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Full Length Research Paper

Ultra-wide microstrip band pass filter using short circuited stubs

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A novel ultra-wideband microstrip filter is proposed and physically implemented. The band pass filter is designed for short-circuited stubs with etched rectangular lattice. The etching provides better return loss. The quarter-wavelength short-circuited stubs are used to realize the lower stop-band characteristics. Simulated and measured result shows that the defected microstrip filter has a good performance, including an ultra-wide pass band of 0.6 to 2.3 GHz, and a small insertion loss. The return loss is found to be higher than 10 dB.

Key words: Microstrip, band pass filter, ultra-wide band, short circuited stubs.

INTRODUCTION

Broadband wireless access communications system is a rapidly expanding market. Such systems commonly employ filters in microwave and mm-wave transceivers as channel separators. Hence there is an increasing demand for low cost, and compact size filters. The recent advances of novel materials and fabrication technologies have simulated the rapid development of microstrip and other filters, to meet such demands (Pozar, 2000).

Ultra Wide-band (UWB) technology has great potential in the development of various modern transmission systems, for instance, through-wall imaging, medical imaging, vehicular radar, indoor and hand-held UWB systems, etc. Therefore, the UWB bandpass filter (BPF) with a wide pass band, sharp out-of-band rejection especially at a lower stop band due to its extensive use in other technologies, low insertion loss, small and flat group delay is highly required (Federal Communications Commission, 2002). Ultra-wideband (UWB) microstrip filter can be constructed from distributed elements such as commensurate (equal electrical length) transmission-line elements (Saito et al., 2003). Since any commensurate network exhibits periodic frequency response, the wide-band bandpass stub filters (Ishida and Araki, 2004). Such a type of band pass filter (BPF) is shown in Figure 1, which consists of a cascade of shunt short-circuited stubs of electrical length θ_c at some specified frequency f_L (usually the lowest frequency of Band pass filter), separated by connecting lines (unit elements) of electrical length $2\theta_c$. This filter consists of 'n' number of stubs, it has an insertion function of degree 'n' in frequency so that its band pass response has 'n' ripple (Wang and Zhu, 2005; Sun and Zhu, 2006; Cai et al., 2005). Figure 2 illustrates the typical transmission characteristics of this type of filter. Referring to Figure 1, electrical length θ_c can be found as follows:

$$\left(\frac{\pi}{\theta_c} - 1\right) f_L = f_H \qquad (1)$$

Where, f_L is the lowest frequency component and f_H is the highest frequency component of the UWB band pass filter.

Theoretically, this type of UWB Band pass filter can have an extremely wide primary pass band as θ_c becomes very small, however, this may require unreasonably high impedance levels for short-circuited stubs. Nevertheless, practical stub filter designs will meet many wide-band applications (Li et al., 2005; Kuo et al., 2006; Zhang et al., 2006). It can be noted that the normalized characteristic admittances of transmission line elements for given terminating impedance Z_0, the associated characteristic line impedances can be determined by,

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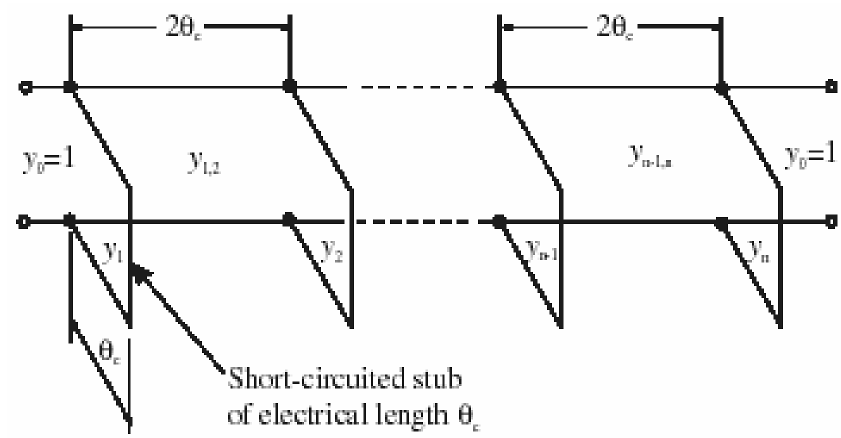

Figure 1. General circuit model for distributed UWB Band pass filter.

