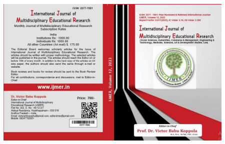


Cover Page

DOI: http://ijmer.in.doi./2023/12.05.45
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:5(3), May: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd May 2023
Publication Date:1st June 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

DESIGN & SIMULATION OF C BAND PLANAR MICROWAVE FILTER FOR WIRELESS APPLICATION

[1]Dhara Vithalapara and [2]Prof. Narendrasinh Gohil
[1]PG Student of Engineering, 2nd Year, 4th Semester and [2]Assistant Professor in Electronics & Communication Department
1&2 Shantilal Shah Engineering College Bhavnagar Gujarat Technological University
Ahmedabad, Gujarat, India

ABSTRACT

Filters play a significant role in microwave components and Microstrip filters are a vital component of microwave systems. This study introduces a simple technique for designing a Microstrip bandpass filter for RF/microwave applications in the C band. The proposed filter has a center frequency in the C band, is lightweight, and is small in size. The study determines various measures like S-parameters and bandwidth and presents the optimized performance of the filter. Furthermore, the CST software demonstrates filter optimization, design, simulation, and results. In this paper, we presented an analysis and simulation of a microwave hairpin filter. This hairpin filter is designed to operate at a frequency of 6.65 GHz with a bandwidth of 2.36 GHz and a return loss of –less than -20 dB. This frequency is presented for microwave C-band. The (4-8GHz) band is used by various radar, surface radar, and some communications satellites and is ideal for some wireless applications Future research will focus on improving the parameters of the filter.

Keywords: Microwave Hairpin Filter, C-Band, Communication. Planar Microwave Filter, Microstrip Patch.

INTRODUCTION

Bandpass filters are a crucial element of signal processing and communication systems, including superheterodyne receivers that are utilized in various RF/Microwave communication systems. As the frequency increases, transmission lines replace discrete components, and low-power microstrip technology is utilized for a more affordable and compact Band Pass Filter solution. This article outlines the design of a microwave C-band Bandpass filter via microstrip technology, utilizing different techniques, including a fifth-order Chebyshev hairpin filter design[1].

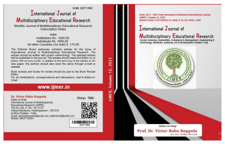
BASIC THEORY

Out of various bandpass microstrip filters, the Hairpin filter is the most commonly used. The concept of designing a hairpin filter is the same as that of parallel coupled half-wavelength resonator filters[2]. The advantage of a hairpin filter over end-coupled and parallel coupled microstrip is it takes up low space. In this filter, space is saved by folding the resonator which is half a wavelength long. Also, the design of this filter is simple than the other microwave filters

Figure A.1 5-pole hairpin filter

Filter Parameter

The performance of a filter can be evaluated based on several parameters, such as the S-parameter, return loss, insertion loss, and VSWR. The S-parameter is a crucial concept in microwave design because it can be easily measured and works well at high frequencies. Return loss refers to the power loss that occurs when power is reflected from the source due to a transmission barrier or an unmatching combination. Insertion loss, on the other hand, refers to the power loss that occurs when some power is transferred to the load due to a component combination. Both return loss and insertion loss can be measured in decibels. VSWR, a comparison between the maximum voltage amplitude towards the standing wave minimum voltage amplitude, is another important parameter in filter



evaluation. Lastly, bandwidth is the difference between upper and lower frequencies on a combination when the amplitude response is 3dB under the bandpass response.

Hairpin Bandpass Filters

A neatly arranged structure characterizes Hairpin-Line bandpass filters. This type of filter implements the resonator folds from parallel-coupled, half-wavelength resonator filters, resulting in a "U" shape design resembling that of a parallel-coupled and half-wavelength resonator. To minimize coupling between resonators, it is crucial to estimate the reduction from the length of a coupled line. Additionally, by carefully considering both arms of the Hairpin resonators, they can function as a set of coupled lines that positively impact coupling. The configuration of the Hairpin BPF is outlined in Figure A above.

Defected Ground Structure (DGS)

There is another form of the DGS unit section. So far, DGS geometries are known to include simple shapes such as rectangular dumbbells, circular dumbbells, spirals, U-shaped, V-shaped, H-shaped, cross-shaped, concentric rings, and so on. DGS agrees to place a notch at almost any location. This will disturb the circulation of shield current in the ground plane, and this disturbance will change the characteristics of a transmission line such as line capacitance and inductance[3].

