

# Realization of Ultra-Wideband Band Pass Filter using Parallel Coupled Micro strip Lines

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## ABSTRACT

A band pass filter based UWB which uses cascaded configuration of microstrip couplings is designed. Existing systems are not concentrating on the UWB design employing sufficient spacing so that they can reduce the unwanted signal reception. There is a need of a technique that enables the design of a planar UWB band pass microstrip filter with less than 1-dB insertion loss across its passband from 3.1 to 10.6 GHz, a wide upper stopband so that a reasonable spacing between the coupled lines will be achieved. We will be showing the performance in terms of E-H plane variation, beam pattern, S-parameter model and antenna calculated dimensions. The entire antenna is designed based on 2.6 GHz. The parameters of the antenna are calculated by using MATLAB in this project.

## Keywords

Keywords are your own designated keywords which can be used for easy location of the manuscript using any search engines.

## 1. INTRODUCTION

A filter is a two port device which is used to remove unwanted signals from the output of a system. The basic function of the filters is to smoothen the output. The electrical performance of the filter is described in terms of insertion loss, frequency selectivity, return loss and group delay variation in the pass band and so on. Filters are required to have small insertion loss in the passband, infinite attenuation in the stopband, large return loss for good impedance matching with interconnecting components and to prevent interference; filter must have high frequency selectivity [8]. To meet these requirements, band pass filters with relatively wide bandwidth are frequently required in the RF front ends. In microwave communication systems, the band pass filter is an very important component, which is usually used in both receivers and transmitters. Ultra-wideband radio technology has been becoming more popular for high-speed high-datawireless connectivity since the federal communications commission (FCC)'s decision to permit the unlicensed operation band from 3.1 to 10.6 GHz in February 2002.

For designing full band ultra wideband bandpass filter we have to fulfill few requirements which are as:

Ultra-wide bandwidth like from 3.1 GHz to 10.6 GHz.

Low insertion loss up to -1db.

Low and flat group delay.

Out-band performance (strongly required to meet the regulation such as the FCC's spectrum mask). The use of microstrip band-pass filter in many wideband applications is restricted by two factors. The first one is the presence of the

second and third harmonic responses. The second factor that limits the use of microstrip band-pass filters in wideband systems is the need for a very narrow spacing between the coupled lines..

## 2. FILTER DESIGN

For the design and analysis of filter circuit, several techniques have been proposed. Generally for microwave applications, butterworth or chebyshev filter may be used. The choice of filter also depends on other factors such as desired rejection, high or low frequency roll off, variation with phase etc. It is now possible to design filter with reduced harmonics. Image parameter, composite filter, insertion loss, butterworth, constant-k, m-derived, chebyshev and elliptic filter methods are available for the design of filter networks but for the flexibility and accuracy, insertion loss method is generally preferred. On network synthesis techniques, the insertion loss method is based and can be used to design filter having a specific type of frequency response [10]. The perfect filter must have zero insertion loss in the passband, linear phase response to avoid signal distortion and infinite attenuation in the stopband but such filters do not exist in practice.

In insertion loss method, a low pass filter prototype is first designed and that is normalized in terms of impedance and cutoff frequency. To convert the normalized design to the one having the desired frequency response, cutoff frequency and impedance level, impedance and frequency scaling and transformations are then used. To facilitate filter implementation in terms of practical components such as transmission lines sections, stubs and resonant elements, additional transformations such as Kuroda identities, Richard's transformation and impedance admittance inverters can be used. Fig.1 shows the flow of steps required for design using insertion loss method. A minimum insertion loss is obtained on the expense of a higher order filter. Fig.1 shows flow of the overall design process [7].

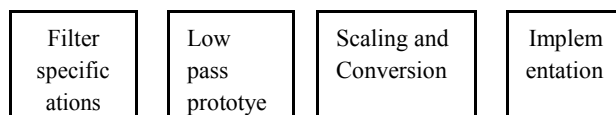


Fig. 1: Flow of steps required for design using insertion loss method

### 2.1 Filter Specification

Butterworth approximation allows no ripple in its attenuation profile. Here butterworth approximation is used to design bandpass filter. Filter design details based on Butterworth approximation:-

filter type= Bandpass

Order of filter (N) = 4

Relative dielectric constant  
 First edge frequency (f1) = 12 GHz  
 Second edge frequency (f2) = 18 GHz  
 Characteristic impedance (Ohms) Z0= 50  
 Center frequency fc = 2.5 GHz  
 Ripple = 3 dB  
 Lumped components (L/C)  
 The filter source / load impedance