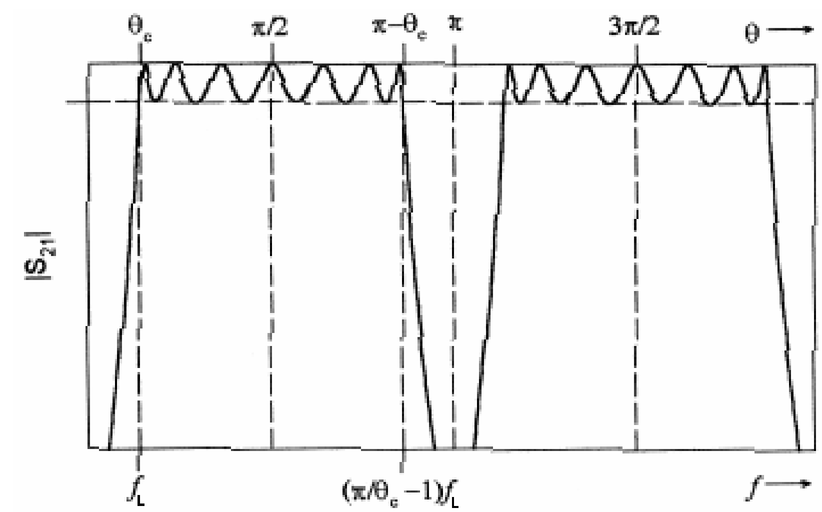

Figure 2. Typical filtering characteristics of the distributed UWB Band pass filter.

$$Z_i = Z_0/y_i$$

$$Z_{i,i+1} = Z_0/y_{i,i+1} \qquad \text{.........} \quad (2)$$

The proposed filter has been designed and simulated using moments method software tool (IE3D Software Release – 8, Developed by M/s Zeland Software Inc.) and the results obtained as been discussed. The band pass filter is physically implemented on a FR-4 'Glass/Epoxy' substrate using conventional fabrication process. Finally the simulated and measured responses have been compared.

ULTRA WIDE BAND PASS FILTER DESIGN

An UWB band pass filter using four short circuited stubs is designed with connecting lines, that are non redundant ($2\theta_c$). The characteristics impedances of these short circuited stubs are defined by Z_1, Z_2, Z_3, and Z_4, and the characteristics impedances of the connecting lines are defined by $Z_{1,2}$, $Z_{2,3}$, and $Z_{3,4}$. The terminal impedance is defined as Z_0. The electrical length for short circuited stubs at 0.5 GHz is chosen as shown below:

$$\left(\frac{\pi}{\theta_c} - 1\right) 0.5 = 2.5 \qquad \text{.........................} \quad (3)$$

Table 1 show the circuit parameters for UWB band pass filter with four short-circuited stubs when θ_c = 30° (Pozar, 2000). Figure 3 shows microstrip layout of a distributed UWB band pass filter using four short-circuited stubs (Figure 4).

Figure 5 shows the filter characteristics of UWB band pass filter after increasing widths of stubs and connecting line elements as: $W_1 = W_4 = 0.7$ mm, $W_2 = W_3 = 0.8$ mm, $W_{1,2} = W_{2,3} = W_{3,4} = 4.5$ mm. Using these dimensions, the layout of designed filter is shown in Figure 6.

Table 1. Circuit parameters for UWB bandpass filter with four short-circuited stubs with $\theta_c = 30°$.

Stub line parameter			Connecting line parameter		
Characteristics impedance (Ω)	**Width (mm)**	**Length (mm)**	**Characteristics impedance (Ω)**	**Width (mm)**	**Length (mm)**
$Z_1=Z_4=154.8$	$W_1=W_4=0.16$	$L_1=L_4=29.52$	$Z_{1,2}=Z_{3,4}=46.36$	$W_{1,2}= W_{3,4}=3.46$	$L_{1,2}=L_{3,4}=26.86$
$Z_2=Z_3=126.7$	$W_2=W_3=0.34$	$L_2=L_3=29.14$	$Z_{2,3}=46.36$	$W_{2,3}=3.46$	$L_{2,3}=26.86$

