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DESIGN AND SIMULATION OF MICROSTRIP EDGE-COUPLED BAND PASS FILTER FOR GPS APPLICATION

Pawan Shakdwipee, Kirti Vyas, Naveen Shakdwipee

pawan21_uda@yahoo.co.in, kirtivyas19@gmail.com, naveens1001@yahoo.com

Abstract— In this paper, band pass filter (BPF) development with the assistance of the Richards-Kuroda Transformation method, on the basis of the known Chebyshev-Lowpass Filter, is presented. The filter is operated at downlink frequency segment of 1.5 GHz for GPS application. The proposed circuit is simulated using Roger R04003 substrate with dielectric constant of 3.38, substrate height of 14 mm and thickness of 32 mm. The simulation results are excellent and the filter is suitable for integration within various microwave subsystems.

Keywords—Band Pass Filter, Chebyshev, Edge-coupled, Microstrip

I. Introduction

A modification that emerged almost in the same time involved removing the top plate leaving only the strip and the bottom plate with a dielectric layer between them to support the strip. That structure was named Microstrip. The Microstrip line it has become the best known and most widely used planar transmission line for RF and Microwave circuits. This popularity and widespread use are due to its planar nature, ease of fabrication using various processes, easy integration with solid-state devices, good heat sinking, and good mechanical support. Therefore,



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a third order chebyshev microstrip edge-coupled filter is designed in the research. The band pass filter is simulated by using Ansoft Designer software.

Many works have been reported that use waveguides for transmission line filter. However, waveguides systems are bulky and expensive. Low-power and cheaper alternatives are stripline and microstrip. These transmission lines are compact. Edge-coupled stripline is used instead of microstrip line as stripline does not suffer from dispersion and its propagation mode is pure TEM mode. Hence it is the preferred structured for coupled-line filters.

II. METHODOLOGY

The design specification of the filter is shown in Table. The specification of dielectric material is obtained from Rogers Corporation. The proposed filter is designed by following the five steps. First step: Determining the order and type of approximation functions to be used. Second step: Finding the corresponding low-pass prototype. Third step: Transforming the low-pass network into a band pass configuration. Fourth step: Scaling the band pass configuration in both impedance and frequency. Fifth step: Transforming the lumped circuit element into distributed realization.

This filter type is often used in the frequency range above 1000 MHz because of it's reliable reproduction, cheap and simple production and high accuracy. An additional advantage: the mechanical dimensions decrease linearly with frequency.

Specifications:

TABLE

SPECIFICATIONS OF BAND PASS FILTER, SPECIFICATIONS OF DIELECTRIC



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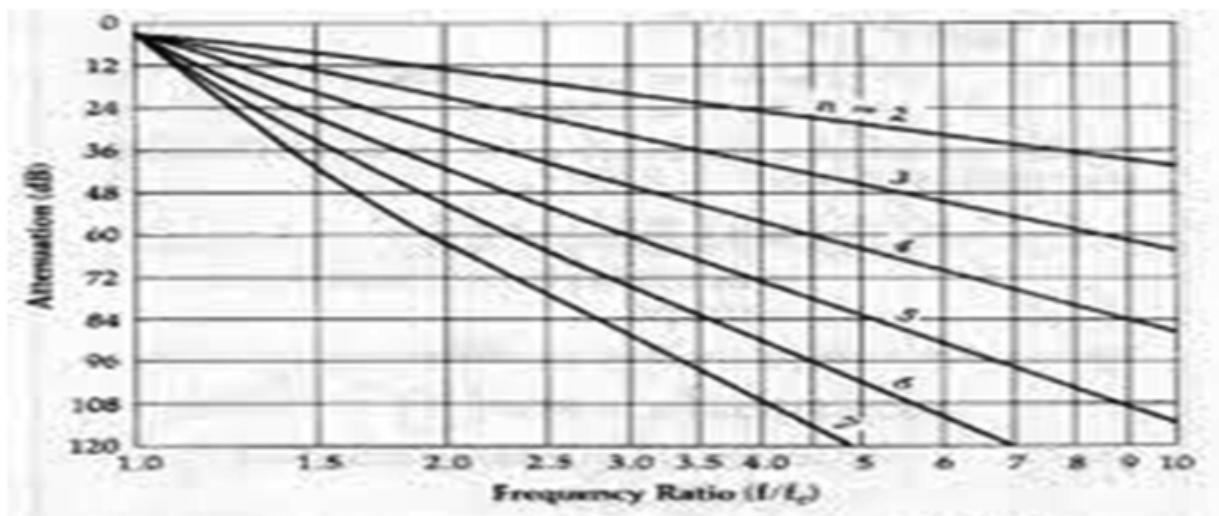
MATERIAL FROM ROGERS CORPORATION

