A New Compact UWB Microstrip BPF for Wireless Communication Using DGS

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Abstract

A novel compact ultra-wide band micro-strip band-pass filter has proposed in this paper for the application of wireless communication systems. By using DGS, desired UWB micro-strip BPF has designed. The designed filter has maintained lesser insertion loss, high selectivity and very good return loss. The proposed pass band filter has guaranteed the sharpness of skirts of the parameters because of appearances of transmission zero near the each pass band edges. The presences of three poles at the pass band in the designed UWB BPF could scale up the bandwidth and enhanced the selectivity. At 6 GHz centre frequencies, the 3dB fractional bandwidth is 56.07%. The simulated values of the insertion loss and return loss of the proposed filter are -0.0184dB and -43.84dB respectively. The Ansoft high frequency structural simulator has used for frequency response of the designed filter.

Keywords

Bandpass filter (BPF);
Ultra wideband (UWB);
Defected ground structure (DGS);
Fractional Bandwidth (FBW);
Insertion loss;
Return loss;
Group delay.

I. INTRODUCTION

The ultra-wideband technology play vital role in the field of wireless communication systems after allowed unlicensed operation of RF band from 3.1GHz to 10.60GHz in the year 2002 [1]. It has numerous demands in wireless communication such as transmitting high data rate and consumes low power while transmitting. While designing the UWB filter there has met many challenges to attain the required UWB bandwidth. The UWB is filtering now-a-days becoming a hot topic of research in the field of microwave communication because of non-stop increases of number of users in wireless communication systems. Compact and higher performance filter are always obligation to encouraging emerging end users to enhance the

sharpness of the skirts and multimedia services [2-7]. In recent times, DGS is extensively used for UWB filter design, because it gives higher system performance rather than other. In most of the communication systems, filter act as vital elements and higher quality filter enhance the systems performance. A BPF is the central component that has used as a transceiver in the communication systems, which is play as a significant character intended for choosing the desired band and attenuated the unwanted frequency in a precise bandwidth. Today designing such a wide passband filter that has a multiple services, that has a vital topic of research for the researcher, which is carried out in recent times. In recent years, there is wide and rapid development of Ultra-Wideband technology, especially in [8-9] in field of radio frequency systems. In microstrip filter design, DGS has used widely in current time to realize the band pass responses like compactness with low insertion loss, exact coupling capability, and impedance ratio (R) and higher design of freedom for choosing the length ratio (μ) to meet the specific band [10-11]. The centre frequency and fraction BW can calculate by (1) and (2):

$$\omega_0 = \sqrt{\omega_1 \omega_2} \quad (1)$$

$$FBW = \frac{\omega_1 - \omega_2}{\omega_0} \quad (2)$$

Where in equation (1) and (2) ω_1 and ω_2 are lower and the upper cut-off frequencies respectively of the proposed filter.

II. DESIGN PROCEDURE AND SIMULATED RESULTS ANALYSIS

The Schematic diagrams of the proposed Ultra-wideband BPF is depicted in Fig.1, Fig.2 and Fig.3. The layout consists of one SIRs, a pair of I/O ports and a DGS structure that forms compactness and allows achieving the required pass-band for UWB wireless applications with a good return loss and

insertion loss. The filter is designed on RT Duriod 5880 substrate with dielectric constant (ϵ_r) of 2.2, tangent loss (δ) of 0.0009 and a thickness of 0.787mm.

Fig 1. Structure of the Propose UWB BPF

The design specification of the UWB passband filter is based on the design response shown in Fig.4, and have a centre frequency (f_c) is 6 GHz. The structures shown in Fig.2 and Fig.3 are designed with a strip width of 0.2mm and 3.85mm to achieve high impedance ($Z_1 = 78.17\Omega$) and low impedance ($Z_2 = 47.33\Omega$) respectively. The fractional bandwidth (FBW) 56.07% so obtained is calculated by using Ansoft HFSS Simulator. The result shows a very low insertion loss (S_{21}) of -0.0184dB and return loss (S_{11}) of -43.84dB with centre frequency of 6 GHz. The design specific parameters considered in this paper are tabulated in Table.1.

