International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 7 ǁ July 2023 ǁ PP. 223-228

Design of 9-10 GHz Microstrip Bandpass filter for Radar Applications

Nyalapatla Chandu
*[*1] M.E. student,*
Department of Electronics and communication Engineering,
Unversity college of Engineering, OU,
chandunyalapatla@gmail.com

Dr. Sandhya Rachamalla,
*[*2] Associate professor,*
Department of Electronics and communication Engineering,
Unversity college of Engineering, OU.

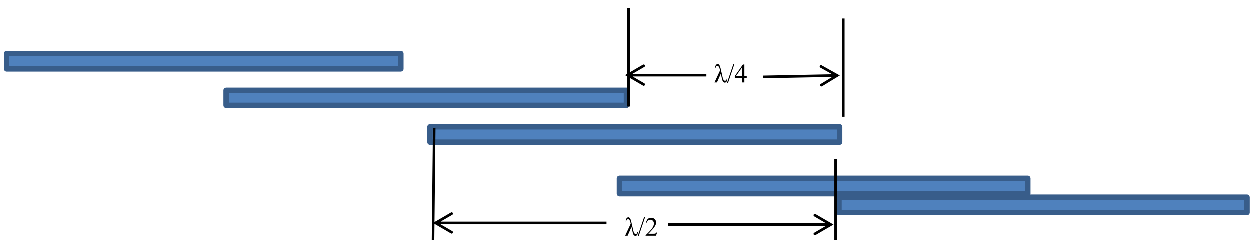
Abstract
An electronic component which is used to get desired band signal is filter. A filter allows the wanted frequencies as passband and removes unwanted frequencies. The Band pass filter (BPF) is one such type of filter which allows certain band of frequencies and reject all other frequencies. Radar, works at X band frequencies, has rapid development in Military, Civil and Navigational applications. To improve the Radar performance, the main component is filter. This paper discusses about the design of 9.5GHz Band pass filter with wide bandwidth i.e., 1 GHz by using Microstrip Hairpin Technology. In microstrip hairpin technology, the substrate used is Roggers RT Duroid 5880 substrate with thickness of 0.254mm (10 mil) and dielectric constant of 2.2. This technology filter is designed in ADS software. After the simulation, the parameters like insertion loss, return loss and VSWR are discussed.
Keywords: *microstrip hairpin technology, filters, X band frequencies.*

Date of Submission: 07-07-2023 Date of acceptance: 19-07-2023

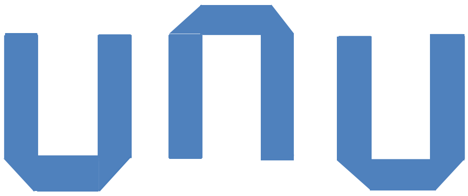
I. INTRODUCTION

Radar, which is used for broad applications in familiar and commercial purpose majorly works in X Band frequencies i.e., 8 -12 GHz. This frequency is highly preferable for naval radar, airborne weather avoidance radar, airborne Doppler navigation radar and police speed radar. Moreover, X-band is also applied in marine radar, coastal surveillance radar, and weather radar [1]. For these applications, Radar needs to perform accurately which require precise filters.

Any filter needs to performance well by rejecting all unwanted frequencies and allowing only wanted signal. The filter has different types mainly Low pass filter, High pass filter, Band pass filter and Band rejection filter. Among all other filters, band pass filter is using for many applications. The band pass filter works as allowing the certain band of signal and rejects all other signals. These band pass filters are designed by variety techniques, each with their own benefits and drawbacks. The techniques are interdigital, edge-coupled, parallel coupled, and hairpin [1]. Comparatively, hairpins are smaller to design. BPF for radar can be designed using microstrip hairpin technology. The size can be decreased by bending the parallel coupled resonators into U shaped resonators



(a)



(b)

Figure 1: transformation of coupled lines into U shaped resonators

1.1 Literature review

In paper [1], Basith Adli et al designed the Hairpin filters by folding half-wavelength microstrip lines into the "U" shape and then cascaded them. The folded structure has the advantages of parallel-coupled filters and effectively reduce the size. Each half-wavelength microstrip line works as a resonator. The hairpin method involves the development of a parallel-coupled line.

In paper [2], Gaurav Chaitanya describes that the resonators transformation from parallel coupled line structure into U shaped shape and tapped line. The advantages of using the substrate roggers RT Duroid substrate are also discussed. In this paper, it is suggested that by varying the length and width of resonators, the frequency can be changed.