DGS form is modified from a simple slot to a much more complex one. A lot of patterns/forms can be cast at the ground plane which later can be used as the DGS unit. The casted pattern will distract the distribution flow and change the antenna impedance. This kind of distraction can change the character of microstrip transmission because the DGS unit can be represented by using the equivalent circuit of capacitance and inductance (LC) DGS is a pattern sketched on the ground plane. The structure of DGS is usually used at the filter combination in a microstrip line which will reject a particular frequency or bandgap. The DGS method is done to change the nature of the waves by making one or more patterns at the ground plane[1]. DGS is one of the EBG (Electromagnetic Bandgap) ways to suppress the surface wave which is often used at the microstrip antenna. The DGS structure has been used at the microstrip line which rejects particular frequency (Khandelwal et al., 2017; Zulkifi et al., 2010)[4]. DGS will suppress the surface wave by omitting (Petchsawang & Duchon, 2009) some parts of the ground plane (Weng et al., 2008; Zulkifi et al., 2010). The purpose of designing BPF by adding DGS can minimize the filter size and omit the harmonics as well as increase the return loss value from the filter (Breed, 2008)[5].

Chevbyshav Response

Chebyshev filters are analog or digital filters taking a steeper roll-off than Butterworth filters and take passband ripple. Chebyshev filters have the property that they minimize the error between the ideal and the actual filter representative over the range of the filter but with ripples in the passband[6]. This type of filter is named Chebyshev because its mathematical characteristics are derived from Chebyshev polynomials[7]

Applications

Different applications of the Microwave filters are Long-range tracking, weather observation, weapon location, increased weather effect in light/medium

LITERARY REVIEW

Jagdish Shivhare and S.B.Jain Explained multiple hairpin filters for the 1400 MHz communication system. This paper presents the design, simulation, optimization, and test results of a new class of 4-pole multiple hairpin line microstrip resonator filters [8]. This design features a smaller size and moderate selectivity compared to conventional hairpin-line resonator filters for L/S-band communication systems. Cheng-Yuan Kung explained a compact dual-band bandpass filter designed to operate at 2.4/5.2 GHz without input/output impedance matching. The design is more compact than conventional hairpin filters. The simulation was performed using IE3D[3].

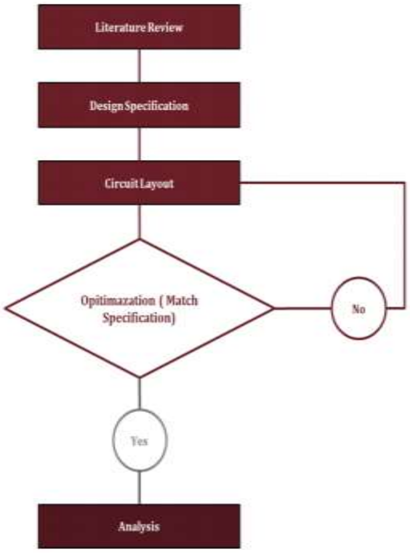
The design of a microstrip hairpin bandpass filter was explained by K. Vidhya and T. Jayanthi using a defected ground (DGS) structure and open stubs. Their design consisted of a 5-pole Chebyshev hairpin BPF which was created by incorporating a dumbbell-shaped DGS and open stubs. To minimize the effects of spurious frequencies, two pairs of DGS structures were etched under the input and output feed lines of the proposed filter. ADS software was utilized in the filter's creation. The authors also introduced a novel technique aimed at eliminating harmonics[9]. Homayoon Oraizi gives the design of a microstrip hairpin filter providing harmonic suppression and impedance matching between source and load impedances. In this paper a multilayer structure is proposed for effective suppression of spurious response[10]. A. A. Suleiman, M. F. Ain1, S. I. S. Hassan and team Explained Design of Hairpin Band Pass

Filters for K-Band Application. Filters are operated at the K-Band frequency segment of 20 – 20.3 GHz[11].

