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Analysis of a Compact Wide-Band BPF using Quarter Wavelength Transmission Lines

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Key words: Wide band BPF, microstrip resonator, reflection co-efficient, transmission co-efficient, satellite communication applications

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Abstract: The development towards the microstrip filters and their applications in different areas of satellite communication and VSAT system on chip made the scientists focus on the compact, lightweight and wide beam filters. In this study, a wide band bandpass filter utilizing quarter wavelength transmission lines is created and analysed. Design equations are presented to calculate the length and width of the quarter wavelength transmission line. An equivalent lumped components circuit, gotten from the proposed structure is introduced and its components are presented. The proposed filter is fabricated and tested to evaluate the suitability for wideband applications. Various parameters such as reflection co-efficient, transmission co-efficient, bandwidth, group delay and quality factor are measured and have made comparison with the simulated results to verify its suitability for satellite communication applications. Miniaturisation of the filter size finds the suitability of a filter to be used for a smaller platform.

INTRODUCTION

Microstrip filters are usually designed depending up on the need of their ideal characteristics and compromises are observed to enhance the performances[1-5]. For instance, for a flexible size which is the most wanted feature, the utilization of a quarter-wavelength resonator will bring about a smaller size design than utilizing a half-wavelength resonator however this requires via holes which may increase the manufacturing cost[1, 2]. To avoid these via. holes and smaller the size, folding these simple structures of resonators is employed[3, 4]. Another arrangement is to plan a Stepped Impedance Resonator (SIRs) and yet, the SIRs are not exceptionally reasonable for low-loss coupling. Linear Tapered Line Resonators (LTLR) can offer a compact size than SIRs and furthermore a low-loss characteristic, however, they are complex in analysis[6]. Yet, to accomplish a compact size, single resonator design with Transmission Zeros (TZs) creation is very beneficial[4, 7].

However, lumped element filters are not difficult to design and are effective; they are difficult to create at microwave band. Consequently, researchers are trying to change the lumped component circuits at microwave band into a simple to manufacture microstrip circuits and the other way around. The aim is to discover direct transformation techniques to execute fast design procedures for microstrip filters, like Richard' transformation, kuroda's identities and impedance/admittance inverters[8]. These circuit changes were especially valuable and successful in microstrip low pass channels (LPFs) and Stopband Filters (SBFs) plans where simple microstrip structures are employed[9, 10]. In the existing literature, microstrip Dual Band-Bandpass Filters (DB-BPFs) are not regularly given their equivalent lumped component circuit because of their complexity. By Sridharan and Sreeja[11] an identical LC circuit of a double band filter is gotten from a straightforward L-shaped microstrip structure. In this article, a novel wide band BPF with its equivalent lumped component circuit is introduced. The design is obtained by combining the required features utilising the quarter wavelength resonators with transmission zeroes creation.

MATERIALS AND METHODS

Filter geometry: Via. holes are avoided in the filter design to make the fabrication process simple and the substrate used for fabrication is FR4 with a thickness of 1.6 mm, relative permittivity of 4.3 mm and loss tangent of 0.0017 mm. The design primarily consists of two quarter wavelength transmission lines united by a semi-circular ring to create a wide band with two transmission zeroes[12, 13].

Filter structure and its equivalent circuit: To obtain better passband isolation an initial BPF contains two quarter wavelength transmission lines united by a semi-circular ring with two transmission zeroes is created. A quarter wavelength transmission line is used for better coupling and is also used to obtain desired transmission zeroes. The proposed filter is designed to resonate at 12 GHz. An-soft HFSS Software is used to examine the properties of a proposed filter[14, 15]. It is fed by a quarter wavelength microstrip transmission lines. The parameters of the proposed filter design in mm are as follows. L = 6, W = 13.02, R_1 = 2, R_2 = 1.5, W_1 = W_2 = 5 and W_3 = 1.1 (Fig. 1 and 2).

