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A Review on Design of Microstrip Low Pass Filter for Wireless Application

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Abstract— Microwave Filters used to select or Confine RF/Microwave frequency signals with a designated specific spectral limits. Rapid growth in microwave and millimeter wave technologies leads to increasing demands of such filters. The highly desirable performances are a sharp cut off characteristic and a wide stop band. Conventional design of microstrip low pass filters basically involves either the use of shunt stubs or the stepped impedance network, which is a high-low impedance transmission line. A novel study describing review of techniques used to design a lumped element low pass filter into microstrip line network, which is normalized in terms of frequency range and impedance.

Keywords: low-pass filters (LPF), high-pass filters (HPF), bandpass filters (BPF)

I. INTRODUCTION

Providing number of advantages over conventional wireless links like, larger bandwidth and smaller device size is leading rapid growth of microwave communication systems to higher frequency band [1], [2].Emerging applications and increasing demand of these systems continue to challenge RF/microwave filters with more requirements—higher performance, smaller size, lighter weight, and lower cost [2-5]. RF/microwave applications can be referred to as communications, radar, navigation, radio astronomy, sensing, medical instrumentation etc. Depending on the requirements and specifications, RF/microwave filters may be designed as lumped element or distributed element circuits; they may be realized in various transmission line structures, such as waveguide, coaxial line, and microstrip. The aim is to achieve more accurate results of desired cut off frequency and return loss. Hence, Micostrip is best option for filter design process [6].On the basis of specific application, Filters can be divided into four categories: low-pass filters (LPF), high-pass filters (HPF), bandpass filters (BPF), and band-stop filters (BSF) [7]. Stepped impedance low pass filters are formed by connecting alternate series connection of high and low impedance microstrip transmission lines. Such filters are simpler to design and offer better stop band characteristics [8].A compact and good performance low-pass filter (LPF) is highly demanded in modern microwave communication systems, especially wireless and mobile communications in order to suppress harmonics and spurious signals [9]. There are several general requirements for a LPF, such as low loss, wide rejection band, and small size in some specific applications. Try to avoid excessive use of italics and bold face.

II. LOW PASS FILTER

A low-pass filter is a filter that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency [3-11]. The amount of attenuation for each frequency depends on the filter design. A general structure of the stepped-impedance low passes micro-strip filters, which cascaded structure of alternating high and low impedance transmission lines [7]. These are much shorter than the associated guided wavelength, so as to act as semi lumped elements. There are two method for deigning of a filter.one is image parameter method and the other one is insertion loss method. Based on properties of transmission line, the image parameter theory is a simple lumped components network. Whereas, in insertion loss method, transfer function i.e. the ratio of output to input voltage defines the filter response. Most of the design are done with insertion loss method due to its advantages like Allows a high degree of control over the passband and stopband amplitude and phase characteristics, with a systematic way to synthesize a desired response [12].

Basic design of microwave filters of type’s low-pass, band-pass and band-stop, operating at arbitrary frequency bands and between arbitrary resistive loads, are made from a prototype low-pass design through:

1) Frequency transformer
2) Element normalization and Simulation of elements by means of sections of microwave transmission line,
3) Design of a prototype low-pass filter with the desired pass band characteristics,
4) Transformation of this prototype network to the required type (low-pass, high-pass, band-pass) filter with the specified center and band-edge frequencies.
5) Realization of the network in microwave form by using sections of microwave transmission lines [3].

Fig. 1: Filter Design Procedure

III. LITERATURE REVIEW

Navita Singh, et.al. In this paper presents a low cost and low insertion loss L-band lowpass filter (LPF) based on high-resistivity silicon substrate. Using the Microstrip technology for simplicity and ease of fabrication, design and simulation are performed using 3D full wave electromagnetic simulator IE3D.

