lower and upper bands, two identical micro strip T equivalents are cascaded. In trial and error method, the length and the width of the short circuited stubs were tuned to get the desired result (removing unwanted succeptance effects).The designed second order micro strip band pass filter is shown in fig.2. The thickness of the conducting strip has been considered as 0.036 mm. The grounded ends are mentioned as via. The dimensions of the filters are given in the following table1.

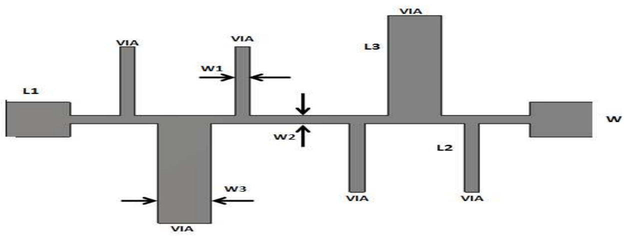

Fig. 2: Top view of Micro strip band pass filter on FR 4 substrate.

The dimensions of the filters are given in the following table 1.

Table 1: Structural measurements.

Parameters	Dimensions (mm)
W	3.13
L1	3
L2	6.2
L3	9
L4	2.71
W1	0.7
W2	0.7
W3	2.5

Width of λg/4 short circuited stubs (W3) have been varied for number of results to get the desired return loss which is lesser than -10dB at 5.5GHz as shown fig.3.

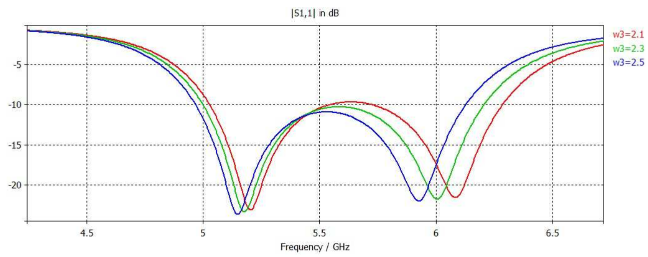

Fig. 3: Variation of return loss for different values of W3.

Results:

The simulated results of final design are shown in fig.4 and group delay in fig.5. The filter has -1.5dB insertion loss and -11dB return loss at 5.5GHz with the pass band fractional bandwidth 50%. The gradual attenuation cut-off at lower and upper stop bands were achieved. The group delay response is flat in pass band.

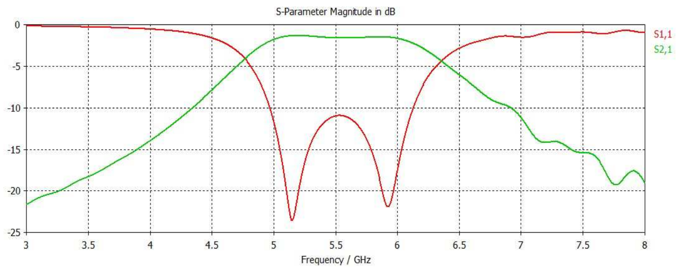

Fig. 4: Simulated S parameters of proposed WLAN band pass filter.

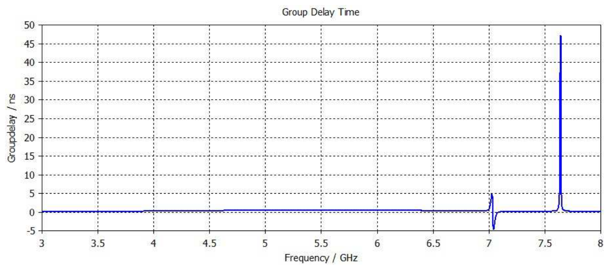

Fig. 5: Simulated group delay.

Conclusion:

A symmetrical compact micro strip band pass filter using short circuited λ/4 resonators for WLAN applications has been designed for a frequency of 5.5GHz. Since the fractional bandwidth is 50%, the pass band was achieved from approximately 5-6GHz. The pass band insertion loss of -1.5dB and return loss of -11dB has been achieved. The gradual cut off attenuation at 5 and 6 GHz and maximum of -23 dB return loss achieved in stop band.

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