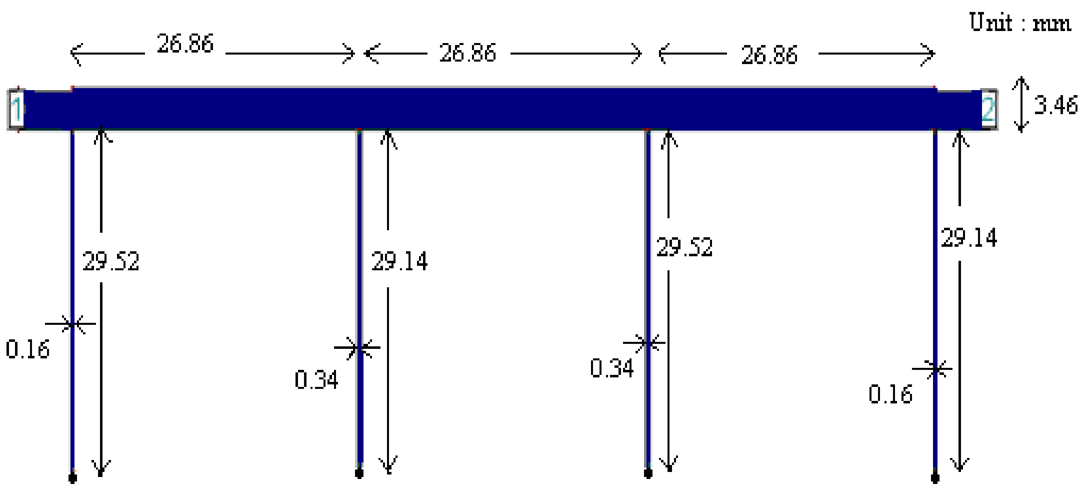

Figure 3. Microstrip Distributed UWB band pass filter using four Short-circuited stubs.

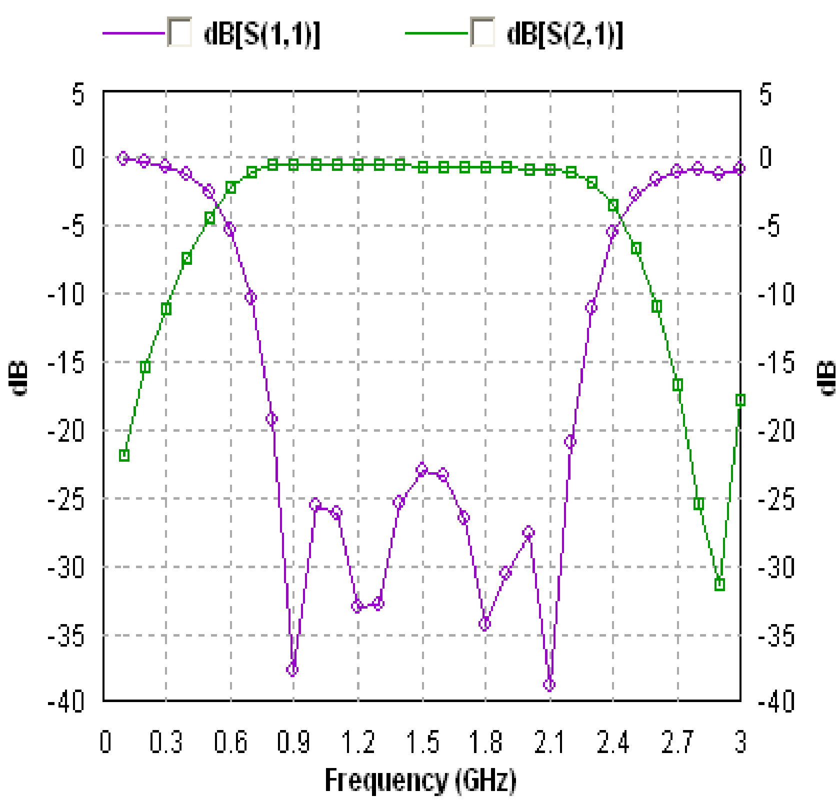

Figure 4. Simulated response corresponding to Figure 3.