Dielectric Material Used Rogers R04003 from Rogers

Input and Output Impedance: $Z = 50$ Ohms
Passband ripple of S21: 0.1 dB (gives S11-maximum of -16.4 dB)
Filter Order: $n = 3$
Passband Centre Frequency: 1.5 GHz (= GPS-reception)
Ripple Bandwidth: .2 GHz

Board and Substrate Properties:

Substrate: Rogers R04003
Thickness: 32 mil (= 0.813 mm)
Dielectric Constant: 3.38
Loss Tangent: 0.0027 at 10 GHz (gives ca. 0.001 at 1 GHz)
Copper cladding (up and down): 1 oz (thickness = 1.35 mil = 0.035 mm)
Cover Height: 14 mm





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Figure . 1 Characteristics for a chebyshev filter with 0.1dB ripple

Microstrip Model :-

After designing an acceptable model of the filter in the ideal case, the design must be realized in microstrip stripline technology to better represent how the filter will respond in a real world scenario. The model used by Designer of two edge-coupled microstrip lines is represented in the figure below. There are two metallic strips on top of a substrate which is itself above a ground plane. Each trace has an independent width w (w_1 and w_2 , but the model shows “ w ”), and the two are separated by a spacing s . The opposite ends of signal input or output are modeled as open, so no open stub is needed as with the ideal transmission line model.

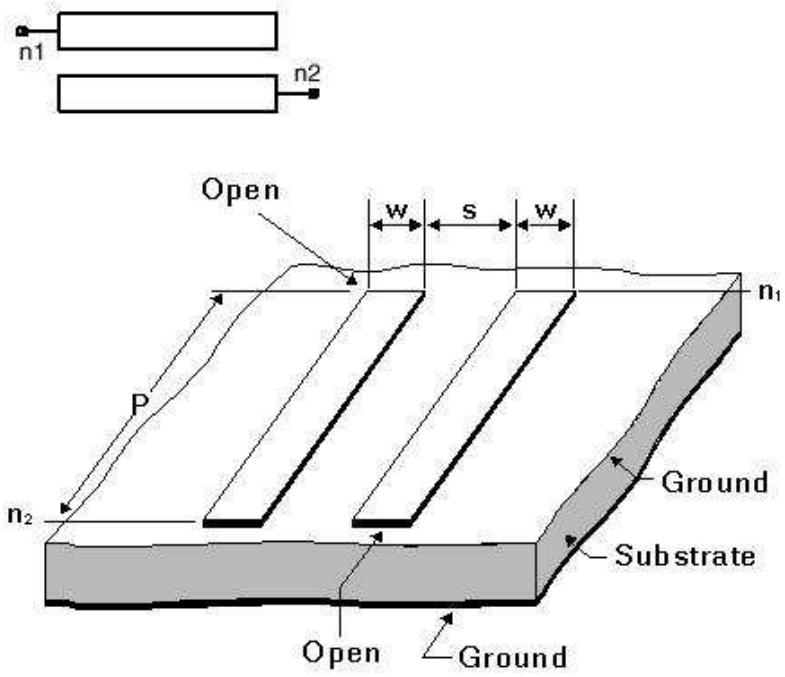
The substrate material Rogers R04003 was chosen out of the available materials in the lab. The selection of dielectric material was based around the synthesis resulting in the highest separation of the first coupled section of all the available sample materials, as it was known that the rapid prototype machine has a minimum milling bit size and that trace spacing will be forced to a minimum of this bit size. The Rogers R04003 sample available has a dielectric constant of 3.38 and a height of 14 mil. Using the FDW, a microstrip Chebyshev filter was generated with a center frequency of 1.5 GHz.