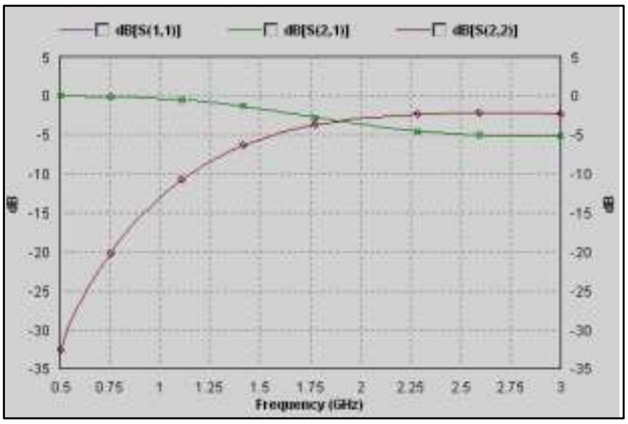

Fig. 2: Simulation response at 1.5GHz

An insertion loss of less than 1.0dB in the passband is achieved by simulated filter. Covering the frequency range from 0.5 GHz to 1.55 GHz a center frequency of 1.5GHz is achieved [1].

K.Rajasekaran, et.al. In this paper describes design of stepped impedance low pass filter by insertion loss method.by adjusting the impedance ratio K, performance of harmonic suppression is improved for X- band. An X-band stepped impedance low pass filter of range 8-12 GHz is designed using ADS simulation tool.

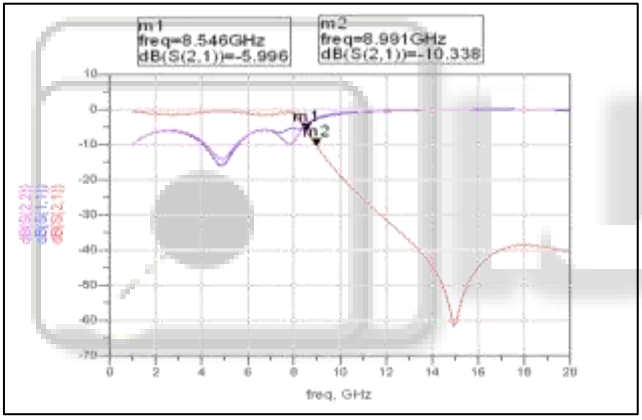

Fig. 3: Simulation response

The simulation results shows that the filter achieves attenuation of 60dB works on 10GHz at the center frequency, which effectively suppresses the parasitic bands. Compared to other filter types, this design works very well with excellent harmonic suppression performance [2].

Shilpi Gupta, et.al.in this paper presents a microstrip stepped impedance low pass filter with low insertion loss and wide pass band. Focusing on the C band for long-distance radio telecommunications applications, the demand of high performance filters that can contribute to systems size and cost, stepped impedance filter is design and optimize at a center frequency of 5 GHz and operating between 4 GHz to 6 GHz range of frequencies. This paper describes a common design technique for micro strip low pass filters that are used to attenuate microwave frequency signals beyond the cutoff frequency. Using different dielectric materials like FR4 and alumina filters for 5 GHz cut off frequency is designed using ADS Simulation tool [3].

