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Design of Novel UWB Coupled Line Band Pass Filter with Improved Stop Band Performance

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Abstract - As we know that the conventional filter synthesis procedure is adequate only for the relatively narrow band filters and is not suitable for the Wideband and Ultra wideband filters .Therefore we are intend to design a Ultra Wideband filter. In this study a compact Ultra Wide Band pass filter consisting of quarter wave resonant conductor like micro strip lines is proposed to design. We have to increase the Bandwidth by using suitable techniques also have to improve the stop band performance. A microwave filter is frequency selective two-port network used to control the frequency response at a certain point in a microwave system by providing transmission at frequencies within the pass band of the filter and attenuation in stop band of the filter. Microwave filters specifically band pass filters have found large number of application in varying fields such as satellite communication, GSM networks, Bluetooth, remote sensing, navigation etc.

Keywords:- GSM, Bluetooth, Remote Sensing, Navigation, Ultra Wideband Filter.

I. INTRODUCTION

The term microwaves may be used to describe electromagnetic waves with frequencies ranging from 300 MHz to 300 GHz, (which correspond to wavelengths from 1 m to 1 mm) The EM waves with frequencies above 30 GHz and up to 300 GHz are also called millimeter waves because their wavelengths are in the millimeter range (1–10 mm) [12]. Filters play an important role in the operation of a wireless communication system and this is especially so when the frequency spectrum is getting more crowded than ever before. Often, in this type of application, passive filters are employed compared to their active counterparts. Passive filters designed around reactive elements only, using lumped-components such as inductors and capacitors or distributed elements such as cascaded resonators, can operate up to the microwave region. At upper microwave frequencies, the parasites in the inductors and capacitors often proved too much a constraint to use them in the wireless system. Hence, many of the filters used in microwave communication systems employ the distributed elements types. A microwave filter is frequency selective two-port network used to control the frequency response at a certain point in a microwave system by providing transmission at frequencies within the pass band of the filter and attenuation in stop band of the filter. Typically frequency responses include low-pass, high-pass, band-pass and band-reject characteristics [13]. Application can be found in virtually any type of microwave communication, radar or test and measurement system.

Today, most microwave filter design is done with sophisticated computer-aided design (CAD) packages based on the insertion loss method. Because of continuous advancement in network synthesis with distributed elements, the use of low- temperature super conductors, and the incorporation of active devices in filter circuits, microwave filter design remains an active research area. In this study, insertion loss method which uses network synthesis techniques to design filters with a completely specified frequency response has been applied. The design is simplified by beginning with low-pass filter prototypes that are normalized in terms of impedance and frequency range and impedance level. Ultra Wide Band (UWB) radio technology has been getting more and more popular for high-speed wireless connectivity, since February 2002 the US Federal Communications Commission (FCC)'s decision to permit the unlicensed operation band from 3.1 to 10.6 GHz. The US Federal Communications Commission (FCC) spectral regulatory agency has selected a definition of UWB signal based on fractional bandwidth [1], or equivalent bandwidth according to which a UWB signal is any signal with a bandwidth at the 10 dB attenuation points greater than 20 percent of the center frequency or an equivalent bandwidth greater than 500 MHz There are several advantages for UWB radio system, such as transmitting higher data rates, lower transmit power, and simplifying the error control coding. In such a system, an UWB filter is one of the key components, which should exhibit a wide bandwidth with low insertion loss over the whole band. In order to meet the FCC limit, good selectivity at both lower and higher frequency ends and flat group-delay response over the whole band are required. The conventional filter synthesis procedure is adequate only for the relatively narrow band filters and is not suitable for the wideband filters [2 - 5]. Basically a wide band filter may be implemented by a direct cascade of the low- and high-pass filters. These wideband filters have good suppression on out-of-band response; however, they have the drawback of large circuit size or imperfect group delay over the pass band. To meet the UWB filter specifications, several studies have been reported to increase the number of sections [6 - 7]. These UWB filters have sharp rejection, but their spurious response would degrade the out-of-band response as an increase in number of sections may lead to large insertion loss as well as poor group delay. Another way to realize wide band pass filters is to use the parallel coupled lines with and without DGS [8-9]. However, the more the fractional bandwidth is required, the smaller the gap size is demanded to enhance the coupling. Recently, broadside-coupled line structures have received great attention due to the merit associated with the electromagnetic coupling. The CPW-to-CPW [10] transitions were first proposed is accompanied by the development of CPW-to-Microstrip [11] transitions and Microstrip-to-CPW transitions. The

