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# IMPLEMENTATION OF MICROWAVE BANPASS FILTER WITH CROSS COUPLED LINE STRUCTURE FOR Sub-6 (3GHz) 5G APPLICATION

**[1]Noor Mohammed S, [2]K.G Padmasine**

[1] II$^{nd}$ MSc, [2]Assistant professor
[1]Department of Electronics and Instrumentation,
[1]Bharathiar University, Coimbatore, Tamilnadu, India.

***Abstract:*** A broadband band-pass filter with a cross-coupled line topology is described in this paper. Coupled parallel lines and an open stub are used to create the cross-coupled line structure. Because of its symmetry, it may be studied using both odd and even-mode approaches. In the pass-band, there are three transmission poles and two transmission zeros. The impact of transmission zeros and poles on impedance properties are then investigated. The suggested band-pass filter's physical specs are then stated. The final insertion loss and return loss of the filter are calculated using HFSS for simulation and optimization. The modelling and measurement results correlate well, indicating a solid design concept.

***IndexTerms* – Microwave filter, s parameter, Sub6 5G.**

## I. INTRODUCTION

Band-pass filters (BPF) with high selectivity are required for Sub6 5G applications. In this paper, a BPF with cross coupled structured line resonator is designed. The equivalent circuit is shown and by using ANSYS HSFF software the design is simulated. A resonator with open stub and cross-shaped structure is used for the design a micros-trip BPF. The proposed BPF uses odd-even mode approach [1]. The pass-band has desired output of above -3dB. And the transmission co-efficient has desired output of above 10dB. The simulated result using the ANSYS HFSS software produced similar results as compared to the theoretical results, hence feasibility of the design verified for the proposed design. The majority of filter designs are complicated and complicated to understand and discuss [2]. For certain filters, creating an analogous circuit for analysis are problematic. Furthermore, most filters necessitate high manufacturing precision. The capacitance value can vary the lower frequency band of the 1st pass-band, but the other three band edges stay intact.

In chapter 2, the details of the cross-coupled line structure and its transmission zeroes and poles are discussed. In the chapter 3 the results and simulations of the proposed BPF are given in detail [3]. Also the plotted the measured S-parameters and bandwidth is calculated along with insertion loss and return loss. And in the section 4 the conclusion is summarized. There are 3 transmission poles in the PB, and there are 2 transmission zeroes which lies out of the pass-band. The performance of the proposed BPF is unaffected by slight changes in impedance characteristics. As a result, processing errors, tiny dielectric constant errors, and filter thickness have minimal impact on performance of the filter.

BPF filters with 3 GHz center frequency is most suitable for Sub6 5G applications. Sub6 5G provides high data speeds compared to the previous cellular technologies such as LTE and 3G. Sub 6 5G can cover more geographical area as compared to mmWave 5G technology. But mmWave 5g provides higher speeds compared to Sub6 5G. The Sub6 5G is used mainly for Internet of things(IoT) applications [4]. High speeds, Low latency, and better power efficiency makes Sub6 5G most suitable wireless technology for IoT. 5G market is expected to grow by 248.2 billion USD by 2026. Thus, the requirements and demands for Sub6 5G antennas and filters will be very high in the coming decade [5]. The IoT devices require good power efficiency as they are generally designed to work for 10 years or more. Better power efficiency of 5G provides IoT devices to last longer. Sub-6 GHz 5G is used by AT&T, Verizon and T-Mobile in USA with expected launch in India by 2023.

Other applications of Sub-6 GHz 5G includes smart cities, interconnected healthcare applications, reliable machine-type communication (MTC) in manufacturing industries and supporting broad range of new and existing applications. Infrastructure concepts for 5G massive-MIMO sub-6-GHz are already being deployed. This means that the technology and system designs needed to allow global carrier build-out at high frequencies, increased output power, and reduced consumption of power must be available now [6]. GaN-based technologies assist carriers and base-station manufacturers meet their 5G sub-6-GHz and mmWave targets.