METHODOLOGY

Methodology/Materials

Designing the hairpin microstrip BPF is done by adding the DGS which operates at the center frequency of 3 GHz. DGS is one of the developing techniques from EBG to suppress the surface wave which is often used at the microstrip antenna. The resonator model used in this filter is the 1-element square groove. The square groove form of the DGS technique produces a smaller filter dimension and can omit the harmonic distortion and increase the value of return loss (Breed, 2008) [3]. The research stages refer to Fig. A.1



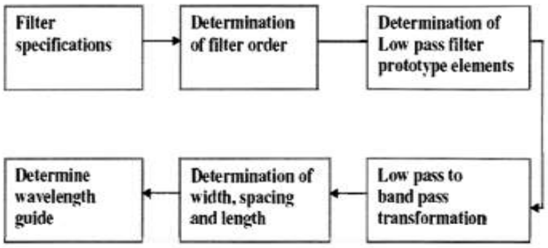


Figure 4 Steps of calculation

Figure 0.1 Design Steps

DESIGN METHODOLOGY

The mutual coupling coefficient between two resonators Mi,i+1, and quality factor at the input and output Qe1 and Qen are the design parameters for the hairpin filter. The Couplingcoefficient and Quality Factor can be calculated as

$$t = \left(\frac{2L}{\pi}\right) * \sin^{-1}\left(\frac{\pi}{2Q_e}\frac{Z_0}{Z_{r_0}}\right)$$

…… [1]

The calculation of the Quality factor and mutual coupling between the resonators [14].

$$Q_{e1} = \frac{g_0 g_1}{FBW}$$

…… [2]

$$Q_{en} = \frac{g_n g_{n+1}}{FBW}$$

…… [3]

$$M_{i,i+1} = \frac{FBW}{\sqrt{g_i g_{i+1}}}$$

……[4]

For i=1 to n-1

Table 0-1 Filter Specifications

BPF Parameters	Value
requency start (f1)	.5 GHz
requency stop (f2)	.8 GHz
requency center (fc)	.65 GHz
andwidth	.36 GHz
eturn loss	-20 dB
nsertion loss	-3 dB
SWR	.62
ilter Order	
requency Response	hebyshev

The hairpin BPF design is embodied by the microstrip line. Substrate Rogers 4350B is used for the microstrip line with the specification shown in Table 3.

Table 0-2 Substrate Specifications

Substrate	Rogers 4350
ielectric effective constant (εr)	.48
hickness (h)	.524 mm
oss tangent dielectric (δ)	.004

RESULTS

Simulation

According to the result acquired from the parameter calculation, the next stage is a simulation that will be using the Computer Simulation Technology 2019 (CST) version with the result shown in Fig. A.1. The response of the proposed filter for Rogers theta is in Fig. A.2 as shown in fig. proposed filter gave a center frequency of 6.65 GHz. The response of the proposed filter for Rogers RT4350 is in Figure A.1 as shown in the figure proposed filter gave a center frequency of 6.65 GHz. Spurious modes which do appear due to in-homogeneities of the microstrip [7, 8] are not shown here.

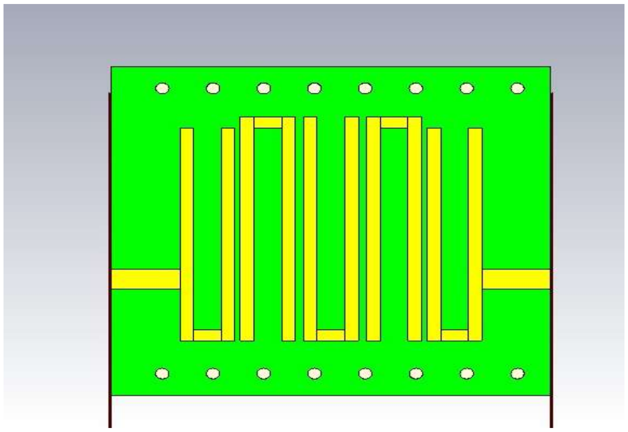
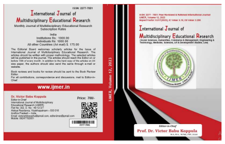


Figure 0.1 Proposed Hairpin filter

Table 0-1 Parameters (mm)