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Coupled Lines, Open Ends Opposite Side, Symmetric





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Figure 2: Model used by Designer for edge-coupled microstrip traces

III. SIMULATION RESULT

The BPF circuit is simulated with Ansoft Designer Student Version 2.2 Software in order to predict the performance of the filter. Few parameters in the circuit are analyzed and have a good relation ship to microwave theory. An optimization process has been introduced along the simulation procedure focusing on the filter dimension in order to improve the response of the filter.



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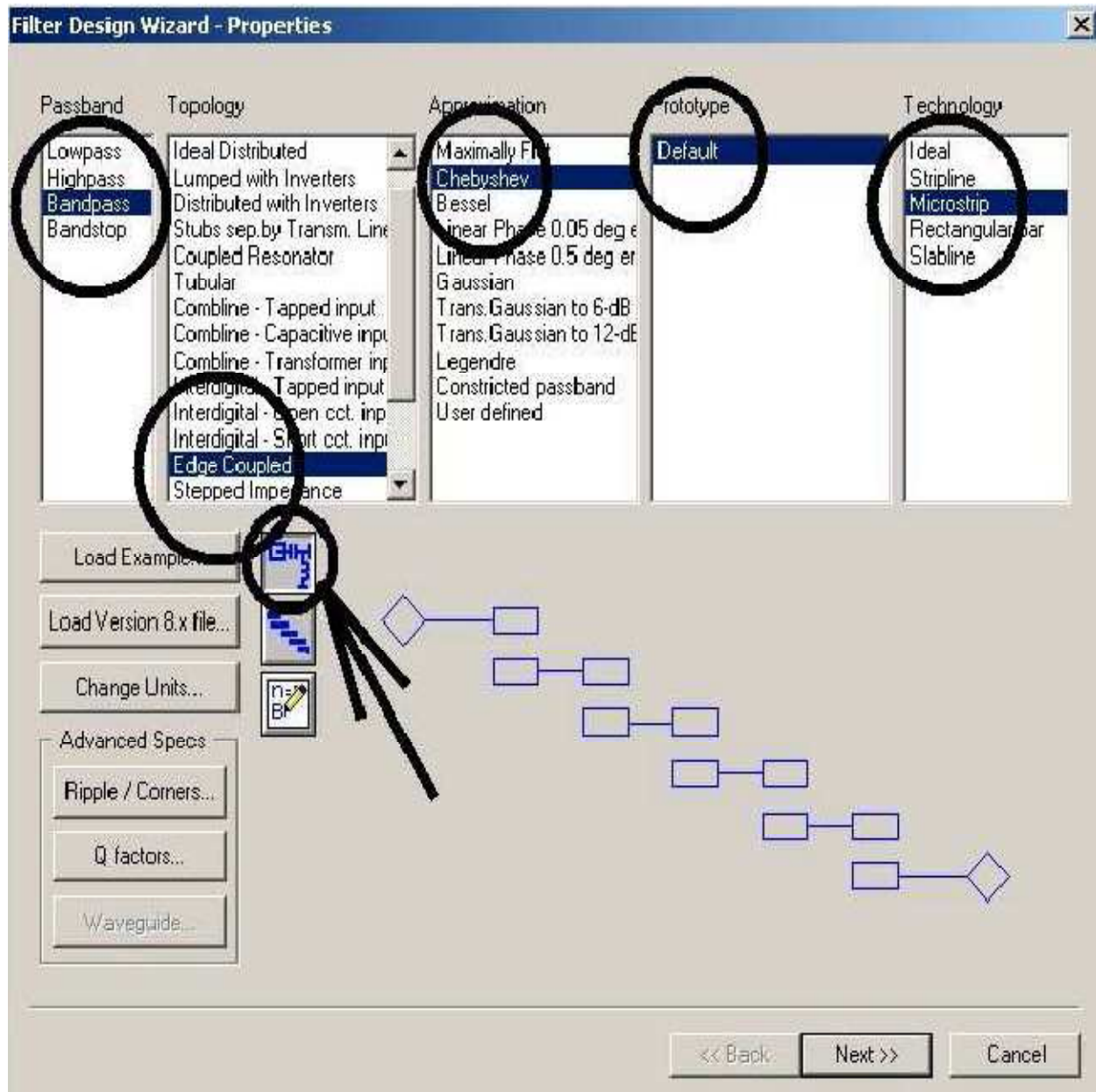