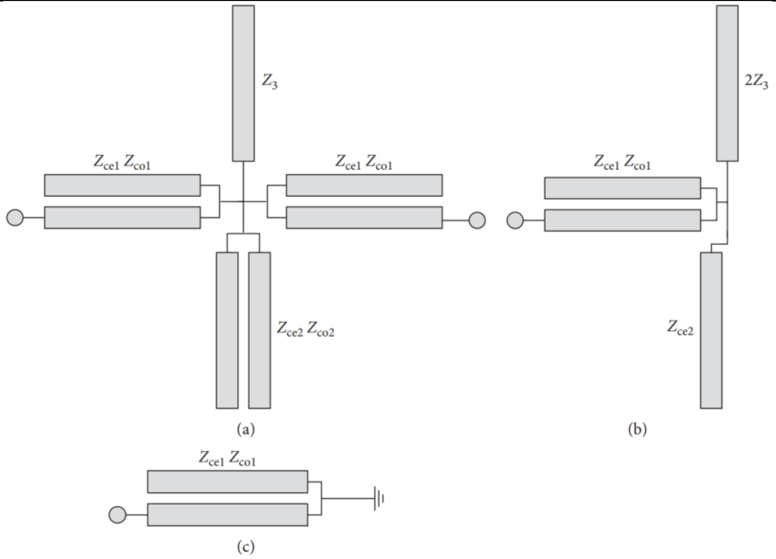


Figure 1: Wideband BPF ideal circuit and comparable circuit design: Ideal circuit, odd and even-mode circuit respectively

## II. FILTER DESIGN AND ANALYSIS

Figure 1 depicts the proposed ideal circuit of three-pole wideband BPF, which consists of parallel linked lines and one branch micro-strip line (a). Figures 1(b) and 1(c) show the circuits in odd and even modes, respectively. The impedance values are calculated using normalized impedances for ease of calculation. The equivalent circuits of odd-mode and even-mode possess the exact same coupling structure. As can be observed in Figure 2, it can be viewed as an analogous circuit with different load levels.