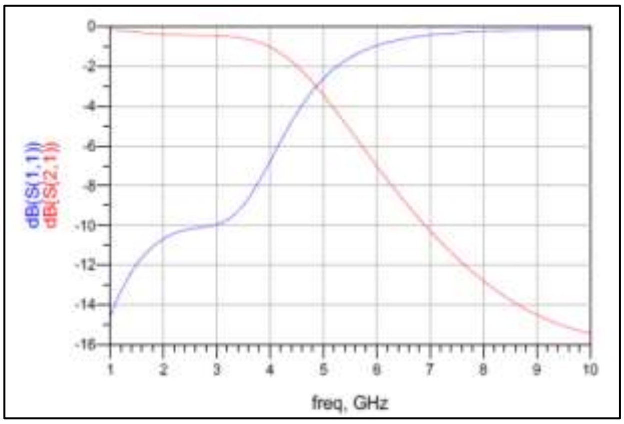

Fig. 4: Simulation response of filter with alumina

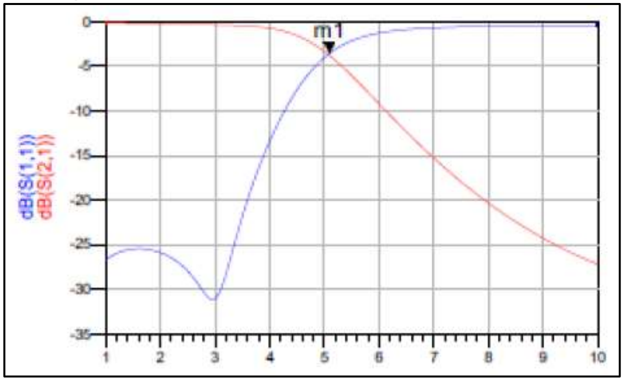

Fig. 5: Simulation response of filter for FR4

Shilpi Gupta, et.al. In this paper describes the designing of a compact stepped impedance low pass filter, which is designed to optimize at center frequency of 5 GHz and operating between 4.5 GHz to 5.5 GHz range of frequencies using Advanced Design System simulation tool. Rogers RT Duroid 6010 with dielectric constant 10.2 is used. This proposed method is highly effective for C frequency band.

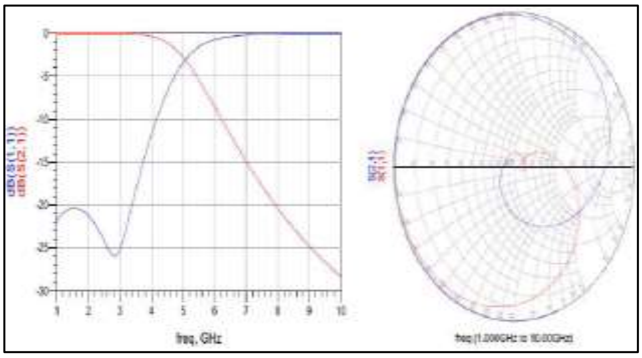

Fig. 6: Schematic layout of modified compact filter

In this paper microstrip lines are arranged in such a way that the size of filter is effectively reduced by using an empirical expression [4].

Akinwande Jubril, et.al. Designed a 3 pole 2GHz Butterworth microstrip low pass filter and fabricated based on the Open-circuited stub microstrip realization technique. The filter is designed using the FR4 substrate and is simulated using the ADS EM simulation tool. A comparison of the fabricated Open-circuited stub filter’s performance with the ADS simulation showed a marginal average deviation of less than 5%.

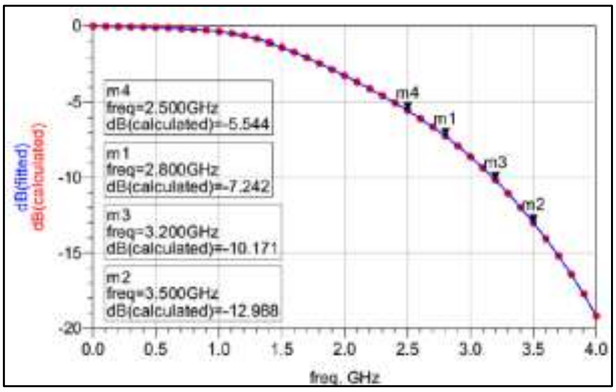

Fig. 7: EM Simulation of 2GHz Butterworth LPF

At the cut-off frequency of 2GHz, the Open circuited stub filter produced an insertion loss of -3.009dB, while the stop-band characteristics exhibited an attenuation of -19.359dB at the stop-band frequency of 4GHz and a peak attenuation up to -35dB at 4.5GHz [5].

Prachi Tyagi, using micro strip layout designed a third order low pass filter for low cost and low insertion loss for. S-band application at 2.2 GHz for permittivity 4.4 value with a substrate thickness 0.6 mm. it is simulated by using 3D full wave electromagnetic simulator IE3D. Photolitho-graphic process is used for fabrication and after fabrication final testing had done by using the spectrum analyzer [6].

Shraddha A. Jadhav et.al. In this paper designed Butterworth and Chebyshev microstrip low pass filters of order five for PTFE substrate using stepped impedance method for 2GHz cut off frequency.