Figure 3:- Working with Filter Design Tool



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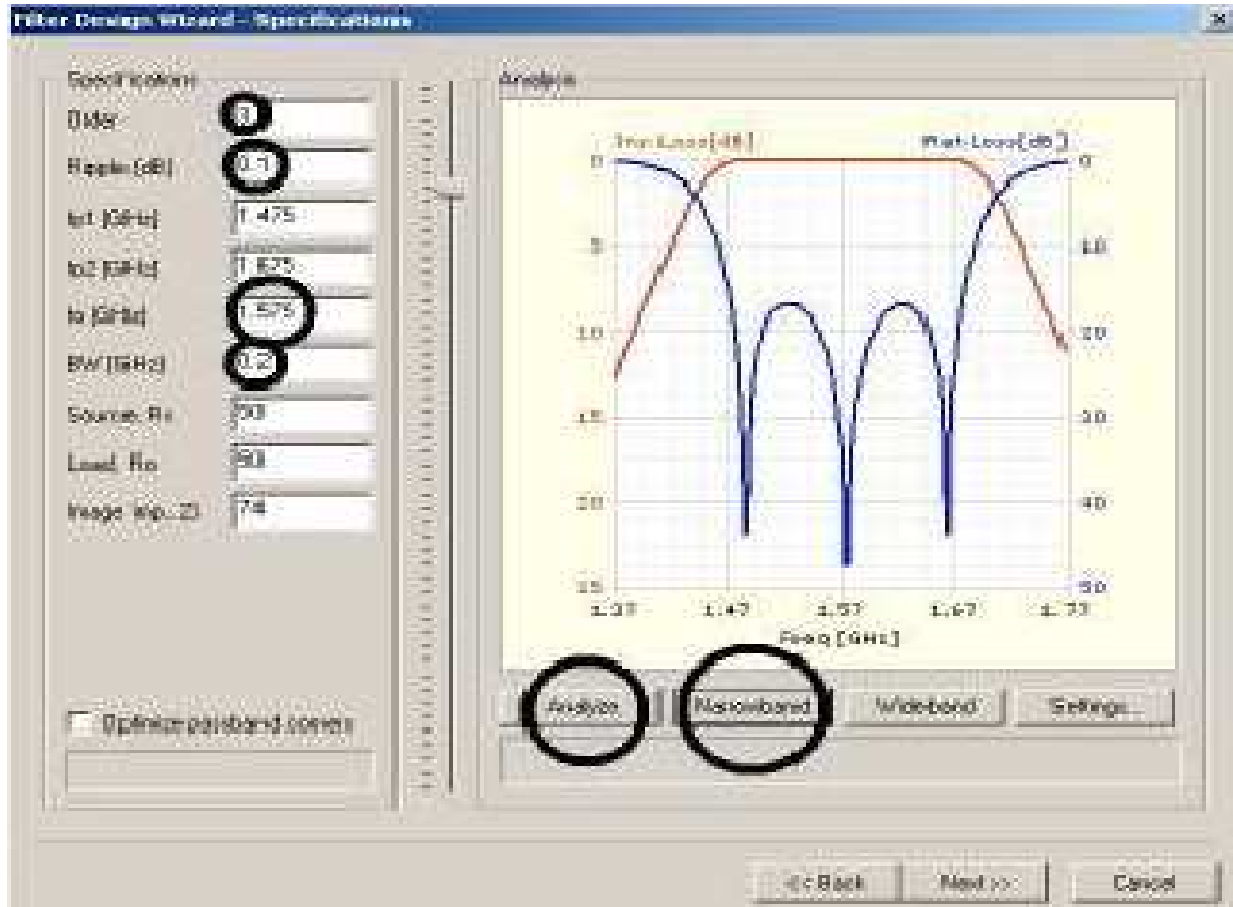