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UWB filter with a multiple-mode resonator was proposed using the Microstrip-to-CPW transitions as inverter circuits. Recently, a UWB filter was proposed using the Microstrip-to-CPW transitions to realize the broadside-coupled structure and then cascading three sections to give good selectivity. In this study a compact Ultra Wide Band pass filter consisting of quarter wave resonant conductor like microstrip lines is proposed to enhance the bandwidth with improved stop band performance. The proposed method can dramatically increase the bandwidth of the parallel coupled-line filter. In addition to the bandwidth an excellent suppression of spurious harmonic responses which are inherent in this type of filter, is achieved with improved skirt characteristics. In order to show the validity of the proposed methods a filter that has a center frequency of 3.5 GHz and a fractional bandwidth (FBW) of 42 (1.515GHz) percent is designed. The designed filter shows insertion loss of about 0.5 dB at center frequency and very flat over the whole band. The measured results show good agreement with the theoretical data’s.

II. OBJECTIVE OF STUDY

The objective of this study is to design of novel UWB coupled line band pass filter with improved stop band performance. The bandwidth of the filter is increased by using bandwidth enhancement techniques, the stop band performance of the filter is improved by using transmission zeros concept.

III. PROPOSED FILTER

Band pass filters (BPFs) at microwave frequencies often use the parallel-coupled line (PCL) filter. They do not require ground connection and, thus they are easily fabricated in planer form. Two or more resonators are cascaded as such to form the coupled multi resonator BPF. Each individual resonator is affected by reactive loading from adjacent couplings and open-ended capacitive fringing. In this project the parallel coupled micro strip BPF operating in the S band. The filter is designed on 0.8mm-thik high-resistivity FR-4 substrate having tan δ=0.001 and center frequency 3.6GHz.

TRANSMISSION ZEROS IN COUPLED LINE. The coupled line section can be represented by the structure shown in the figure 1.1. As depicted in the figure 1.1, C2 represents the capacitance of the two strip conductors in the absence of ground conductor, while C1 represents the capacitance between one strip conductor and ground conductor. The inductive coupling between the strip conductors (called mutual coupling) is represented by L1.

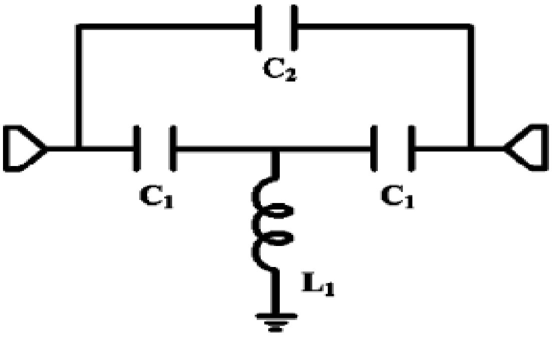

Figure 1.1 Equivalent Circuit of the Coupled Line Section

By symmetry of the circuit, the even- and odd-mode input impedances (Zeven and Zodd) are expressed as [16-18].

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$$Z_{even} = j\left(2\omega L_1 - \frac{1}{\omega C_1}\right)$$

$$Z_{odd} = \frac{1}{2j(C_1 + C_2)}$$

By superposition, the transfer function is written as

$$S_{21} = \frac{(Z_{even} - Z_{odd})Z_o}{(Z_{even} + Z_0)(Z_{odd} + Z_o)}$$

Where Zo is the characteristic impedance of the input port.
A transmission zero is created when the transfer function is equal to zero, i.e.
Zeven = Zodd

To examine the effect of the transmission zeros in the coupled line sections, the simulated insertion loss responses with different electrical lengths θ at f_o= 3.5 GHz are shown in Figure 12. For the ideal case in which the even- and odd-mode electrical lengths are equal (θo=θe), the S_{12} response for the coupled-line section of θ=90^0 an inherent transmission zero at 2f_o (7.0 GHz), while that for the case of θ= 69.6^0 has an inherent transmission zeros at 2.5f_o (8.75 GHz). The location of inherent transmission zeros associated with the microstrip coupled-line section may properly be adjusted by its geometrical parameters, as illustrated in **Figure1. 2**