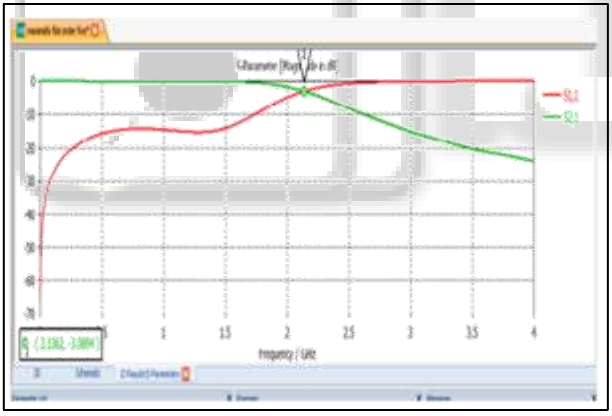

Fig. 8: Simulation of Butterworth LPF.

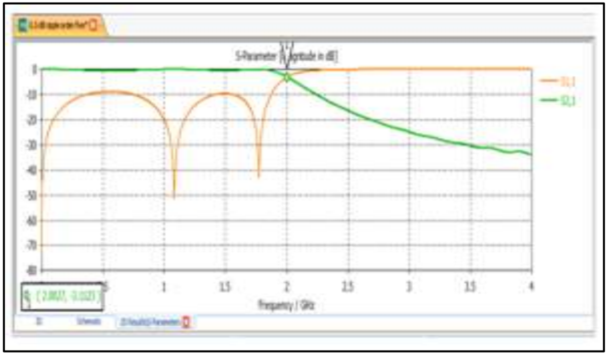

Fig. 9: Simulated result of stepped impedance chebyshev (0. 5dB ripple) low pass filter.

The numerical results are validated using CST microwave studio simulator [7].

Niharika Singh Verma and Pankaj Singh Tomar describes the design of low cost and low insertion loss microstrip stepped impedance Fractal low pass filter (LPF) by using microstrip layout which works at 0.4 GHz for permittivity 4.7 value with a substrate thickness 1.6 mm with pass band ripple 0.1dB. Microstrip technology is used for simplicity and ease of fabrication.

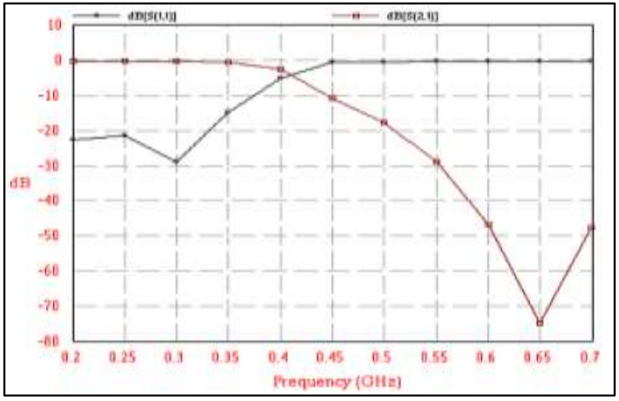

Fig. 10:.Simulation result of Fractal LPF

The design and simulation are performed using 3D full wave electromagnetic simulator IE3D [8].

Mohsen Hayati et.al. In this paper, presented an ultra-wide stopband with high attenuation in the stopband region, within very small circuit area is achieved for the proposed filter using novel asymmetric structures for resonator and suppressor. . The size of filter corresponds to compact electrical size of 0.156 λg × 0.128 λg, where λg is the guided wavelength that 2.92 GHz. Also, the maximum variation of the group delay in 80 percent of the passband region is only about 0.2 ns. The transmission zeros of the resonators can be adjusted as a function of high impedance and low impedance microstrip lines, and due to the asymmetric structure, the proposed suppressing cell can be located within the resonator structure without occupying a large area. For verification, a 2.92 GHz LPF is designed and fabricated.