Figure 4:- “Analyze” and then “Narrow Band” to get the characteristic filter curves.

Filter Order = 3

Ripple = 0.1 dB

Centre Frequency $f_0 = 1.575$ GHz

Bandwidth BW = 0.2 GHz.



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Now the Filter Designer likes to know the Substrate Properties. So enter

$\epsilon_r = 3.38$ Substrate Height = 0.813 mm

Conductive Thickness = 0.035mm

Cover Height = 14 mm

Centre Frequency = 1.575 GHz

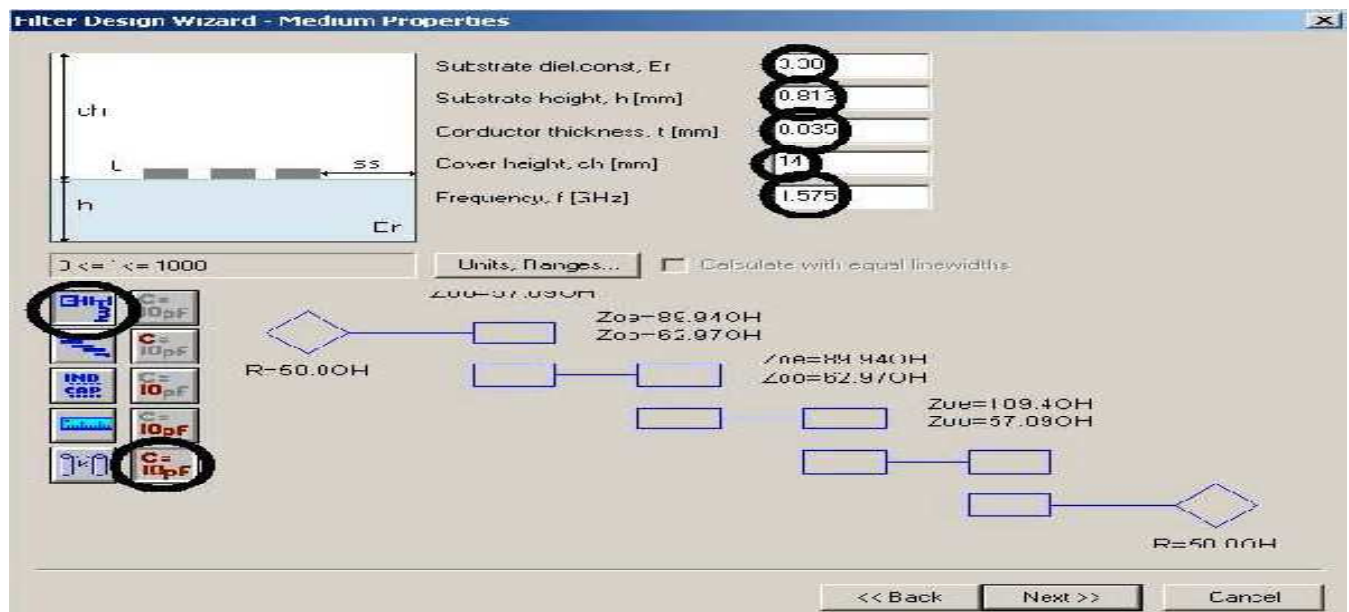


Figure 5:- Configuration For filter Specifications



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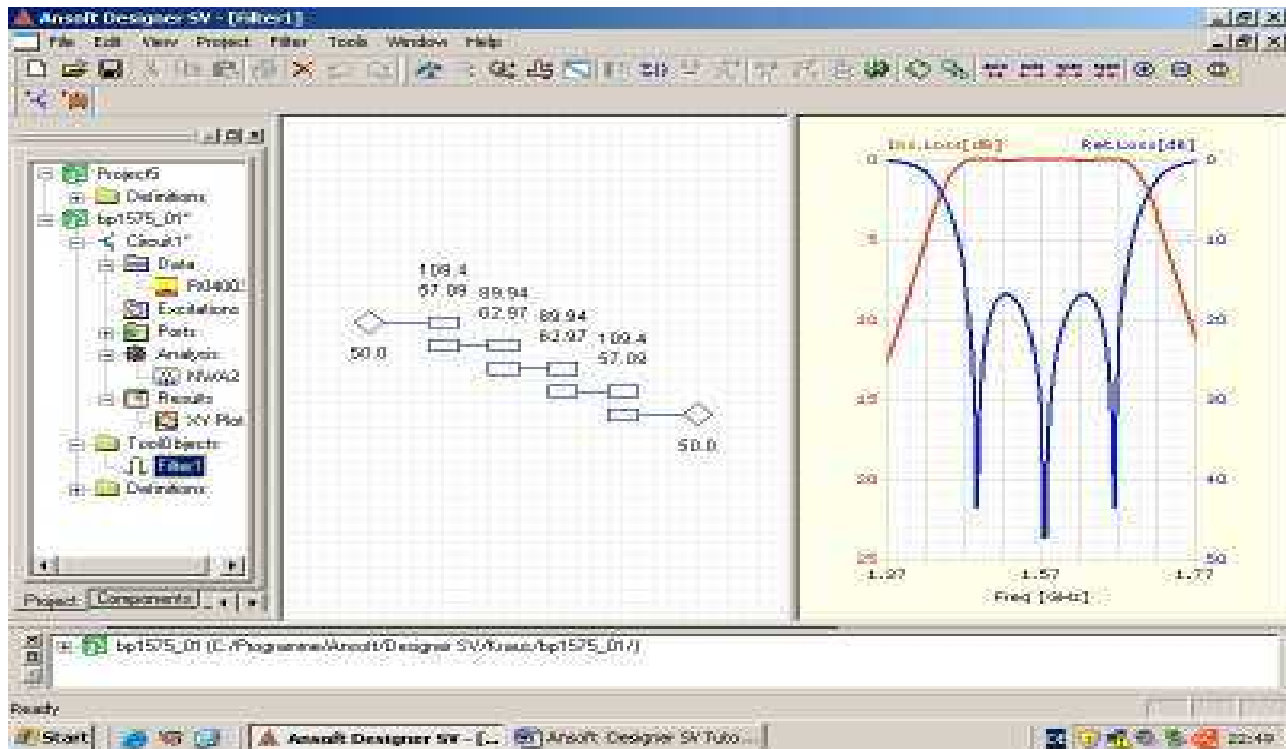


