Design and Development of a Multi-Fold Microstrip Hairpin Line Bandpass Filter at 1400 MHz for Communication Systems

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ABSTRACT

RF and microwave bandpass filters are key components for most of the recent communication systems. A conventional hairpin-line resonator size is normally very large. A Multi-folded hairpin line resonator filter helps to reduce the size, if the required selectivity characterstrics are not critical. This paper presents the design, simulation, optimization and test results of a new class of a 4-pole multi-fold hairpin line microstrip resonator filter with 60-65% reduction in size and moderate selectivity compared to the conventional hairpin line resonator filters for L/S band communication systems.

General Terms
Microstrip, substrate, RT-duroid, thermal conductivity, surface resistivity, heat distortion temperature.

Keywords
Hairpin line filter, Multi-fold hairpin line resonator, dielectric constant, coupling coefficients, selectivity, insertion loss, quality factor, bandwidth, ADS software, IE3D Zealand software, computed response.

1. INTRODUCTION
The requirement of small size, high quality and lower cost hairpin line resonator filters for wireless communication systems, are posing new challenges. The hairpin line resonators are composed of a transmission line and a lumped element capacitor and is represented by parallel -coupled lines instead of the lumped capacitor, shown in fig.1a,1b, 1c and 1d.

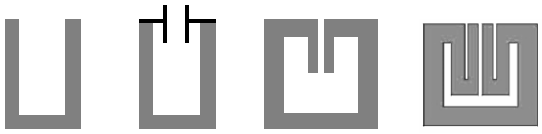

Fig 1-a **Fig.1-b** **Fig. 1-c** **Fig. 1-d**

In the proposed filter the multi-folded resonators are cross coupled. Such a filter can be realized using filter with cross coupling between adjacent resonators [1][2].

2. THEORY
The proposed multi-fold hairpin line bandpass filter is shown in fig.1[3].The filter has four pole cross coupled structure.In this configuration, significant couplings exist between any two adjacent resonators.The capacitive couplings between resonators 1 and 3 and resonators 2 and 4 are negligible.

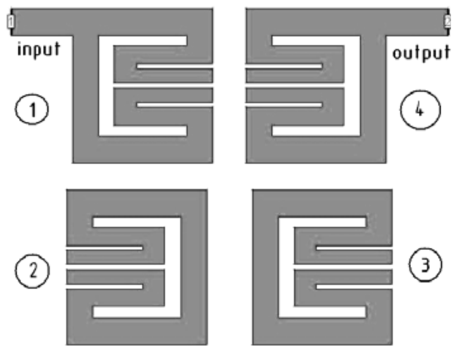

Fig 2: The multi-fold hairpin line bandpass filter

There are four significant coupling coefficients between adjacent resonators, as shown in an equivalent circuit [3].

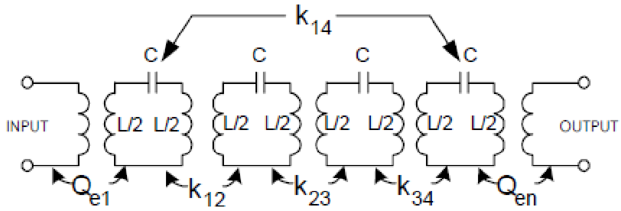

Fig 3: An equivalent circuit of the four-pole cross-coupled bandpass filter

3. DESIGN PROCEDURE
To reduce the size of hairpin resonators, the arms of the resonator are reactively loaded with parallel coupled lines. Filters using these miniaturized resonators are 60-65% smaller in size than the filters that use conventional hairpin resonators [4-5].Design calculations of a 4 section multi-folded filter can be done in the following steps[3]:

a. Specify the centre frequency, passband ripple and the bandwidth of the bandpass filter.

b. Design of a single half-wavelength resonator.

c. Calculate the fractional bandwidth FBW.

d. Calculate the external quality factor.

e. Calculate the desired coupling coefficients.

f. Determine the gaps between the resonators.

g.Optimize the filter circuit for the desired response.

In this work we have used the substrate of dielectric constant 10.2, thickness of 1.27 mm and tangent loss of 0.003.

