PARALLEL COUPLED BANDPASS FILTER FOR Wimax

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***Abstract* – The paper concentrates on the design of a parallel coupled bandpass filter (PCBPF). The design is developed at the centre frequency of 5.77 GHz. The bandwidth of the filter is 9%. This type of filter is suitable to be used in the Wimax systems. The filter is implemented by using epoxy laminate with ε_r=3.0 with thickness of 0.75mm thickness.**

Index terms – **Microstrip, filter elements, *parallel coupled Bandpass Filter(BPF)***

I. INTRODUCTION

Microwave communication systems are expanding rapidly to the higher frequency spectrum such as the C-band and X-band, this is mainly because they can provide many advantages over conventional wireless links, for example the larger bandwidth and smaller device size. Waveguide components are widely used at these frequencies and offer very good performance, however the result is high production costs and bulky systems [1]. Therefore a more convenient and efficient component need to be designed and created which is the microstrip filter.

Bandpass filters (BPFs) at microwave frequencies often use the parallel-coupled microstrip technique. Two or more resonators are cascaded as such to form the coupled multi-resonator BPF. Each individual resonator is affected by reactive loading from adjacent couplings and open-ended capacitive fringing. [2]

Parallel coupled microstrip filters have been widely used in the RF front end of microwave and wireless communication systems for decades. Major advantages of this type of filter are easy synthesis procedure, good repetition, and a wide range of filter fractional bandwidth [3].

Filters play an important role in the operation of a wireless communication system and this is especially so when the frequency spectrum is getting more crowded than ever before. Often, in this type of application, passive filters are employed compared to their active counterparts. Passive filters designed around reactive elements only, using lumped components such as inductors and capacitors or distributed elements such as cascaded resonators, can operate up to the microwave region [4].

At upper microwave frequencies, such as in the X-band, the parasitic in the inductors and capacitors often proved too much a constraint to use them in the wireless system. Hence, many of the filters used in microwave communication systems employ the distributed elements types.

This paper presents the parallel coupled microstrip BPF operating in the wireless C-band. The filter is designed on 0.75mm-thick high-resistivity silicon substrate. The design and simulation are performed using the Agilent Technologies Genesys software.

II. COUPLED LINE FILTER

For a microstrip bandpass filter implementation, the coupling between resonators decreases with increasing substrate height. Generally, microstrip or stripline bandpass coupled line filters, with bandwidths less than about 20% can be easily fabricated. However, where wider bandwidth filters are desired, very tightly coupled lines are generally needed. This can be achieved by reducing the substrate height used, where the track separation required to realize the coupled line filter becomes smaller [5].

However, this small track separation can present a problem in terms of manufacturability. Also, quite often the characteristic impedances of the stub resonator are in reality difficult to realize as well. Thus the relationship between the substrate height, minimum coupling gap, realizable characteristic impedances and overall loss must be addressed to gain the required filter performance.

Coupled line filters can be designed to satisfy either a Butterworth (maximally flat) or Chebychev (equal-ripple) response. In this study, a 3rd order bandpass filter has been designed with a center frequency of 5.77GHz with a 9% bandwidth using coupled resonators to give a maximally flat response.

The first step in designing a filter is to design a prototype lowpass filter with the desired passband characteristics. Lumped-element lowpass filter consist of a ladder of inductors and shunt capacitors. The synthesized lowpass filter, normalized for system impedance has series inductors in henries and shunt capacitors in farads. The second step is the transformation of the lowpass lumped-element filter prototype to the BPF. The third step is the practical design of a microwave filter where the resulting circuit in the BPF is converted into the distributed elements. [2]

The BPF is designed by following the design procedure based on the even- and oddmode impedances of the coupled lines [1], and is further optimized using Genesys software. Figure 1 shows the lumped circuit of the filter. Figure 2 shows the ideal PCBPF and figure 3 shows the top view and various sections of the designed microstrip filter structure. The filter is designed on silicon substrate Roger Duroid 3003 (Ro3003) shown in table 1.

Specification	Value
Permittivity, ε_r	3
Substrate height (mm)	0.75mm
Loss tangent, *tan* δ	0.0013
Copper thickness (mm)	0.035mm
Copper width (mm)	1.39mm