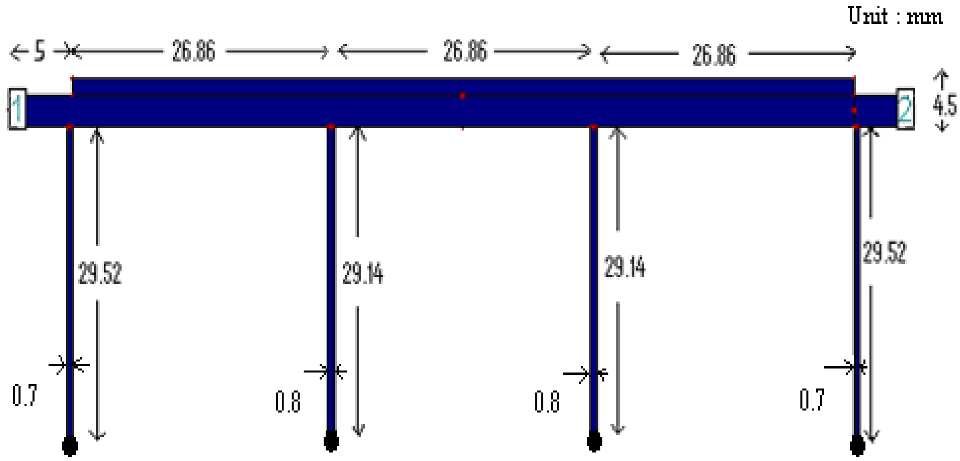

Figure 5. Microstrip UWB band pass filter using four Short-circuited stubs.

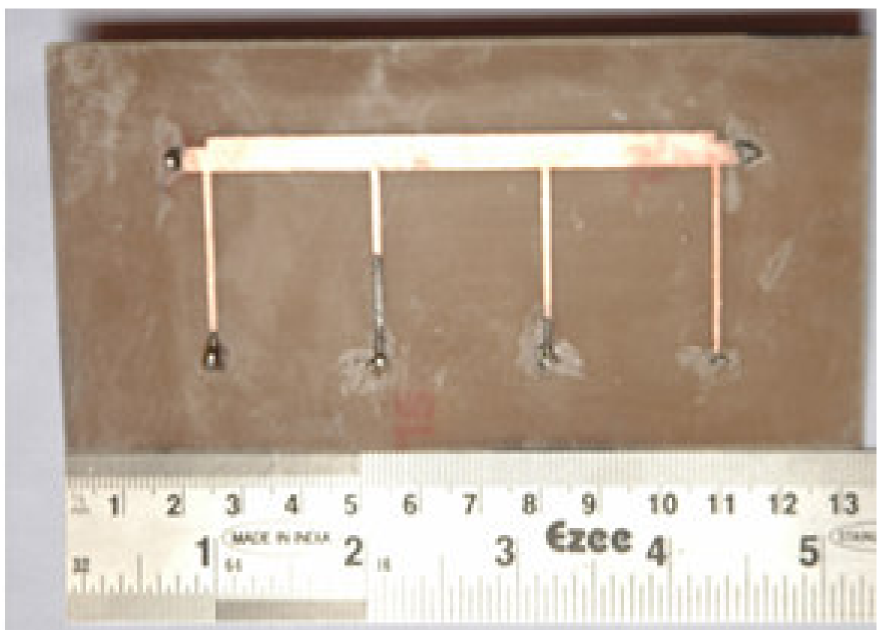

Figure 6. Photographed layout of the UWB band pass filter with via-hole grounding.

RESULTS AND DISCUSSION

The simulated and measured results of insertion loss and return loss of the proposed UWB band pass filter using four stubs are shown in Figures 7 and 8, respectively, which show fractional bandwidth 113% with center frequency 1.5 GHz. Also the return loss is noted to be 13.99 dB. After etching a rectangular lattice of length 24.86 mm and width 2.5 mm on the conventional design, better performance in the form of return loss is achieved for the UWB band pass filter. The defected microstrip UWB filter is shown in Figure 9. From the simulated result of this etched filter, the return loss is found to be 29.55 dB. The fabricated layout of the UWB band pass filter with etched rectangular lattice is shown in Figure 10. The comparison plots of simulated and measured results are shown in Figures 11 and 12.