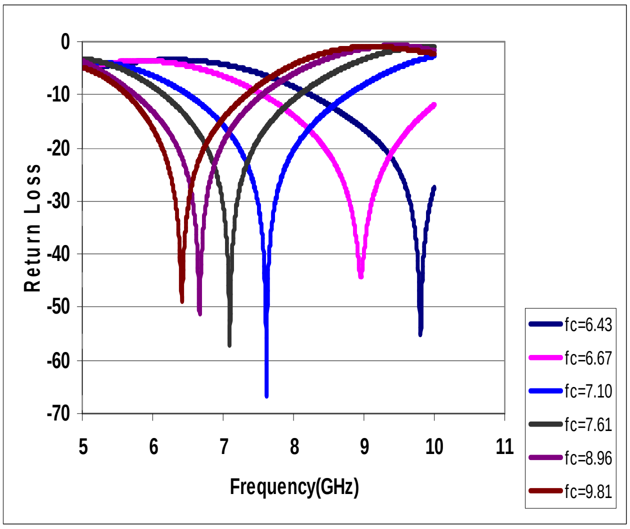


Figure 1.2 Adjustment of the Electrical Length ・(at f0 = 3.6 GHz) of Micro Strip Coupled-Line Section to Vary the Location of Inherent Transmission Zero. (w = 1.188 mm, s = 0.28 mm, Substrate Dielectric Constant εr = 4.4, Thickness =0.8 mm.)

For the practical microstrip coupled line, the inherent transmission zeros moves to higher frequencies due to the unequal even- and odd-mode phase constants, which changes the slow wave factor (SWF). Therefore, by taking advantage of the inherent transmission zeros associated with the coupled-line sections, the length of coupled-line section as shown in Figure 13 may properly be chosen such that these inherent transmission zeros fall around $3f_o$ for suppression of the spurious pass band.

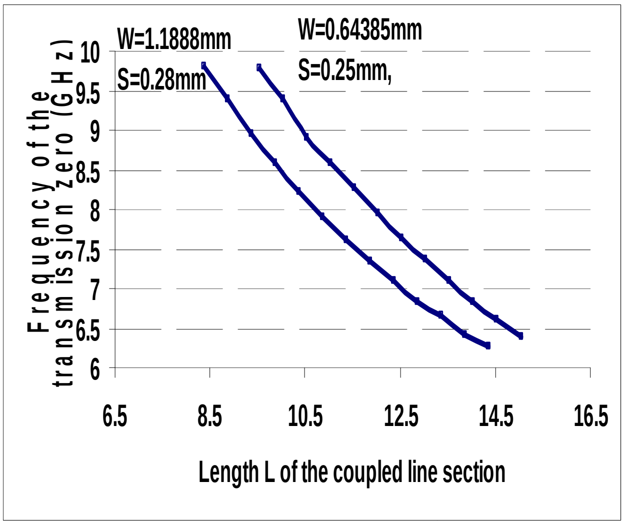


Figure 1.3 Curves to Relate the Frequency of Inherent Transmission Zeros to the Length L of Microstrip Coupled Line Section

The locations of these induced inherent transmission zeros may be controlled by suitably adjusting the value of cross-coupled capacitance. Figure 1.4 shows the simulated responses of a section of coupled line circuit model for which the centre frequency is designed at 3.5 GHz. .Specifically, the transmission zeros will move toward the centre frequency as the value of capacitance increases. Based on this information, one may suitably choose the value of capacitance so that the locations of this cross coupled transmission zeros may be adjusted for the desired selectivity.