Figure 6:- Software Result Of Odd and Even Impendences



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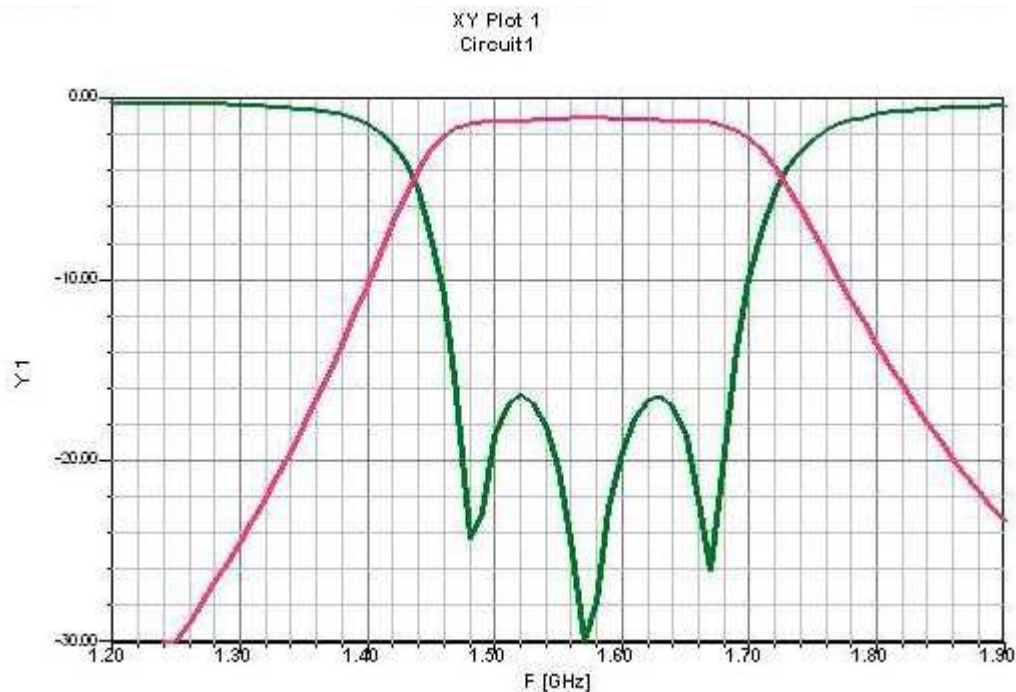


Figure 7 :- Simulated Insertion Loss and Return Loss

The simulated insertion loss is less than 0.01 dB in passband. Also the response is flat and uniform over the entire pass-band. Reflection coefficient is 0.00001 which is nearly equal to 0 and a perfect match exists. Therefore, all simulated results are nearly identical to the design specifications. The simulated group delay for the designed filter is depicted in Fig 7. It is clear from the result that the insertion loss and Return loss. Moreover, the simulated group delay has a very low peak-to-peak variation of less than 3ns across the passband of the filter. Therefore, the designed filter shows attractive characteristics for BPF applications.

IV. CONCLUSION

Experimental implementation of this work involves the Roger R04003 substrate with dielectric constant of 3.38 dielectric characterization at microwave frequencies, which has been



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investigated. The measured parameters were also in good agreement with the simulated results. This paper describes a procedure for designing microstrip edge-coupled band pass filter. It also rejects image signal appearing at the frequency range between 1.5 GHz. Third-order microstrip edge-coupled band pass filter is used in order to realize these objectives. Since the practical inductors and capacitors lose their intrinsic characteristics at high frequencies, lumped element filter is converted into distributed microstrip edge-coupled band pass filter. The filter is simulated with Ansoft Designer software to predict the performance of filter. The simulated insertion loss is less than 0.01dB in the desired passband. All simulated results are nearly identical with the calculated results and also they are in good agreement to the design specifications. An effective general procedure that may be applied to the design of many RF circuit designs has been reviewed. The authors utilized the proposed procedure in an effort to design an edge coupled band-pass filter centered at 4 GHz with a 15% bandwidth based on Chebyshev approximation. Simulation results the authors agree that the errors are not overly extensive and the presented process may be considered a success.

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Pawan Shakdwipee received the Electronic & Communication engineering degree from Geetanjali Institute technical Studies, Udaipur, 2009 (HONOURS) and M.Tech degree Arya College Of engineering & IT Jaipur, RTU Kota University, India 2012. His research interests include Antenna Design, signal processing for communications, and adaptive signal processing.

Kirti Vyas is associated professor in Arya College Of Engineering & IT from Jaipur. Her research interests include Antenna Design, signal processing for communications, and adaptive signal processing and multiway analysis.

Naveen Shakdwipee received the Electronic & Communication engineering degree from B.Tech Techno India NJR Institute of Tech. R.T.U. 2012 (HONOURS). His current research interests are primarily in signal processing for communications, convex optimization, crosslayer resource allocation for wireless networks, and multiway analysis.