A Novel Compact Ultra-Wideband Band-Notched Band-Pass Filter

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ABSTRACT
In this paper, a new miniaturized ultra-wideband bandpass filter is simulated. The structure of the new ultra-wideband bandpass filter is constructed using stepped-impedance resonator. The input admittance of the proposed filter is calculated and compared with the conventional structure. The frequency response of the filter is simulated by an EM simulator tool. The parameters of the proposed filter are optimized where this filter provides a ultra-wideband bandpass filter with a notch-band in the passband. Moreover, two transmission zeros exist on the lower and upper sides of the pass-band.

Keywords
band-notched, ultra-wideband, bandpass filter, stepped impedance resonator

1. INTRODUCTION
Ultra-wideband bandpass filters are of the essential microwave passive components for modern communication systems. Generally, the design of a ultra-wideband bandpass filter requires a high technology including via-hole and wire-bonding or multi-layer structures. The demand for low-cost, good selectivity and portable ultra wide-band BPF regarding U.S Federal Communication Commission (FCC), the unlicensed use of UWB (BW of 7.5 GHz for commercial purposes, encourages research toward miniaturization of such components. The recent publications report several different models to design these components including multi-mode resonators (MMR) [1] – [3], defected ground structures (DGS) [4], microstrip-to-microstrip and microstrip-to-coplanar waveguide (CPW) [5], doable-layer conductor-backed CPW [6]. While the first group realizes UWB BPFs, there is not any transmission zeroes and thus their skirts are not very sharp to have a good selectivity as well as hardly realizing band-notched. The second group are not compatible with monolithic microwave integrated circuits (MMIC) accompanied by a relatively large size and the last one has bulky volume with complicated design procedure as well as high cost [6].
In this paper, a novel structure of stepped-impedance resonator is proposed and analyzed using input admittance of the structure. Afterwards, the structure of the stepped-impedance resonator is somehow developed and an UWB BPF is designed and proposed by paralleling two resonators [7] where obviously shows a better performance than that of the conventional MMR ones [3] and much
easier structures that that of other mentioned topologies [6]. Additionally, a UWB notch-band BPF is designed and simulated utilizing the proposed structure. The structure of the proposed ultra-wideband bandpass filter is simulated on a substrate with constant dielectric of 2.2 with thickness of 31-mil (0.787 mm) and the frequency response of this filter is presented in terms of insertion loss (S_{21}) and the return loss (S_{11}) where it is shown that the proposed filter has a notch-band within the pass-band of the filter.

2. THE PROPOSED STRUCTURE
Fig.1 (a) shows the proposed structure of stepped-impedance resonator in which the first section of the resonator is a simple microstrip line and the second section includes two high impedance parallel microstrip lines.

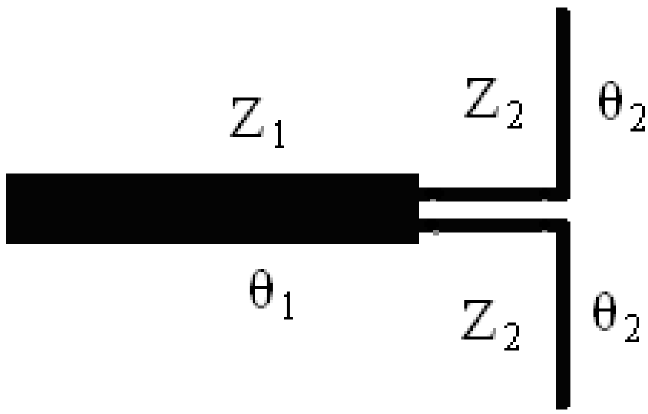


Fig 1: the developed stepped impedance resonator

In this section, is demonstrated transmission zeroes conditions to design a band-notched UWB BPF. The admittance of a simple SIR as derived in [8] can be calculated as given in equation (1):

$$Y_{in} = jY_2 \frac{Y_1 \tan(\theta_1) + Y_2 \tan(\theta_2)}{Y_2 - Y_1 \tan(\theta_1)\tan(\theta_2)} \quad (1)$$

According to (1), the input admittance of the proposed resonator can be calculated as given in equation (2):

$$Y_{in} = jY_2 \frac{2Y_1 \tan(\theta_1) + Y_2 \tan(\theta_2)}{Y_2 - 2Y_1 \tan(\theta_1)\tan(\theta_2)} \quad (2)$$

After calculating the input impedance of the proposed resonator, two resonators of the proposed structure are arranged in parallel and the new model of ultra-wideband bandpass filter is designed. Fig.2 shows the layout of the proposed filter.