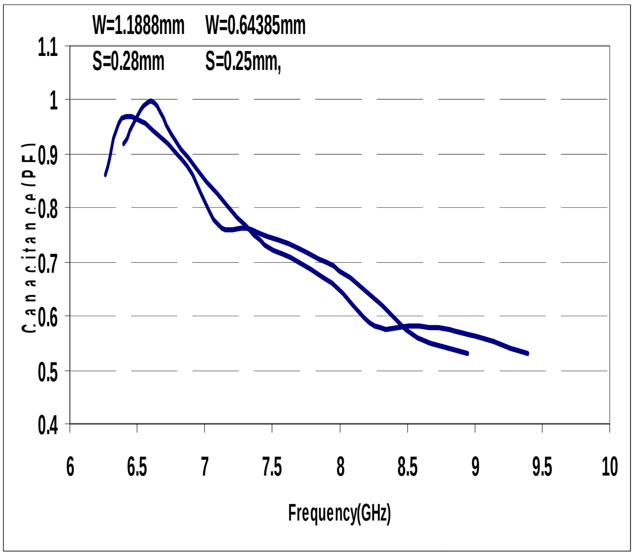
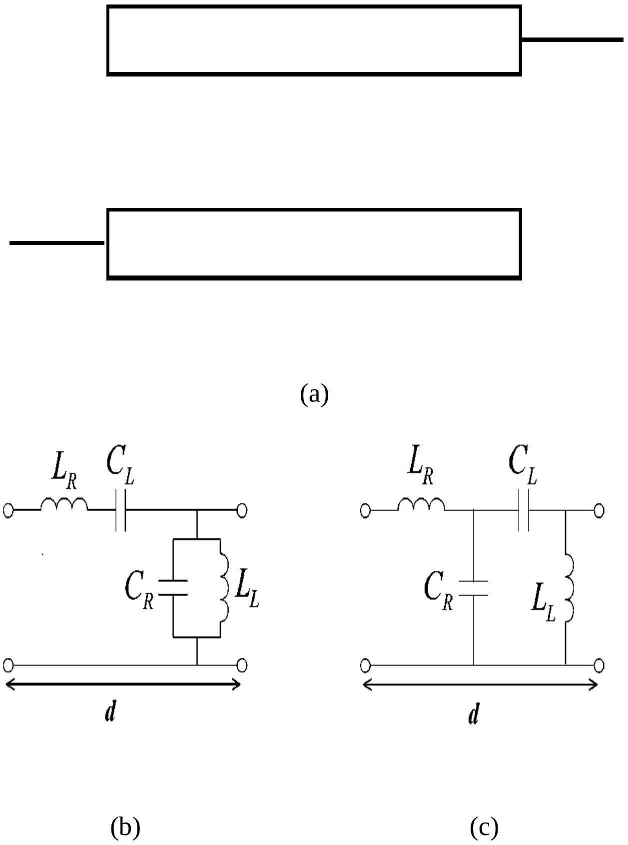


Figure 1.4 Curves to Relate the Cross-Coupled-Induced Transmission Zeros Frequencies to the Values of C.

The coupled line section can be approximated over a range of frequencies by a lumped element equivalent circuit model as shown in Figure 1.5. We see that a coupled line section leads to an equivalent shunt LC resonator, and an admittance inverter occurs between each pair of LC resonator.



(a)

(b) (c)

Figure 1.5 (a) Coupled Line Section. (b) Infinitesimal Circuit Model (c) Equivalent Infinitesimal Circuit Model in Balanced Case

When $L_R.C_L= C_R.\ L_L$, all of the energy is transmitted from the input port to output port. It is called balanced (or matched) condition. The characteristics impedance of the circuit at the balanced case is

$$Z_o = \sqrt{\frac{L_R}{C_R}} = \sqrt{\frac{L_L}{C_L}}$$

The **bandwidth** of the circuit is given as

$$BW = \frac{f_o}{Z_o}\sqrt{\frac{L}{C}}$$

Where L is the inductance, C is the capacitance and Zo is the Characteristics impedance of the circuit. From the above formula, it is clear that the bandwidth of the circuit is enhanced when the ratio of L and C will be maximum, which can be achieved by properly choosing the width and gap of the coupled line section. To enhanced the bandwidth of the filter an EM simulation has been used to tune the geometrical parameter of the coupled line section, as illustrated in Figure 16. The figure shows the simulated response to relate the frequency verses inductances and capacitances of the coupled-line section with its spacing and width as parameters. Centre frequency of the coupled line section is designed at 3.5 GHz. Based on this information; one may suitably choose the value of the inductance and capacitance such that the ratio of inductance and capacitance should be maximum.