Fig 2. Propose UWB filter (front view).

Fig 3. Propose UWB filter (back view).

From the obtained UWB responses, magnitude of S_{21} and the phase difference of transmission is shown in Fig.4. As seen from Fig.4, the two zeros f_{Z1} and f_{Z2} appears in each pass-band edges which granted the sharpness of the design filter scattering parameters and thus increases the selectivity.

Fig 4. The Simulated $|S_{21}|$ and $|S_{11}|$ and their Phase difference.

The Fig.4 also depicts the magnitude of S_{11} and the phase difference of transmission of the UWB BPF responses. The three poles f_{P1} , f_{P2} and f_{P3} that appear in pass-band enhance the bandwidth of the design filter. The results show a returns loss (S_{11}) of -43.84dB with centre frequency of 6 GHz. The equations (3) and (4), shown below can be used for calculation of capacitance and the inductance of the DGS in [6].

$$C = \frac{\omega_c}{Z_0 g} \cdot \frac{1}{\omega_0^2 - \omega_c^2} \quad (3)$$

$$L = \frac{1}{4\pi^2 f_0^2 C} \quad (4)$$

Where, Z_0 is the Characteristic impedance of the input/output ports, ω_c is the cut-off frequency of the low-pass filter, and 'g' used for lump element value of the prototype Low pass filter.

The Fig.5 show the group delays which varies between 0.12-0.13 ns at centre frequency of 6 GHz. The group delays are obtained by taking the derivative of the phase and are inversely proportional to bandwidth. The simulated results depict that the proposed UWB BPF filter presents a good and satisfactory delay.

Fig 5. Simulated Group Delays for the filter.

The UWB band passfilter is realized using Rogers RT/ Duriod 5880 substrate with dielectric constant (ϵ_r) of 2.2. The substrate tangent loss (δ) is approximately 0.0009 and has a thickness of 0.787mm. It is designed and tested by the HFSS Simulator. The Dimension & design parameters details are listed in Table.1 microstrip width considered here as 0.2mm. The dimension obtained for the BPF is minimum compared to the recently available filter. The size of it $19.1 \times 28 \text{ mm}^2$ as can be depicted from comparison Table.2.

Table1. Dimensions & design parameters considered

DGS value (mm)	Length (mm)	Width (mm)	Space (mm)
LD=1.5	L=13.8	W1=2	S=0.2
LD1=4.6	L1=11.9	W2=0.2	S1=0.2
LD2=3.7	L2=18.1	W3=0.15	
LD3=8.8	L3=13.25		

Table 2. Comparison of proposed filter with some other existing UWB BPF

Filter Size (mm ²)	Passband (GHz)	S ₁₁ (dB)	S ₂₁ (dB)	FBW (%)	Comparison of model
284.2	4.6-10.6	15	0.5	79	Ref.[12]
840	3.1-10.6	10.5	1.35	110	Ref.[13]
204	3.1-10.6	20	1	109	Ref.[14]
450	3.1-10.6	12.5	0.45	110	Ref.[15]
108	3.1-10.6	14	0.60	104	Ref.[16]
120	3.1-10.6	20	0.60	110	Ref.[17]
534.8	4.57-7.95	43.84	0.0184	56.07	Proposed Design

III. CONCLUSION

A novel compact UWB BPF is obtained for the application of UWB wireless communication with centre frequency (f_c) is 6 GHz, which was proposed here using microstrip SIRs and DGS. The proposed Filter has a major advantage of controlling mechanism of the resonating modes of the SIRs and thereby the pass band (PB) can be tuned. This control mechanism of the microstrip SIRs can be achieved by proper selection of the length ratio (u) along with the impedance ratio (R) to match with the expected or desired responses for UWB band pass filter application. The circuit overall dimension is reduced in comparison with other conventional DGS UWB BPF. The filter which is proposed here, possesses high return loss of -43.84dB, low insertion loss -0.0184dB only and also better pass band selectivity in comparisons with available UWB BPF. The Fractional Bandwidths (FBW) of the filter is 56.07%. The simulation results and analysis prove that the proposed filter shows better performance compared to other cited works in this paper.

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