In insertion loss method, filter response is defined by its insertion loss or power loss ratio, PLR:

$$P_{LR} = \frac{\text{Power available from source}}{\text{Power delivered to Load}}$$

$$\frac{P_{inc}}{P_{load}} = \frac{1}{1 - |\Gamma(\omega)|^2}$$

Where  $\Gamma(\omega)$  is the reflection coefficient seen looking into the filter. The passband is the region from  $\omega=0$  to the cutoff value  $\omega_c$ ,  $k_2$  is the passband tolerance and  $N$  is number of filter elements. Band pass filter could either be realized using lumped components or distributed components [8]. Lumped components consists of discrete elements like inductors, capacitors etc.

It is hard to realize filters with lumped elements because at frequency above 1GHz. In this paper, we describe the design and simulation of a parallel coupled line microstrip band pass filter with butterworth response.

## 2.2 Design of Prototype Low Pass Filter

It is a normalized practice to first design a low pass prototype filter of 1 rad/sec and unity source and load impedance. To provide a modified filter design for particular application, this designed prototype filter acts as template. The source and load impedance  $Z_0 = Z_L = 1\Omega$ . After designing prototype low pass filter, impedance and frequency scaling is done.

## 2.3 Impedance and Frequency Transformation

For unity cut off frequency and unity source impedance and load impedance, the low-pass filter prototypes are designed. Impedance scaling and frequency scaling is done in order to design bandpass filter. New values of L and C are obtained by using below equations [9]

With desired cut-off frequency and source impedance, the new element values are obtained. In this paper  $Z_L = Z_s = 50$ , the cut-off frequency is chosen as 2.5 GHz.

## 2.4 Low Pass to Band Pass Transformation

When the prototype filter is ready of 1 rad/sec and unity source and load impedance, it can be used for impedance scaling and frequency scaling. For broadband applications, it is possible to design bandpass filter with better response. To realize band pass characteristics of the filter, a low pass to band pass transformation is required. The L component in the low pass prototype is converted to serial combination of  $L1'$  and  $C1'$  and the C component is converted to parallel combination of  $L2'$  and  $C2'$ . The characteristic impedance  $Z_0$  is generally considered as 50  $\Omega$ . If  $\omega_1$  and  $\omega_2$  are cutoff frequencies of BPF than, fractional bandwidth  $\Delta$  and center frequency are given [8] as

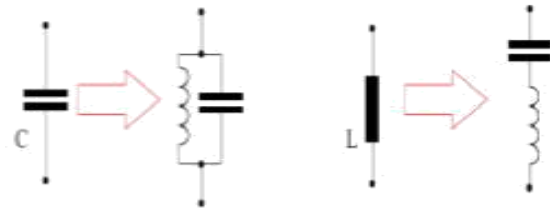


Fig. 2: Schematic illustrating transformation of LPF to BPF

## 2.5 Filter Design Using Microstrip Lines

There are different methods to implement microstripbandpass filters. In this paper, parallel coupled is most important. Below figure 3 represents the generalized structure for microstrip coupled line filter.

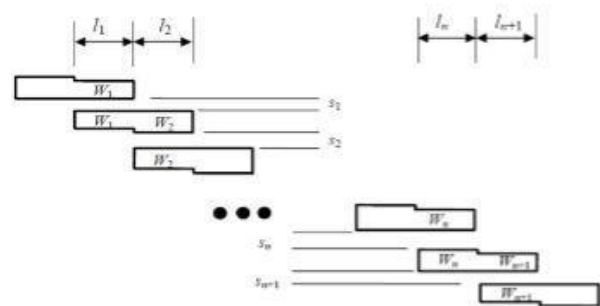


Fig. 3: General structure of parallel (edge)-coupled microstripbandpass filter.

### • Lumped to Coupled-Line Transformation

The microstripbandpass filters can be implemented by using different methods. For designing microstripbandpass filter with  $N + 1$  coupled line sections, the required equations are as follows [9]:

1. for 1st coupling  $Z_0 J_1 = \sqrt{\frac{\pi \Delta}{2g_1}}$
2. for intermediate coupling  $Z_0 J_n = \frac{\pi \Delta}{2\sqrt{g_{n-1}g_n}}$
3. for final coupling  $Z_0 J_{N+1} = \sqrt{\frac{\pi \Delta}{2g_N g_{N+1}}}$

## 3. PROJECT METHODOLOGY

For pages other than the first page, start at the top of the page, and continue in double-column format. The two columns on the last page should be as close to equal length as possible.