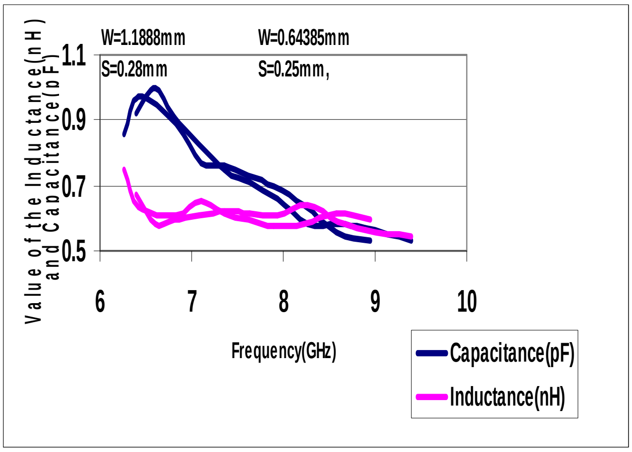


Figure 1.6 Curves to Relate the Frequency with Inductance and Capacitance of Microstrip Coupled-Line Section

A fifth order Butterworth filter is presented here as an example. The centre frequency of the filter is 3.5 GHz. The filter is designed using broad side coupled lines and symmetrically configured, where the system termination are 50 Ω, as shown in the figure 1.7.

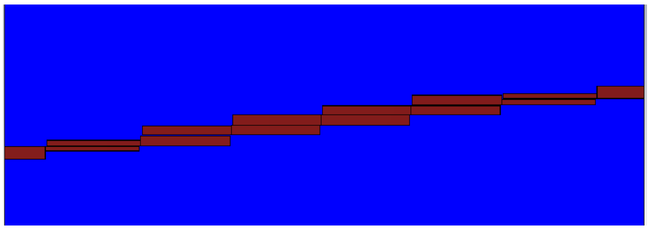


Figure 1.7 Designed Coupled Line Band Pass Filter

IV. RESULT AND ANALYSIS

The filter as shown in Figure 4.6 occupies an intrinsic chip area of 83.64x30 mm2, which predicts the insertion loss of less than 0.5 dB in the pass band and maximum return loss of -10.0dB throughout the operation frequency of S-band wireless communication. Figure 4.7 shows the plot of the simulated performance of the filter.

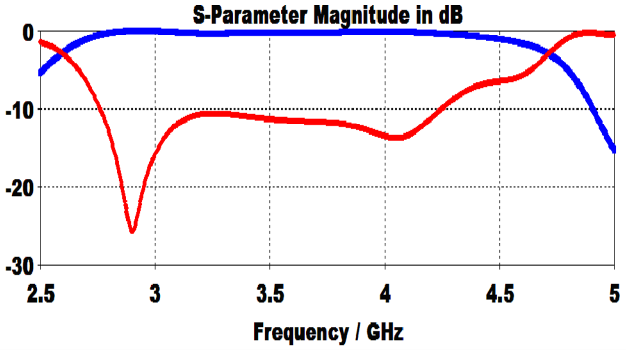


Figure 4.7 Return Loss of the Coupled Line Filter

Very good frequency response (return loss in less than -10 dB in pass band, see appendix B for details) is obtained in the required S band, indicating that the modeling of the filter took into account all necessary parasitic effects and that the manufacturing process is well controlled. The simulated filter has a center frequency of 3.6GHz with a 10dB bandwidth of 1.515 GHz (42%) covering the frequency ranges from 2.6 GHz to 4.2GHz**.**

V. CONCLUSION

In this study we have presented Ultra wide band pass filter using parallel coupled line resonator. Within the pass band the filter exhibits low insertion loss, large return loss. The bandwidth of the filter has been increased considerably by suitable choice of the ratio of the capacitance and inductance, also staggered tuning is used to enhance the bandwidth of the filter. Sharp attenuation is obtained by using the inherent transmission zeros associated with the coupled line section to suppress the spurious response. The location of transmission zeros may easily be adjusted by varying the length of the coupled line section with its width and spacing as a parameter. The designed band pass filter achieved an insertion loss of less than 0.5 dB with a 10 dB bandwidth about 42%.

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