Conclusion

An UWB Band pass filter using short circuited stubs with via-hole grounding is designed and physically implemented. The simulated and measured responses ensured that a fractional bandwidth of 113% is obtained. The return loss for the UWB filter is found to be 13.99 dB at the center frequency 1.5 GHz. With etching of three rectangular lattices of dimension of 24.86 and 2.5 mm,

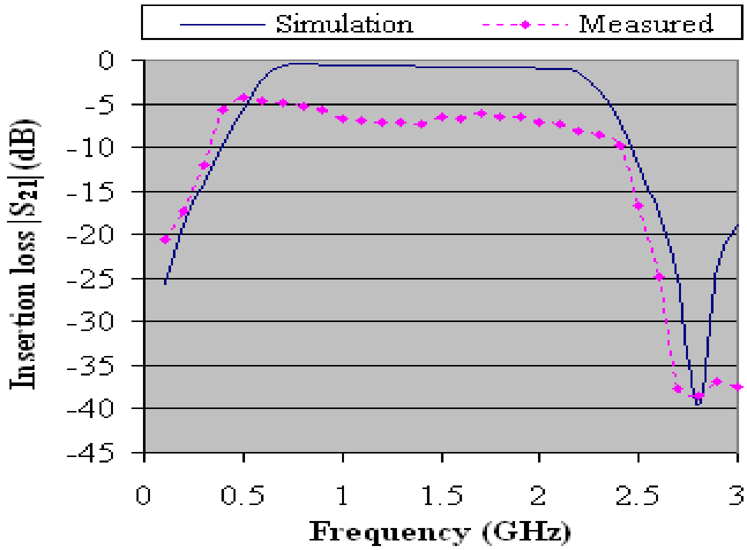

Figure 7. Comparison plot of insertion loss of the UWB Band pass filter

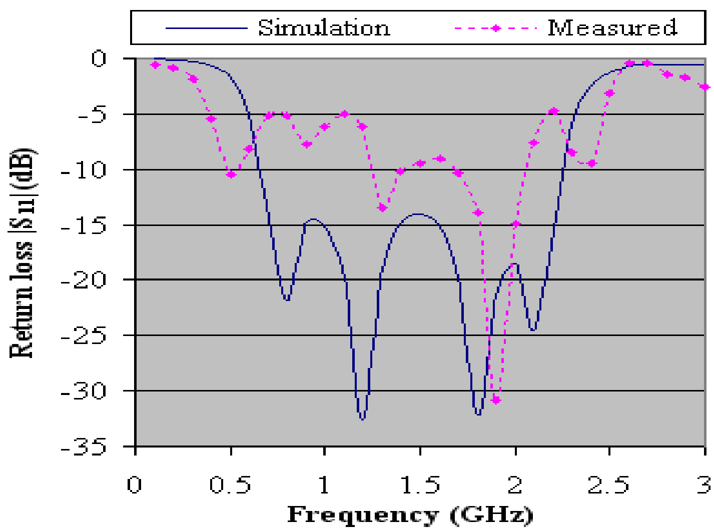

Figure 8. Comparison plot of return loss of the UWB Band pass filter.

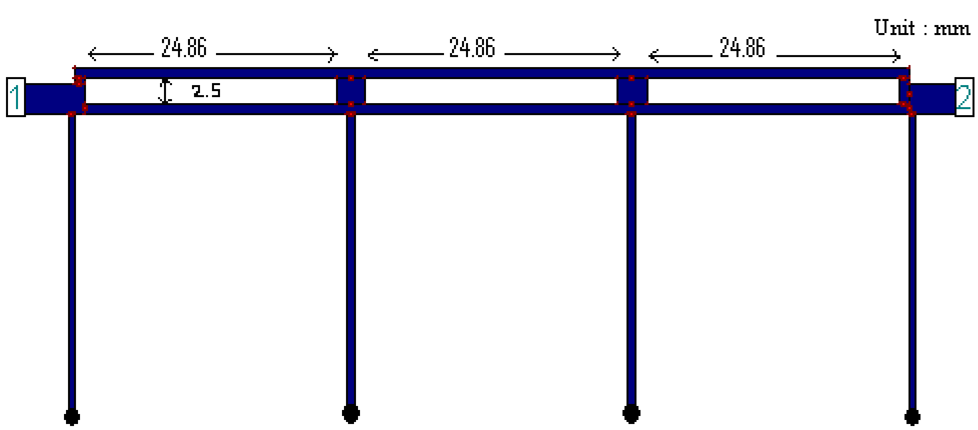

Figure 9. Layout of the etched UWB band pass filter.