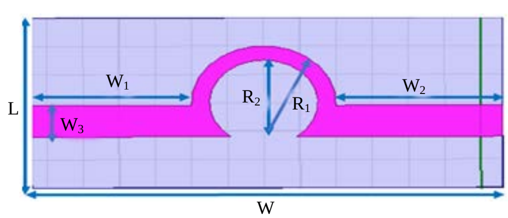

Fig. 1: Top view of the proposed BPF

Fig. 2: Bottom and top views of the fabricated prototype

RESULTS AND DISCUSSION

For real time validation, the built prototype is fabricated and tested. The plots show that there is a very close understanding between the simulated and the measured results. The filter's return loss characteristics are detailed in Fig. 3 and 4 and the reflection co-efficient is observed to be below 10 dB. The maximum possible filter's bandwidth is found to be 0.6, 1.6 and 0.7 GHz. The insertion loss is far below 3 dB in all states[16-18]. Figure 5 provides a summary of the performance parameters based on the literature, from which it is

Fig. 3: Measuring the transmission co-efficient by using vector network analyser

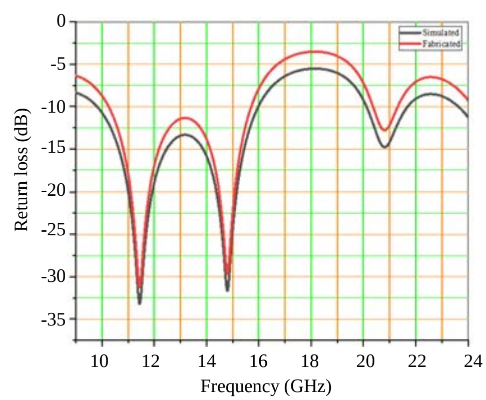

Fig. 4: Simulated vs. measured results of reflection co-efficient of the proposed BPF

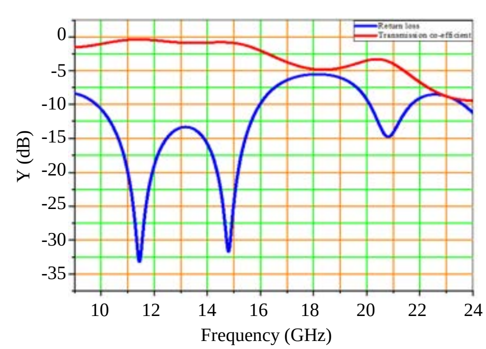

Fig. 5: Simulated vs. measured results of transmission co-efficient of the proposed BPF

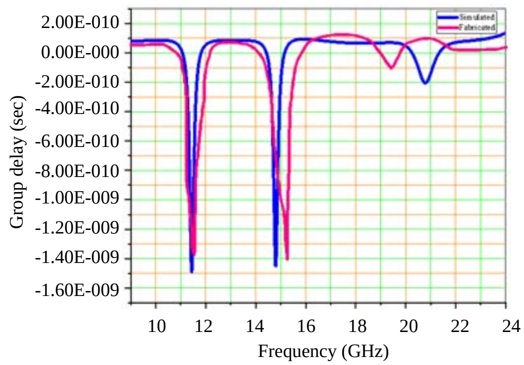

Fig. 6: Simulated vs. measured results of group delay of the proposed filter

noted that the proposed filter offers better return loss, transmission coefficient and wider bandwidth. Using the vector network analyzer, the reflection co-efficient of the manufactured filter was calculated and the proposed filter resonates at 10.28, 12 and 14.62 GHz. The relation between the measured and computed group delay is shown in Fig. 6 for the designed band of 10-17 GHz, the variance of reflection coefficient across frequencies is <10 dB[19-21].

CONCLUSION

Utilizing simple concentric microstrip open loop transmission resonators that are adaptable and readily reproducible, the filter is developed. The proposed design is lightweight, practical and numerous activities are performed. The proposed filter is easily replaced by the filter bank with large number of filters hence it can reduce the complexity of a transceiver. The manufactured filter addresses the problem of bandwidth control, efficient utilisation of spectrum and other complexities of the receiver, making it ideal for the production of futuristic wireless communication devices[22, 23].

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