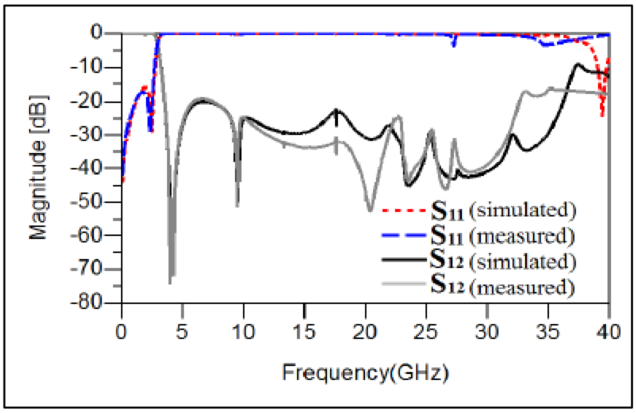

Fig. 11: Simulated and measured S parameters of fabricated filter.

The experimental results, in comparison with the other LPFs, show that the proposed LPF has significant advantages in the stopband characteristics with acceptable sharp roll off. The measured passband insertion loss is below 0.1 dB, and the rejection band over –20 dB is obtained from 3.42 GHz to 36.2 GHz [9].

Sheetal.Mitra, D.K. Kumuda, describes the design and fabrication of S-band low pass filter by using microstrip layout operating at 2.5 GHz for permittivity 4.1 with a substrate thickness 1.6 mm for order n=6. Microstrip technology is used because of its simplicity and ease of fabrication. The design and simulation of lowpass filter are performed using AWR microwave office software. Finally, it was tested using vector network analyzer.

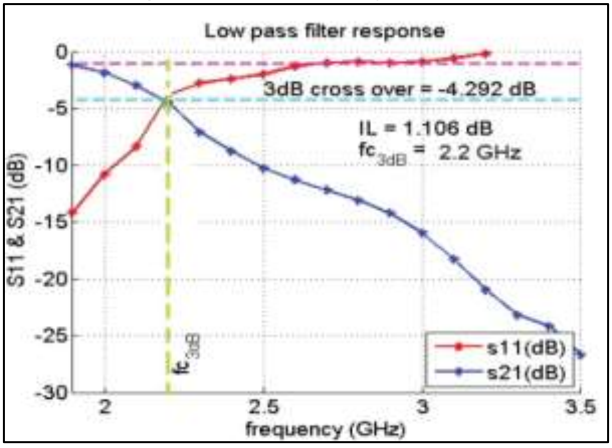

Fig. 12: Measured response of filter

The practical simulation and measured results have been a fairly good agreement together [10].

Singh, Pravesh Singh, in this paper designed a lowpass filter by using the stepped impedance method. This paper presents a low insertion loss and the low cost design S-lowpass filter(LPF) with the use of microstrip layout having the center frequency at 2.5GHz with the permittivity of value 4.4 and the height/thickness of the substrate is 1.27mm for the order n=6. The use of microstrip provides the advantages of simplicity and ease of fabrication.

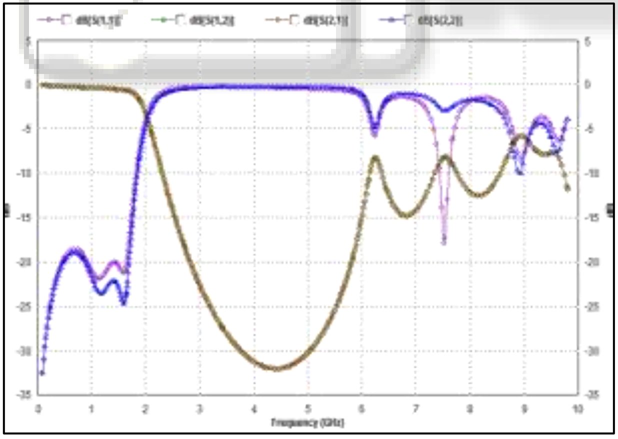

Fig. 13: Simulation result of filter at 2.5GHz

The design and simulation are performed by using the 3D full wave electromagnetic simulator IE3D [11].

Phani kumar, et.al. In this paper describes designing of Butterworth approximated stepped impedance low pass filter at 1.2 GHz with microstrip line implementation. Designed filter is simulated.