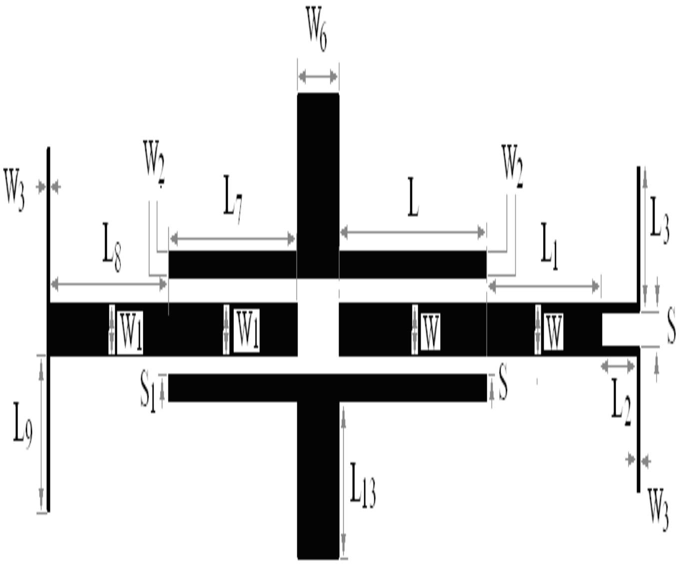


Fig2: the layout of the band-notched UWB BPF with L= 12 mm, L_1=3.4 mm, L_2 = 1.2 mm, L_3 = 3.9 mm, L_7 = 6 mm, L_8 = 2.3 mm, L_9 = 5.2 mm, L_{13} = 2.2 mm, W= 0.3 mm, W_1 = W_3= 0.2 mm, W_2 0.28 mm, S = 0.1 mm, S_1= 0.12 mm

After deriving the initial parameters of the new structure, its parameters are optimized using advance design systems software (ADS) which have been given in the caption of Fig.2. after optimizing the parameter of the new ultra-wideband bandpass filter, its frequency response is simulated . Fig.3 shows the layout of the new band-notched filter which has been implemented in ADS software.