Table 1. Table captions should be placed above the table

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Microstrip antenna is characterized by using thickness, dielectric constant and length, width of patch. The performances of design microstrip antenna such as radiation pattern, return loss, directivity and gain are simulated by using MATLAB R2010a software. Microstrip line is one of the most popular types of planar transmission line because it can be fabricated by photolithographic process [10]. It consist of a thin conductor of width  $w$  and a ground plane separated by a low-loss dielectric material with relative permittivity.

**Table 2. Antenna Dimensions Details**

Sr. No.	Antenna Parameters	Values in mm
1	Patch Width (W)	2.3
2	Patch Length (L)	5.2

The thickness  $t$  of the conductor forming the line is negligible compared to the substrate height  $h$ .

$$\frac{t}{h} < 0.005$$

The relations depend only on line dimensions  $w$  and  $h$  and effective dielectric constant  $\epsilon_e$ . For narrow

microstrip lines ( $\frac{w}{h} < 1$ ), we obtain the line impedance and effective dielectric constant [11] given by

$$Z_0 = \begin{cases} \frac{60}{\sqrt{\epsilon_e}} \ln \left( \frac{8d}{W} + \frac{W}{4d} \right) \\ \frac{120\pi}{\sqrt{\epsilon_e} [W/d + 1.393 + 0.667 \ln (W/d + 1.444)]} \end{cases}$$

### 3.1 Design of Microstrip

When  $Z_0$  and  $\epsilon_r$  is given we can find  $\frac{w}{h}$  by using following equations[10]

$$\text{For } \frac{w}{h} \leq 2 = \frac{w}{h} \frac{8 e^A}{e^{2A} - 2}$$

Where the factor A and factor B is given by

$$A = \frac{Z_0}{60} \sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1} \left( 0.23 + \frac{0.11}{\epsilon_r} \right)$$

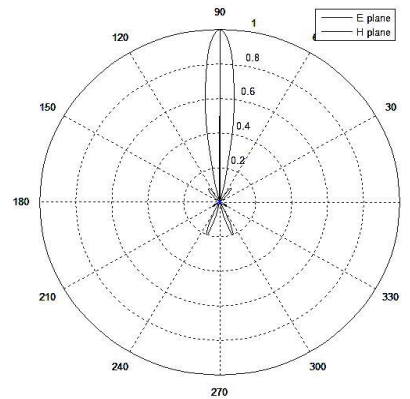
$$B = \frac{377\pi}{2Z_0 \sqrt{\epsilon_r}}$$

If the substrate thickness  $h$  increases or if the conductor width  $W$  decreases, fringing fields become more prominent and cannot be ignored in mathematical model [11].

## 4. SIMULATION RESULT

The simulated result of proposed ultra wide band bandpass filter structure with wide upper stopband is presented in this section. The proposed filter is simulated by the help of the Matlab2010a simulation software. The proposed filter is working on whole ultra wide band from 3.1 GHz to 10.6 GHz. The insertion loss is very flat over the whole band. The performances of design microstrip antenna such as radiation

pattern, return loss, directivity and gain are simulated



**Fig. 4: Radiation plot of E and H plane pattern**

This filter is designed on the RT/Duroid 6010 LM substrate with the dimension of 25.5X 8 mm and the thickness of 1.27mm. The RT/Duroid substrate which is used for the designing of filter has the relative permittivity of 10.2. All antennas have atleast two basic characteristics important for any application i.e radiation pattern which includes gain, beamwidth, sidelobe level, axial ratio etc and input impedance includes bandwidth, resonant resistance.

The E plane pattern is broad and smooth having a beamwidth of the order of 100 degrees. The H plane pattern is similar except it goes to zero at origin because of conducting ground plane. The beamwidth of E plane pattern and its value at angles far from broadside can be controlled by changing the length of patch antenna.

**Table 3. Simulation Result Table**

Sr. No.	Simulation Parameters	Values
1	Microstrip height d	0.635
2	Substrate dielectric constant	10.2
3	Frequency Configuration (GHz)	2.6
4	Wavelength (mm)	0.1154
5	Length of microstrip (mm)	0.0196
6	Radiation resistance (Ohm)	4.342
7	Characteristic impedance	108.47
8	Directivity	43.14
9	Efficiency	1
10	Gain	69.45

**Fig.5: A general radiation pattern of microstrip antenna**

## 5. CONCLUSION

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