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Improved Compact Broadband Bandpass Filter Using Branch Stubs Co-Via Structure with wide stopband characteristic

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Recently, the broadband bandpass filters are particularly promising in the design of broadband filters with compact size and superior stopband performance due to the fast development of broadband wireless communication systems. Because of the rapidly expanding broadband systems, the requirements for filter design have become stricter. Until this date, developing broadband BPFs were made. However, these filters have several drawbacks, such as large size by using cascaded circuits and complex meander configuration for compact size but the waves are scattered, and reducing the transmittance power is reduced due to reflection loss and radiation loss at the given obstacle. Recent years, a method to implement broadband bandpass filters with cascaded series and shunt transmission line sections was proposed. This method, with short-circuited stubs, indicated that the physical implementation of these filters consists of a cascade of shunt stubs of equal length alternating with non-redundant connecting lines of equal length, each of them twice the stub electrical length. In this study, the redundant connecting lines of a traditional broadband bandpass filters (Fig. 1(a)) was effectively substituted by the stub structure, and is shown in Fig. 1(b). The stubs significantly were improved filter behavior by attenuating the undesired spurious bands without using extra cascaded circuits. Furthermore, the proved co-via structure is formed by the branch stub based on impedance transformation theory. By this way, not only to reduce the size but also to avoid the complex meander configurations would be realized in the connecting lines, which is benefic for the passband performance.

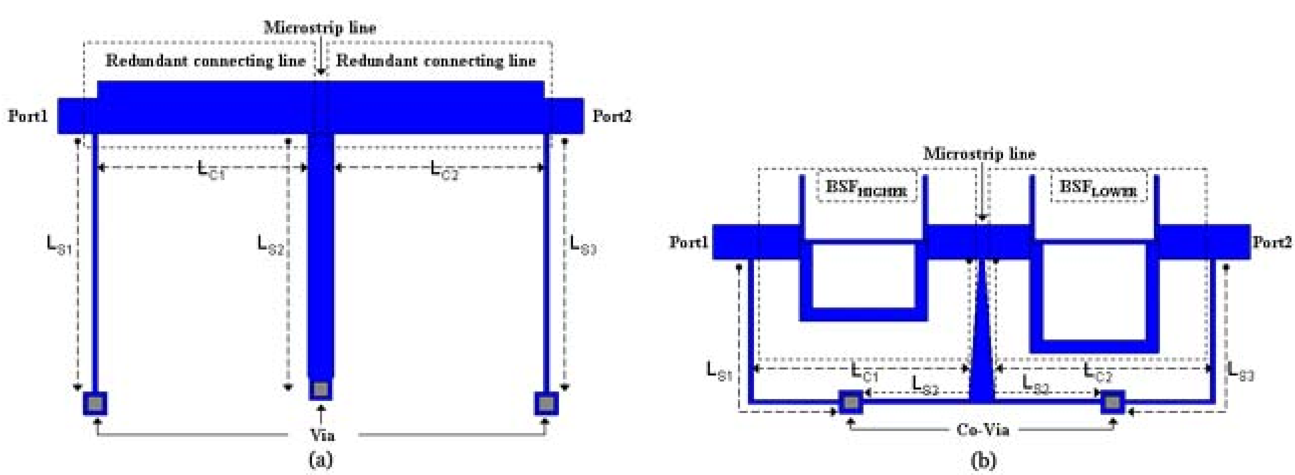
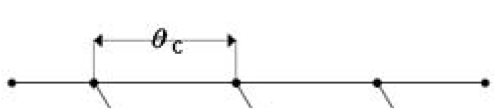


Figure 1. Geometry of (a) the traditional broadband BPF and (b) the proposed branch stubs co-via broadband bandpass filter with combined BSF substituted for redundant connecting lines.