In paper [3], T Hariyadi et al, suggested that the resonators' width decide the desired frequency and DGS technique. DGS technique is used to supress the undesired frequency by changing the ground plane surface.

The book [4] by David Pozar describes the resonator's spacing and design of microstrip hairpin filters.

1.1.1 Filter specifications

The BPF is designed with the microstrip hairpin technology i.e., U shaped resonators. These resonators are made with the copper. This filter is constructed with the 3 layers namely ground plane, substrate which is madeup of Roggers RT Duroid 5880 and top most layer is copper resonators. The U-shaped resonators act as the inductor and gap between each resonator act as the capacitor. These inductance and capacitance built the band pass filter. Some specifications to design this filter are shown in table 1.

Table 1: Filter design specifications

Start frequency (f_L)	9000 MHz
Stop frequency (f_H)	10000 MHz
Center frequency (f_C)	9500 MHz
Bandwidth	1000 MHz
Filter hairpin order	7
Return loss	≤-10 dB
Insertion loss	≥-3 dB
VSWR	1-1.5
Matching impedance	50 Ω
Frequency response	chebyshev

1.1.2 Filter parameters

To design the microstrip hairpin bandpass filter, the parameters are need to be calculated. The order of the filter depends on the ripple, rejection level, start, stop & center frequencies. The spacing between resonators is derived using the Chebyshev filter technique [4]. The width of the resonator channel is calculated by the substrate parameters which is shown in table 2 and all other parameters are calculated, which are mentioned in table 3 as per paper [1].

Table 2: substrate parameters

Substrate name	RT Roggers Duroid
Substrate thickness	0.254mm
Dielectric constant (ε_r)	2.2

Table 3: design parameters

Resonator tapped width, W_t	0.27mm
Resonator tapped length, L_t	5.15mm
Resonator length, L_1	4mm
Resonator length, L_2	4.6mm
Resonator width, W_r	0.7mm
Total Resonator width, W_t	2.8mm
Spacing S_1	0.21mm
Spacing S_2	0.28mm
Spacing S_3	0.3mm

1.2 THE SIMULATION

As per the parameters, the bandpass filter is designed in the ADS software. The design model is shown as Figure 2. After the design, the fabricated bandpass microstrip filter is shown as figure3.

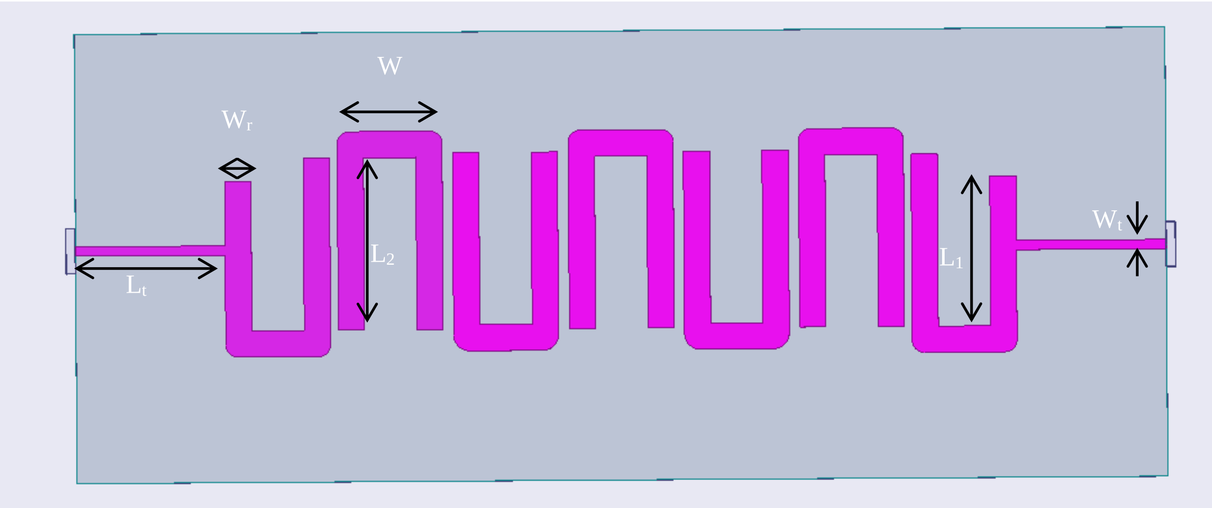


Figure 2: Design model of microstrip band pass filter

Figure 3: Fabricated microstrip band pass filter

1.3 RESULT AND DISCUSSION

The results of the filter after the simulation in ADS software as shown in figure 4. The reflection coefficient is above -15 dB over the frequency range of 9- 10 GHz with the bandwidth of 1 GHz. This bandwidth is formed due to the decreasing the width of the resonator strips. The transmission coefficient (S21) is -2 dB over the range of 9 – 10 GHz with the rejection of above -75 dB at 1.5 GHz away from the passband frequency. By increasing the order of the filter, the rejection becomes high. The frequency can be varied by both the resonator height and the radius or width of the resonator. It is observed that by decreasing the resonator height and radius of resonators, the bandpass frequency of the filter moves to higher frequencies and vice versa. The insertion loss of the pass band depends upon the spacing between the resonators. The VSWR of the simulation results is varied between 1.14 to 1.3.