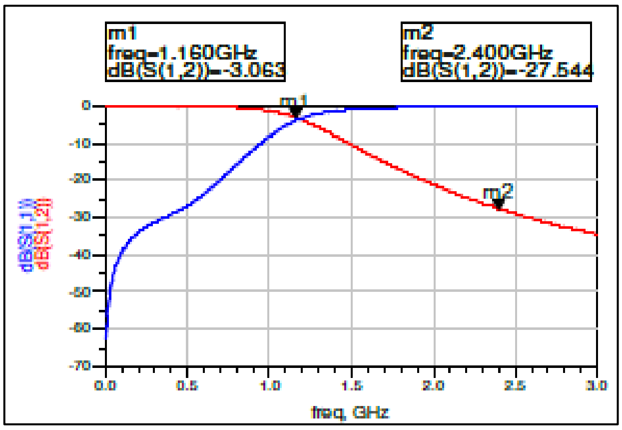

Fig.14: Simulated S parameter of filter

Using Advanced Design System (ADS) software and is fabricated with photolithographic technique. The designed microwave component is tested with Rhode & Schwartz Network Analyzer and practical results are agreed with simulated one [12].

Omid Borazjani and Arman Rezaee designed a low pass microwave filter by step impedance method in which the alternative part of high and low characteristic impedance are used. Varying every high or low impedance characteristics such as length or width desired characteristics can be obtained, simulated using HFSS software.

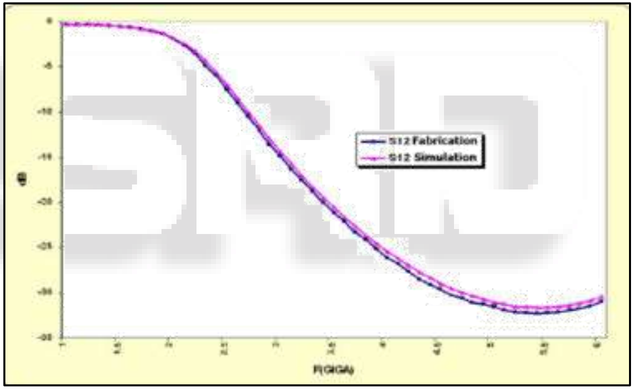

Fig. 15: Comparison of built filter and simulation

Complexity of this filter rather than other filters. Results of practical measure and simulation have been a fairly good agreement together [13].

Shubhankar Paul, A. Barapatre designed a filter without rectangular photonic band gap (PGB) and with rectangular photonic band gap (PGB).

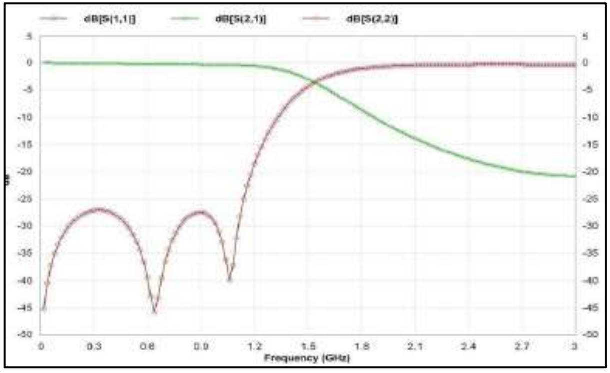

Fig. 16: Simulated performance of stepped impedance, L-C Ladder type without rectangular photonic band gap (PBG) LPF.

The development of the Micro strip low pass filters are simulated by using IE3D simulator software [14].

Garvansh et.al. Designed different order stepped impedance low pass microstrip line filter using IE3D software at 5GHz frequency and implemented on FR/4 substrate using conventional fabrication process. Design and analysis of the stepped impedance microstrip low pass filter has been described using moment's method commercial software tool [15].