Y4	Y3	CH	Y1	Y5	SH	X11
4.3	6.55	0.035	19.4	1	1.524	3.7



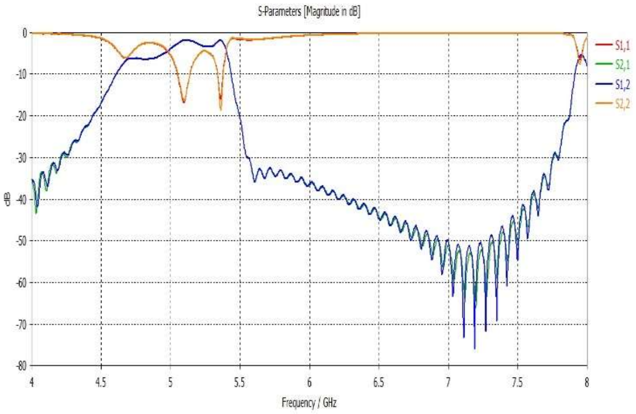


Figure 0.2 S11 and S12 graph

CONCLUSION

The layout of the final hairpin bandpass filter designed with all the determined dimensions is illustrated. In this project, a Chebyshev microwave hairpin filter with a cutoff frequency of 6.65 GHz was designed and fabricated. All the given parameters will be used to determine the hairpin configuration. After the calculation, simulation software will be used to determine and observe the characteristic of the design hairpin filter that meets the parameters. All the processes are recorded and included in the research paper

References

1. R. Levy, R. V. Snyder, and G. Matthaei, "Design of microwave filters," IEEE Trans. Microwave Theory Tech., vol. 50, no. 3, pp. 783–793, Mar. 2002, doi: 10.1109/22.989962.
2. M. F. B. Fauzi, "DESIGN OF MM-WAVE HAIRPIN FILTER".
3. N. Ismail, T. Surya Gunawan, S. Kartika S, T. Praludi, and E. A.Z. Hamidi, "Design of microstrip hairpin bandpass filter for 2.9 GHz – 3.1 GHz s-band radar with defected ground structure," Mal. J. Fund. Appl. Sci., vol. 14, no. 4, pp. 448–455, Jan. 2019, doi: 10.11113/mjfas.v14n4.1073.
4. M. Hamidkhani and F. Mohajeri, "DUAL-BAND COMPLEMENTARY SPLIT-RING RESONATOR (CSRR) WITH HIGH-QUALITY FACTOR AND ITS APPLICATIONS IN LOW PHASE NOISE OSCILLATORS AND SMALL MULTI-BAND DIPLEXERS AND FILTERS," PIER M, vol. 52, pp. 33–44, 2016, doi: 10.2528/PIERM16082503.
5. R. V. Snyder, G. Macchiarella, S. Bastioli, and C. Tomassoni, "Emerging Trends in Techniques and Technology as Applied to Filter Design," IEEE J. Microw., vol. 1, no. 1, pp. 317–344, Jan. 2021, doi: 10.1109/JMW.2020.3028643.
6. K. Mahendran, Dr. R. Gayathri, and H. Sudarsan, "Design of multi band triangular microstrip patch antenna with triangular split ring resonator for S band, C band and X band applications," Microprocessors and Microsystems, vol. 80, p. 103400, Feb. 2021, doi: 10.1016/j.micpro.2020.103400.
7. L. Tang, X. Jiang, H. Wei, and W. Liu, "A NOVEL MINIATURIZED C-BAND BANDPASS FILTER," PIER M, vol. 106, pp. 167–177, 2021, doi: 10.2528/PIERM21092103.
8. H. Oraizi and N. Azadi-Tinat, "Optimum Design of Novel UWB Multilayer Microstrip Hairpin Filters with Harmonic Suppression and Impedance Matching," International Journal of Antennas and Propagation, vol. 2012, pp. 1–7, 2012, doi: 10.1155/2012/762790.
9. A. Bage and S. Das, "A FREQUENCY RECONFIGURABLE DUAL POLE DUAL BAND BANDPASS FILTER FOR X-BAND APPLICATIONS," PIER Letters, vol. 66, pp. 53–58, 2017, doi: 10.2528/PIERL17010504.
10. S. Pandey and P. V. A. Professor, "International Journal on Recent and Innovation Trends in Computing and Communication Review of Reconfigurable Microstrip Patch antenna for Wireless Application", [Online]. Available: http://www.ijritcc.org
11. X.-H. Luo, X. Cheng, J.-A. Han, L. Zhang, F. Chen, and X. Deng, "A Design of Miniaturized C Band Filter Based on Tai-chi Resonators," 2019 International Conference on Microwave and Millimeter Wave Technology (ICMMT), 2019, doi: 10.1109/icmmt45702.2019.8992320.