Table 1: Substrate properties

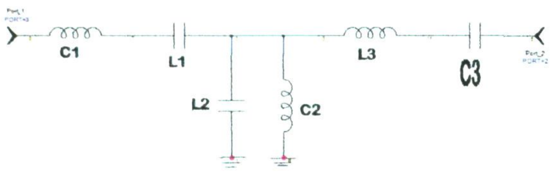

Figure 1: Lumped element circuit

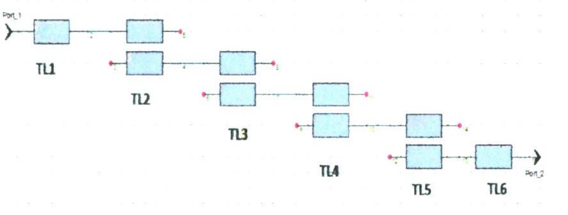

Figure 2: Ideal Parallel Coupled Bandpass Filter

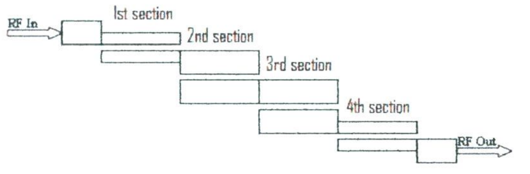

Figure 3: Top view of the simulated parallel coupled microstrip BPF structure

With this, the filter requires even- and odd-mode characteristic impedances (Zoe, Zoo) of 61.478Ω and 53.254Ω, respectively, for the first coupled line section, which translates to a line width of 1.214mm and line spacing of 0.7mm on a 0.75 mm silicon substrate. The next coupled line section requires Zoe and Zoo of 60.954Ω and 61.769Ω, respectively, yielding a line width of 2.723m and line spacing of 0.7mm.

The last two coupled line sections are symmetrical to the first two, thus they have the same dimensions as stated earlier. The dimensions of the I/O ports are corresponding to a 50Ω microstrip line which could be considered as subminiature version A (SMA) adapter. The comparison between ideal and real simulation result have been done in order to distinguish the result after manual fabrication.

III. SIMULATION AND MEASURED RESULTS

The coupled lines are designed for the Wimax frequency centred at 5.77 GHz. Based on the simulation result in the Figure 4, the insertion loss, S12 is at 0.98 dB at 5.77 GHz while the return loss, S11 is at -40.237dB at the frequency of 5.77 GHz

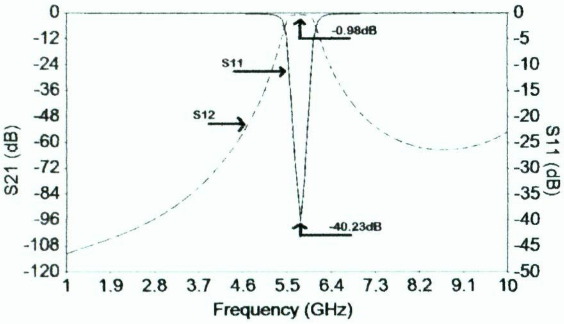

Figure 4: Simulation results

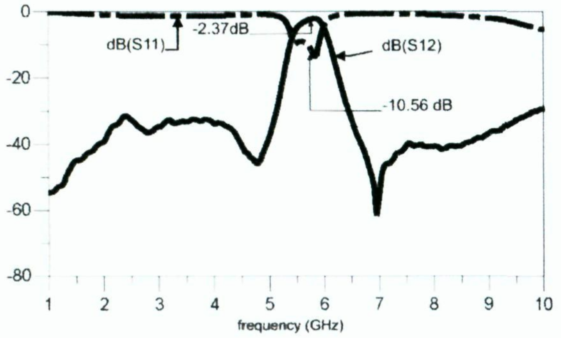

Figure 5: Measurement result of the microstrip design

Figure 5 shows the measurement result. The response was slightly different between the simulation and the measurement design. It seems that the return loss had shifted to -10.56dB and the insertion loss had shifted to -2.3676d at frequency 5.77 GHz. The comparison of the insertion loss and the reflection loss between the ideal, simulated and the measured values are shown in table 2.

Losses	S11(dB)	S12(dB)
Specification	< -20	0
Simulation	-40.23	-0.98
Measured	-10.56	-2.37

Table 2: The insertion and reflection loss at 5.77GHz

There are several factors must be considered after the fabrication process. One of the most important parts is the parasitic and stray elements, which may reduce the performance of the filter [6]. It can be occur from the ground plane of the devices. Other than that, it was perhaps due to the affect from the fabrication error and unperfected ground. It can be improved by more careful fabrication and measurement technology.

Figure 5 represent the fabricated PCBPF filter that has been designed according to the specification. Fabrication process start after the result achieved the targeted parameters [6]. The filter dimension is 4.83cm length and 3.5cm width.

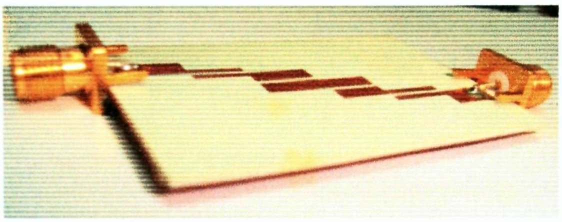

Figure 5: Prototype of the PCBPF

IV. CONCLUSION

A parallel coupled line bandpass filter for Wimax application was successfully designed, simulated, fabricated and analyzed by using epoxy laminate ε_r=3.0 with thickness of 0.75mm. It was small in size, compact, light and very low cost of fabrication. However, there is some slight discrepancy between measured and simulated values.

V. RECOMMENDATION

In future, this approach can be modified to improve the performance of the filter. Other substrate with higher relative permittivity can be used that probably can improve the performance of the design at high frequencies and reducing the size of the filter. Besides, other methods can be used on designing this kind of filter for such as using Step-impedance

VI. REFERENCES

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