4. FILTER SPECIFICATIONS AND CALCULATED DIMENSIONS

1. Center Frequency : 1480 MHz
2. 3dB Bandwidth : ± 80 MHz w.r.t.c.
3. Passband ripple : 0.2 dB (max)
4. Stopband bandwidth : ± 175 MHz w.r.t.c.
5. Lower side attenuation : 30 dBc at 1305 MHz
6. Upper side attenuation : 30 dBc at 1655 MHz
7. Intput impedance : 50 Ohms
8. Output impedance : 50 Ohms

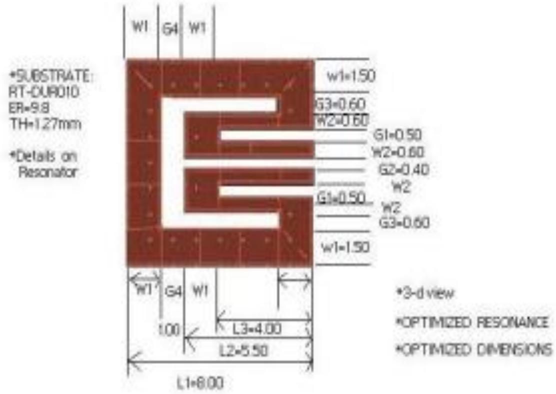

Fig 4: Dimensions of a multi-fold resonator at 1400 MHz.

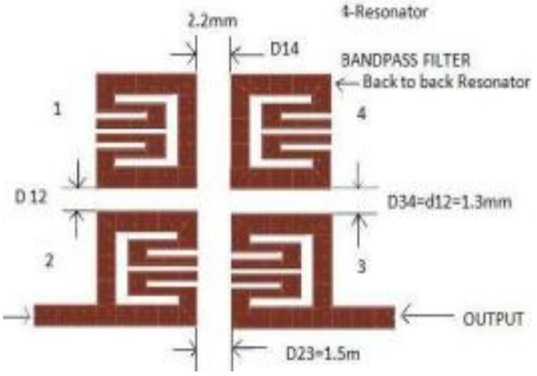

Fig 5: Arrangement of 4 resonators in the Bandpass filter

5. SIMULATED RESULTS USING ADS AGILENT-MAKE SOFTWARE

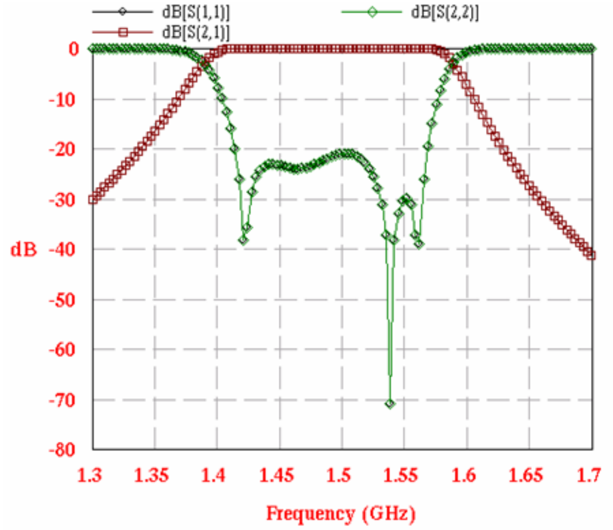

Fig 6: Simulated response at 1480 MHz centre frequency

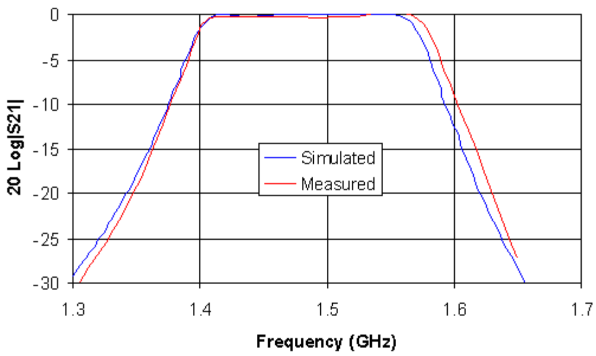

Fig 7: Simulated and measured response of the multi-fold bandpass filter

6. FABRICATION OF FILTERS

The filter circuit is fabricated on a RT-Duroid dielectric substrate having εr=10.2 and thickness 1.27 mm. Standard fabrication process have been adopted [7-9]. The simulated and measured results are very close to the internationally achieved results [6][10]

7. CONCLUSION

This paper describes a 4 section multi-fold hairpin line bandpass filter design technique.The calculations of the filter can be done without using Full-wave EM simulator.The used formulas allow analytical calculations of the filter.The limitations of the design results in terms of inaccuracy of coupling between the adjacent and cross coupled multi-fold hairpin line resonators.

8. REFERENCES

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