In the cause of suppressing the undesired spurious bands, let redundant connecting lines effectively is applied to build the

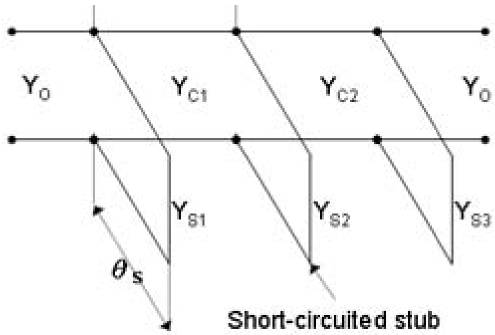


Figure 2. Circuit model for a pseudo distributed bandpass filter with three short-circuited stubs.

bandstop structure, which results in size reduction, as compared to the conventional broadband bandpass filters implementation. Based on a circuit model for a pseudo distributed bandpass filter with 3 short-circuited stubs, the filter design was constructed and shown in Fig. 2. The characteristic admittances of the short-circuited stubs are defined by Y_{S1}, Y_{S2} and Y_{S3}, and the characteristic admittances for the redundant connecting lines are defined by Y_{C1} and Y_{C2}. The terminal admittance is defined as Y_O. The electrical length of redundant connecting lines (θ_C) is equal to that of the stubs (θ_S). The electrical lengths were chosen as $\theta_C = \theta_S = 45$•for both the redundant connecting lines and the short-circuited stubs at 4 GHz. In order to obtain the desired circuit parameters, the characteristic admittances for the short-circuited stubs and the redundant connecting lines are selected as $Y_{S1} = Y_1 = Y_{S3} = Y_3 = 0.0087\Omega^{-1}$, $Y_{S2} = Y_2 = 0.0164\Omega^{-1}$, and $Y_{C1} = Y_{1,2} = Y_{C2} = Y_{2,3} = 0.0258\Omega^{-1}$. To illustrate the performance, a microstrip of broadband bandpass filter centered at 4 GHz with a fractional bandwidth (FBW) of 120% is simulated in a FR4 substrate (permittivity = 4.4, thickness = 0.8 mm).

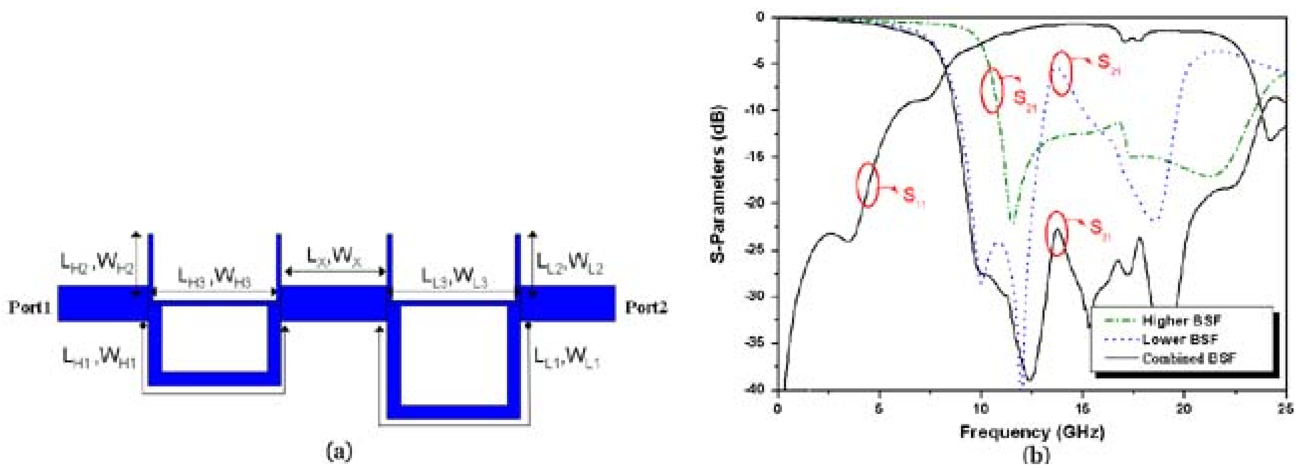


Figure 3. (a) Geometry and (b) simulated results of the combined BSF consists of higher BSF and lower BSF.