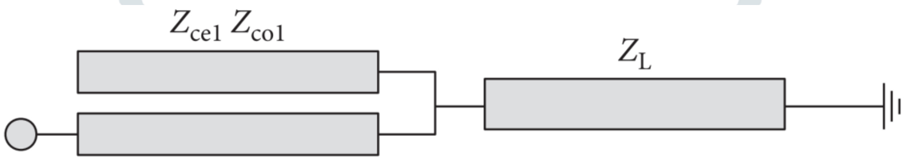


Figure 2: Equivalent circuit having load $Z_L$

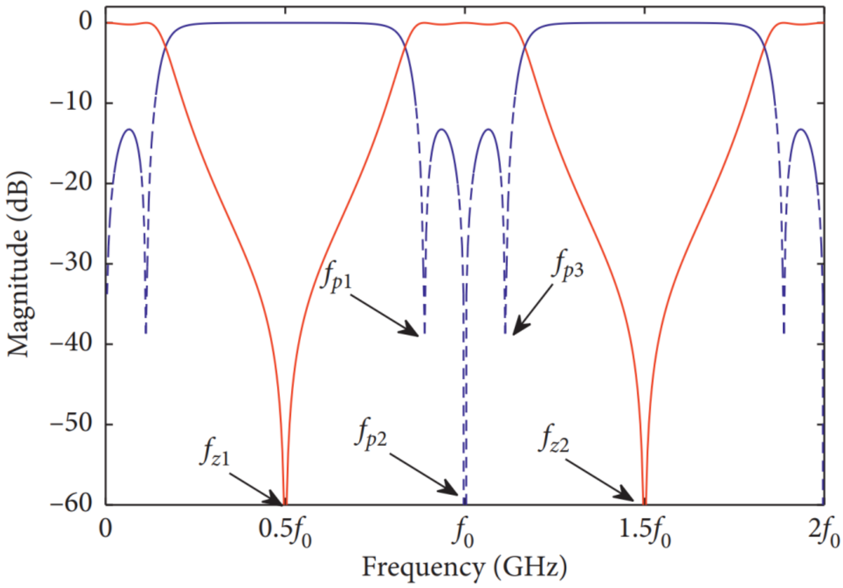


Figure 3: Frequency response of figure 2

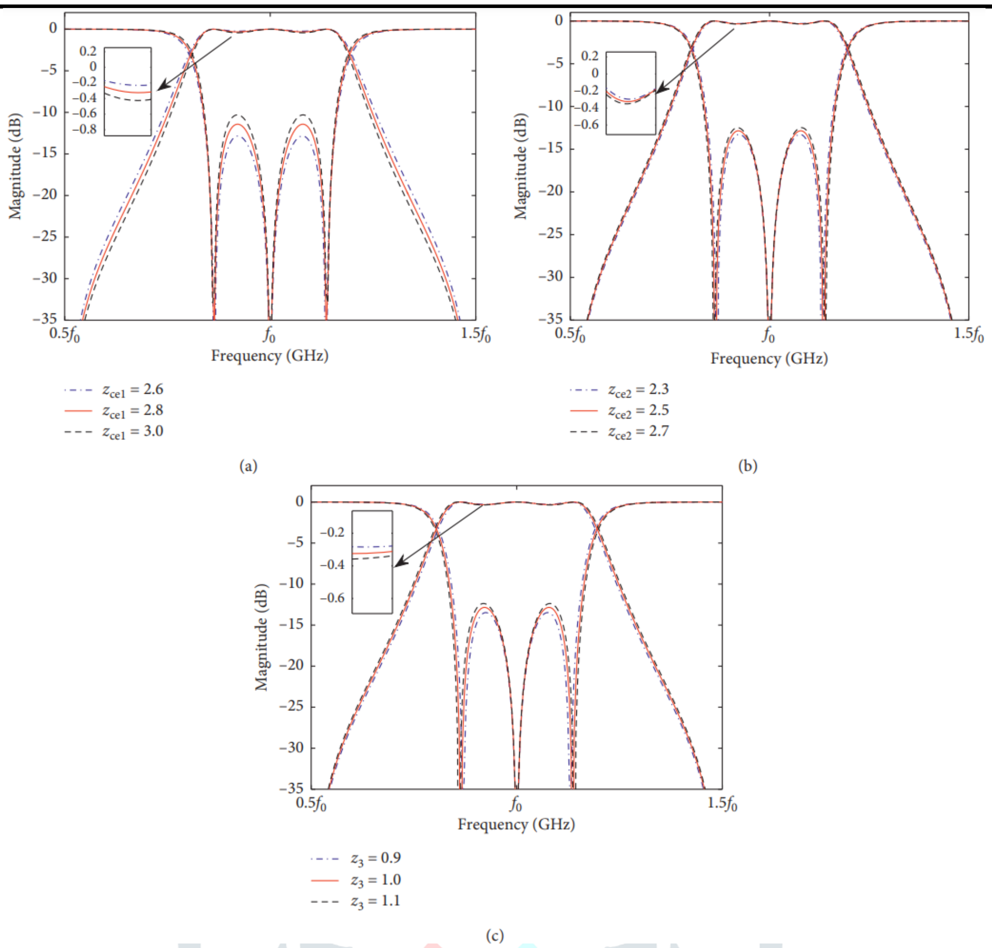


Figure 4 : Frequency response of designed BPF simulated having varying impedance

Figure 4 depicts the design parameters. Within the fundamental design parameters of $Z_{ce1}$ = 2.8, $Z_{ce2}$ = 2.5, and $Z_3$ = 1. The placements of the transmission poles do not change much when $Z_{ce1}$ and $Z_{ce2}$ are changed. When $Z_3$ grows, the transmission poles $f_{p1}$ and $f_{p3}$ move farther from the central frequency $f_0$, as seen in Figure 4(c). The filter bandwidth proposed is increased. Furthermore, as the normalized impedance values vary, the pass-band return loss changes. The performance of the simulated BPF is unaffected by slight changes in impedance characteristics. As a result, processing errors, tiny dielectric constant errors, and filter thickness will have minimal impact on the performance of the filter.

## III. BPF Results and Discussion

The BPF filter is simulated on ANSYS HSFF software with the parameters shown on the figure 15 below.

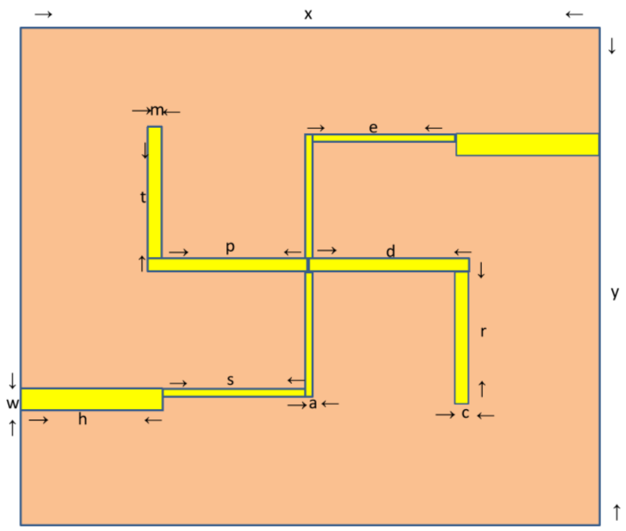


Figure 5: Layout for simulated BPF(dimensions in mm)

Figure 5 shows the simulated BPF's finalized dimensions. 5 (a=0.5mm, d=10mm, c=1.8mm, r=16.5mm, m=0.6mm, p=11mm, t=14.9mm, , h=5mm, w=1.54mm,x= 50mm, y=68.7mm, s=14.8mm, and e=11.4mm).