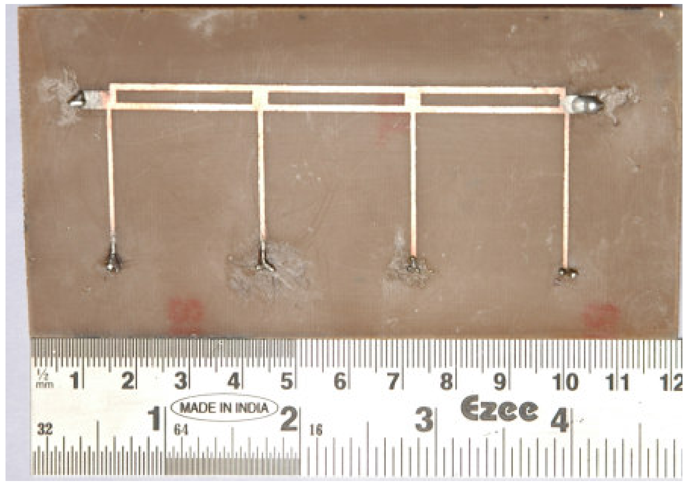

Figure 10. Fabricated layout of the etched UWB band pass filter.

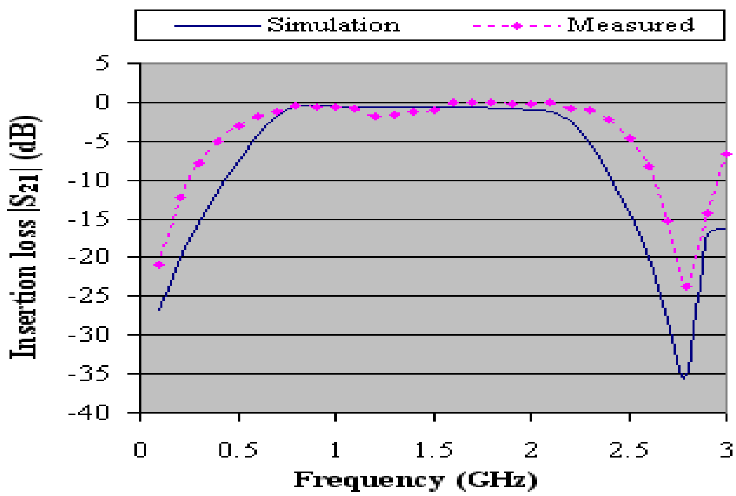

Figure 11. Comparison plot of insertion loss for the etched UWB filter.

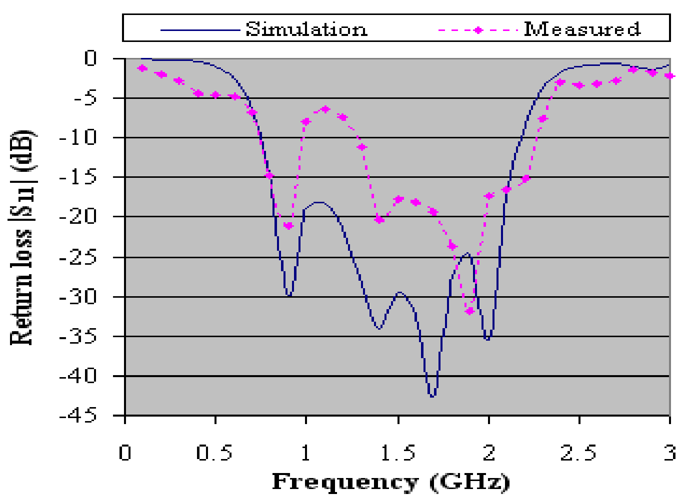

Figure 12. Comparison plot of return loss for the etched UWB filter.

the return loss can be decreased to 29.55 dB. The proposed band pass filter is fabricated on top of FR-4 ‘Glass/Epoxy’ substrate and a good agreement between simulated and measured results has been achieved.

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