In order to achieve a sharp cutoff frequency response, more sections are needed, but increasing sections will also increase the loss in the passband and circuit size. The combined bandstop structure is shown in Fig. 3(a). In this paper, a non-uniform structure with different resonance of the sections was proposed, the one-wavelength section (L_{L1}) of the proposed lower sharp bandstop structure (LBS) is differ from the higher wide bandstop structure (HBS) operated frequency of the one-wavelength section (L_{H1}) for producing the demanded sharp lower rejection behavior without adding too much size as like uniform structure maybe lengthen all the three sections just for the same lower rejection. As a whole, each section was designed with a center stopband frequency of 15.2GHz except L_{L1} designed as wavelength at 12.2GHz. This way makes the stopband be formed as a sharp one, and operated on lower frequency avoiding size increased too much. Just as well, the proposed combined bandstop filter results in size reduced and more feasibility for any integrated microwave circuits. The performance of the combined non-uniform bandstop filters achieves a wide stopband and a good selectivity as shown in Fig. 3(b). The short-circuited stubs (L_{S1}, L_{S3}) have been bent with 90 degree angles in such a way to result in the same via hole with the middle parted short-circuited stub (L_{S2}), which based on impedance transformation theory. Therefore, the proposed filter by using the branch stubs to form the co-via structure demonstrates the feasibility of this concept is proposed. Not only reduce the size around 70% and reduce the radiation loss due to the complex meander configurations occur in the connecting lines. Additionally, we can get a fine tuning of the passband bandwidth adopting the tapped line technique to design the middle stub. Fig. 4 shows the simulated and measured performances of (a) S-parameters and (b) group delays of the proposed broadband bandpass filter. Proposed filter characteristics are good with in-band insertion losses below 1.5 dB and return losses better than 15 dB between 1.95–6.25 GHz. The performance of out-of-band is also good with spurious passband attenuation higher than 20 dB up to at least 20.3 GHz and a flat group delay, which the variation of the measured group delay is less than 0.15 ns in broadband passband. For the selected center frequency and on a substrate with a dielectric constant of 4.4, substrate height of 0.8mm, the proposed microstrip filter is only 19.5 mm × 10 mm in size. A good suppression broadband bandpass filter (BPF) has been designed and implemented in this study. The bandpass filters are realized and are simulated by full-wave EM simulation. Experimental results of the fabricated filter were agreed well with the design specification. The proposed filters showed wide passband, low insertion loss, flat group delay, and excellent out-of-band performance. Therefore, the filter looks promising for use in wireless communications due to its small size and excellent performance.

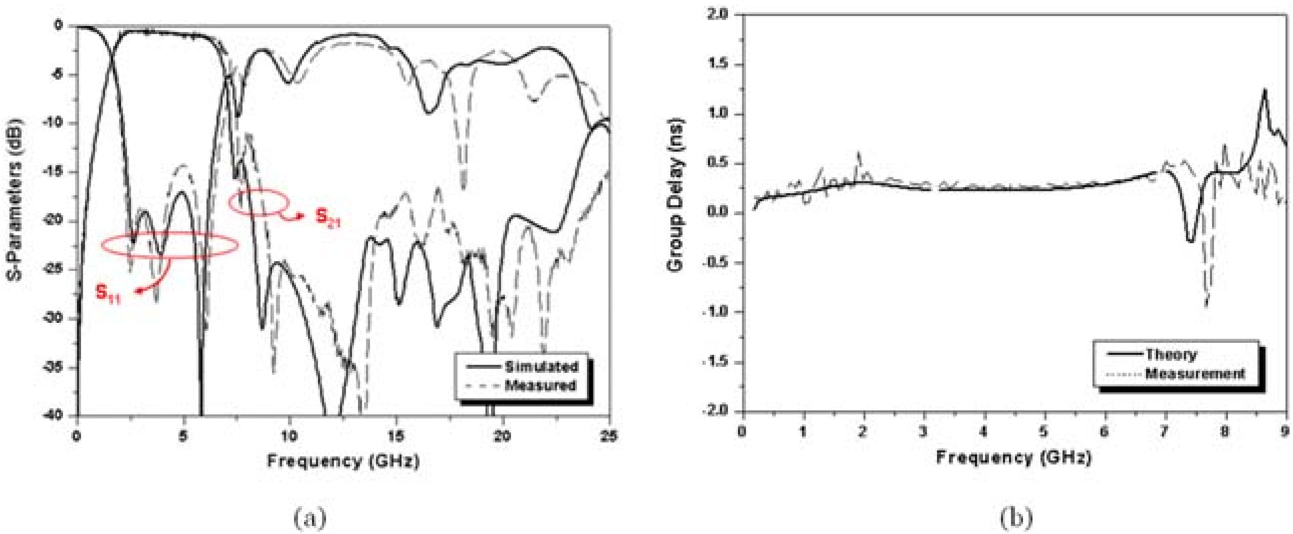


Figure 4. Measured and simulated (a) S-parameters and (b) Group delay of the proposed broadband BPF.