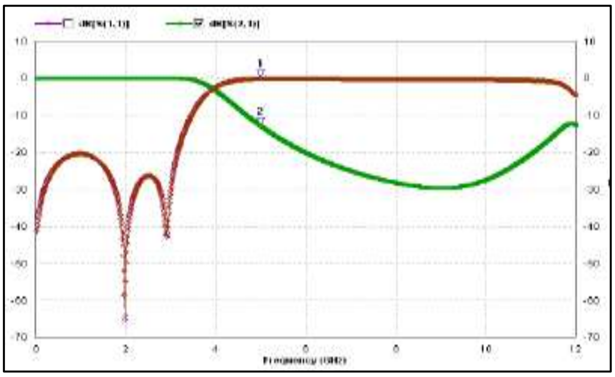

Fig. 17: EM Simulated Performance for fifth order filter

Garvansh, et.al in this paper, designed a simple seventh order stepped-impedance microstrip line low pass filter by method of moments, using FR4 material with dielectric constant 3.7 at 5GHz frequency.

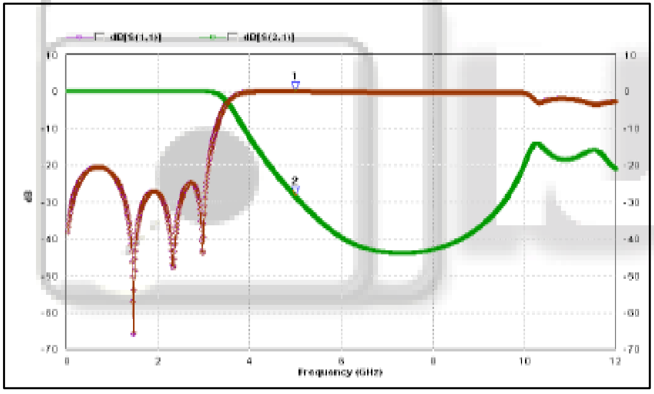

Fig. 18: EM Simulated Performance of filter

The analytic result obtained through IE3D software and thoroughly discussed [16].

Aarti Solanki, et.al. In this paper designed a microstrip low pass filter for L-band Application i.e. for L-band (1-2GHz). Microstrip Filter is designed from the methods of Step impedance low pass prototype filter, basic property of microstrip filter like simulated design, return loss, amplitude frequency graph and smith chart discussed.

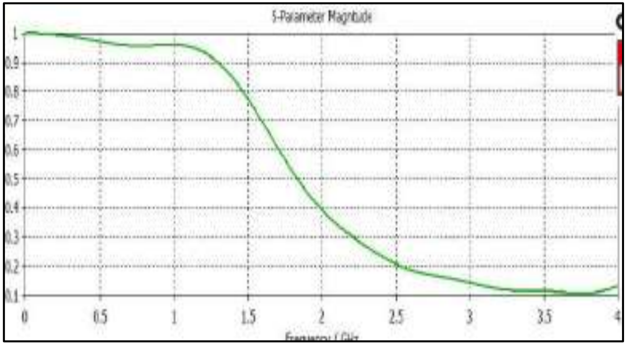

Fig. 19: S-Parameter Magnitude vs. frequency

A -3dB return loss is shown at the frequency of 1.584GHz and this frequency come in the L-band [17].

Surabhi Patankar, Devendra Kumar presents stepped impedance low pass filter based on defected ground structure (DGS) cells and implemented on FR/4 substrate of relative permittivity is 4.3. By tuning its dimensions cutoff frequency could be changed. Design and analysis of the stepped impedance microstrip low pass filter has been described using CST software tool.

In this paper, 5th order stepped impedance low pass microstrip line filter have been designed at 1.4 GHz frequency [18].

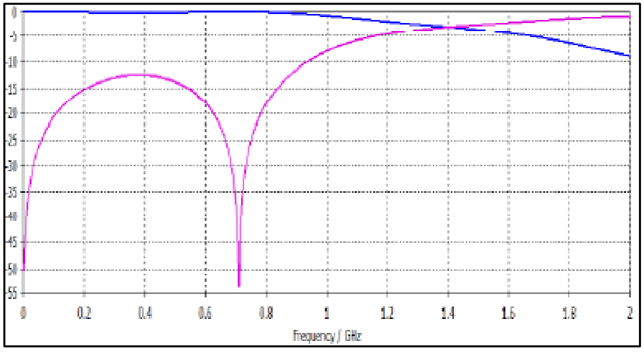

Fig. 20: Simulated result of stepped impedance 5th order low pass filter with DGS

Vishakha Dayal Shrivastava, et.al in This paper describes designing of Chebyshev approximated stepped impedance low pass filter at 2.4 GHz with the permittivity of value 4.2 and the height/thickness of the substrate is 1.6mm for the order n=3.