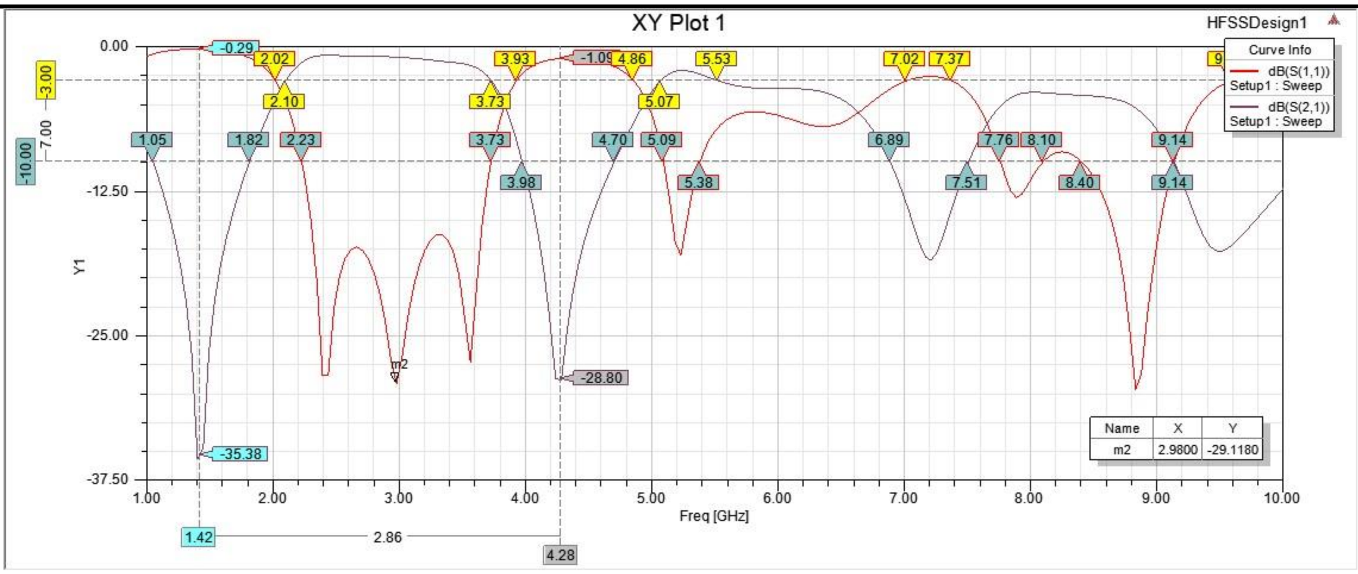

Figure 6: S-parameters of the modeled BPF simulated and measured

Figure 6 shows the measured S-parameters with simulated values from Ansys HFSS . The figure shows Lower stop-band of 1.42 GHz and upper stop-band of 4.28 GHz with center frequency of 3Ghz The design has a reflection co-efficient of -29.11dB. The pass-band ranges from 2.1 GHz to 3.73 GHz with a bandwidth of 1.63. The resultant transmission co-efficient is 35.28 and 28.8. Transmission pole locations are 2.4 GHz, 3 GHz, and 3.6 GHz. These values are tabulated in the table 1 below.

Table 1: The resulting parameters.

| PARAMETERS | VALUES |
|---|---|
| Lower Stop-band | 1.42 GHz |
| Upper Stop-band | 4.28 GHz |
| Reflection Co-efficient | -29.11 dB |
| Centre Frequency | 3 GHz |
| Pass-band | 2.1 GHz to 3.73 GHz |
| Bandwidth | 1.63 |
| Transmission Co-efficient | 35.28, 28.8 |
| Transmission Poles location | 2.4 GHz, 3 GHz, 3.6 GHz |

## IV. CONCLUSION

This study shows a BPF with a cross-coupled linked line structure. While using the even and odd-mode techniques, the filter variables see little impact on the suggested BPF's resonant qualities. As a result, minor differences in dielectric constant and thickness have a small effect on the filter's effectiveness. The results of the ANSYS HSFF software simulations agree well with the measured values, suggesting that the suggested synthesis method is legitimate.

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