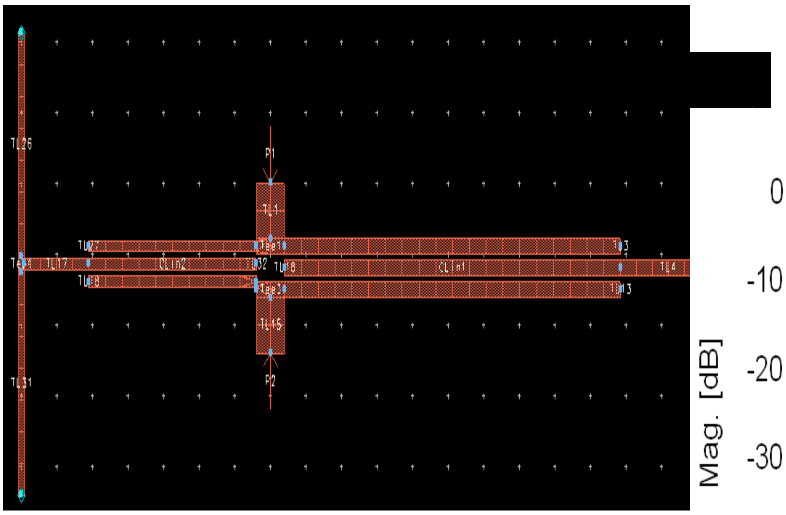


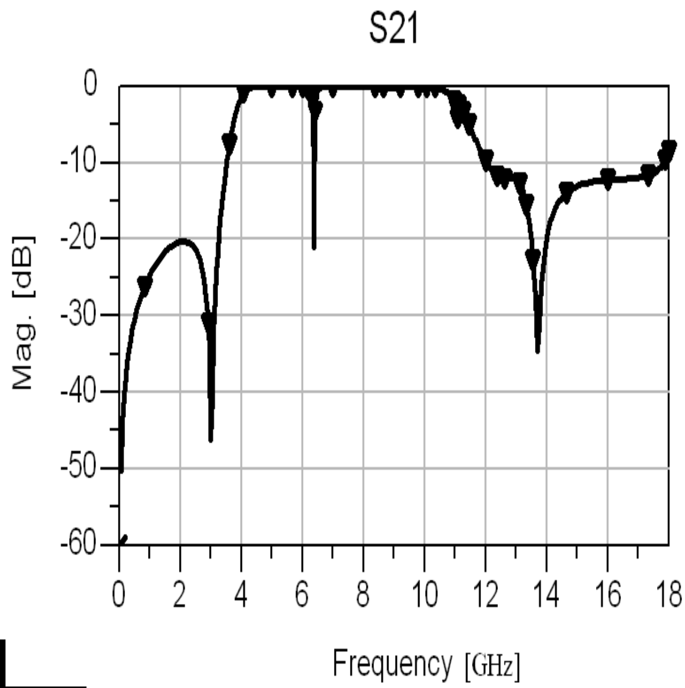
Fig3: The layout of the proposed ultra-wideband bandpass filter in ADS

3. SIMULATED RESULTS

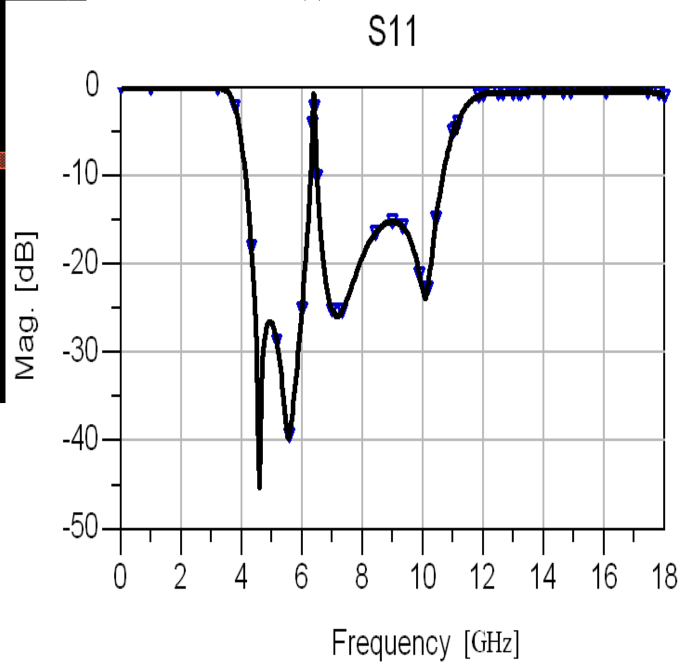
Based on the given layout of the proposed structure in Fig.3, a band-notched UWB BPF is designed and simulated using two parallel stepped impedance resonators.

To have a comparable frequency performance with the conventional bandpass filters, the initial estimated parameters of the two BPFs are optimized using a full-wave electromagnetic (EM) simulation tool (ADS). The optimized physical values of the compact BPF's parameters are given in the beneath of Fig. 2.

To distance the input and output port avoiding isolation problems an extra transition at the input and output is used .to reduce the size of this filter the open-stubs can be bended where The actual size of the filter structure is 26 × 8 mm^2. After optimizing the parameters of the new filter, its frequency response is simulated in ADS from DC to 18 GHz. Fig.4 (a) and (b) give the insertion loss (S_{21}) and the return loss (S_{11}) of the proposed ultra-wideband bandpass filter.



(a)



(b)

Fig 4: (a) Simulated insertion loss of the ultra-wideband bandpass filter (b) Simulated return loss of the ultra-wideband bandpass filter

The 3-dB bandwidth of the simulated filter is about 7.657 GHz from 3.87 GHz to 11.527 GHz where merits the BW authorized by FCC.

4. CONCLUSION

A novel compact band-notched UWB BPF has been proposed using two parallel stepped impedance resonators (SIR). The existence of transmission zeroes has been formulated and proved the capability of tuning them to design three types of dual-band, UWB and band-notched BPFs. Two UWB BPFs have been designed and simulated using an EM simulator tool. Finally a compact band-notched UWB BPF has been designed and simulated.

A size reduction around 16.3% has been reported in comparison with the most recent band-notched UWB BPF accompanied by transmission zeroes at the lower and upper stop-bands provided a much sharper cut-off frequencies and much better selectivity than those of the conventional one lacking any transmission zero.

5. REFERENCES

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