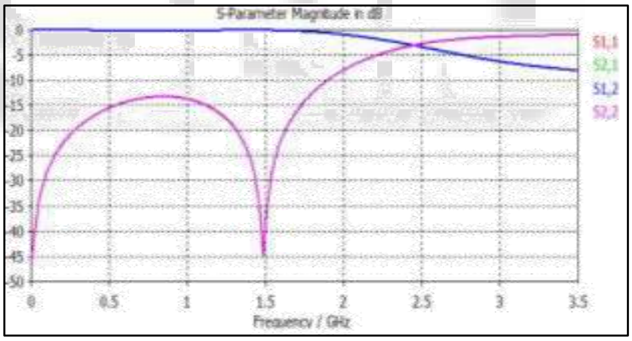

Fig. 21: CST performance of LPF

Designed filter is simulated using Computer Simulation Technology [19].

Deep K Chauhan and Falguni Raval, designed an order 3 Chebyshev microstrip low pass filter with a 1 dB pass band ripple on a duroid substrate using step impedance method for 1GHz cut-off frequency using Ansoft Designer and Ansys HFSS [20].

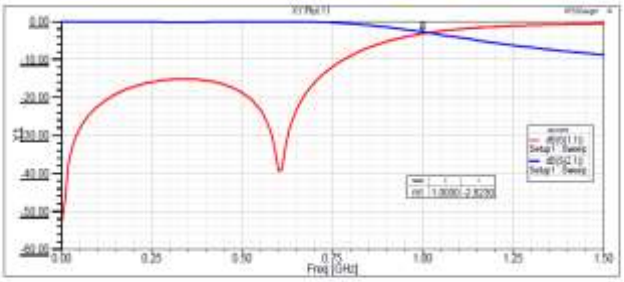

Fig. 22: simulated result of ANSOFT HFSS for microstrip low pass filter

Inder Pal Singh, Praveen Bhatt presented two simple designs, Chebyshev 3-pole microstrip stepped-impedance lowpass filter in L-band (1 GHz) and folded arm microstrip lowpass filter which is widely being implemented in GPS systems, mobile phones and defence telemetry. By altering the stub size and its position frequency is tuned. The two filters are implemented, designed for 1 GHz cut-off frequency at 3dB with a passband ripples less than 0.1dB and it shows sharp stopband 1 GHz to 4.9 GHz. Effective permittivity of the substrate is 10.8 and height 1.27 mm. The filter is miniaturized by folding its inductive arm at 900 and its dimensions are optimized. Area of folded arm lowpass filter is reduced by 27.9% with respect to the traditional stepped impedance lowpass filter.

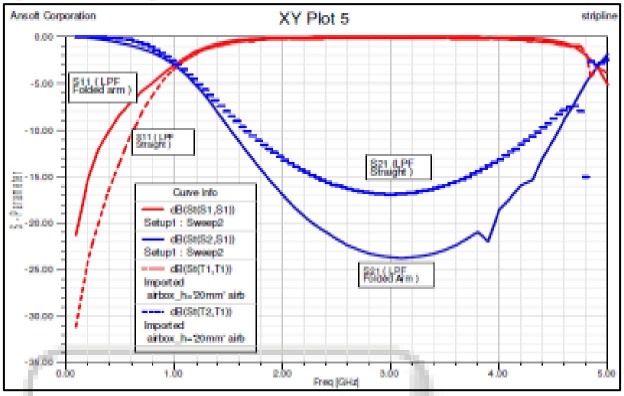

Fig. 23: Comparison of simulated S-parameter response of open-stub lowpass filter and folded arm lowpass filter

These LPF filters are designed and simulated on Ansoft-HFSS platform. Satisfactory results are obtained comparing the theoretical and simulation results [21].

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