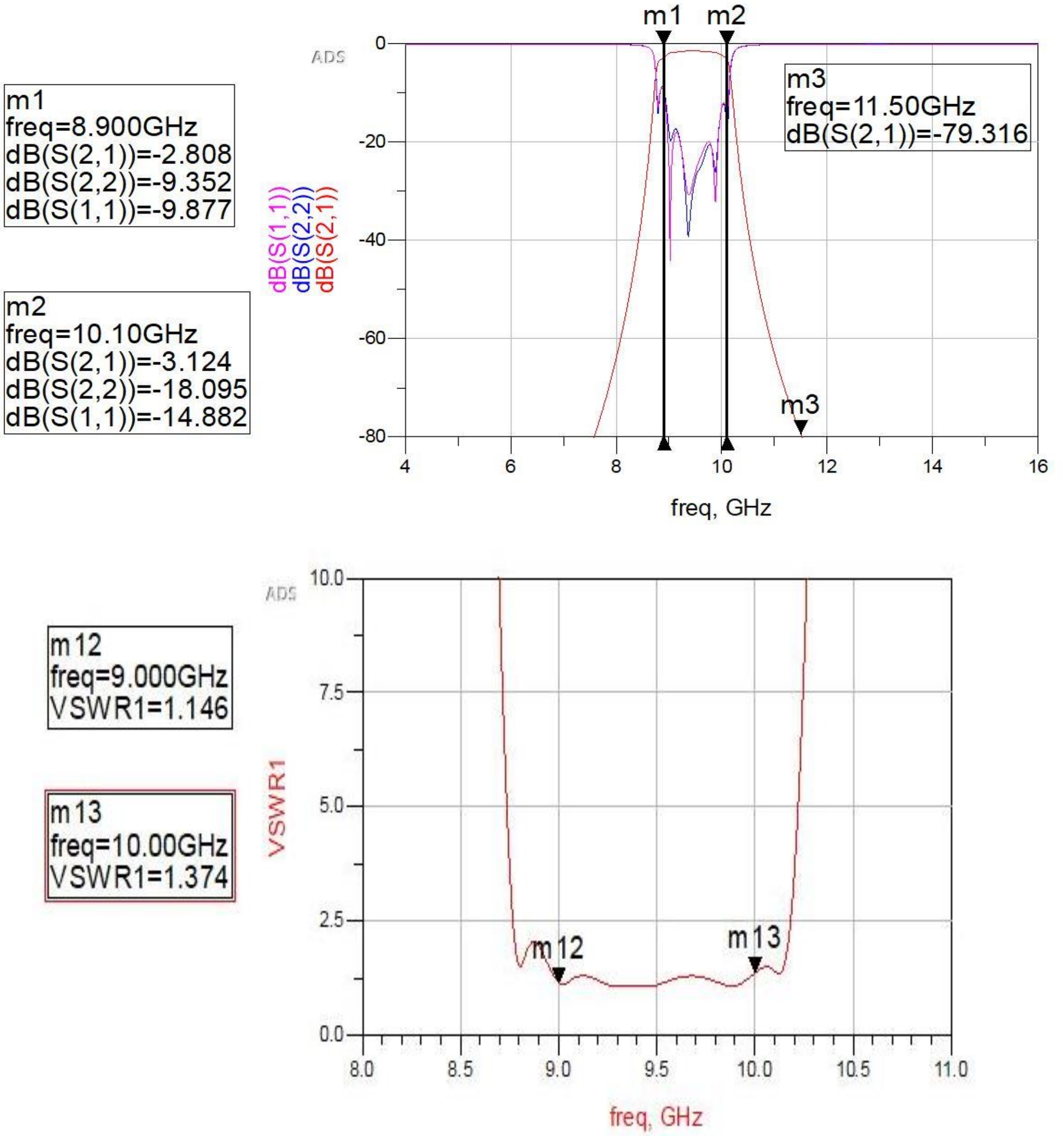
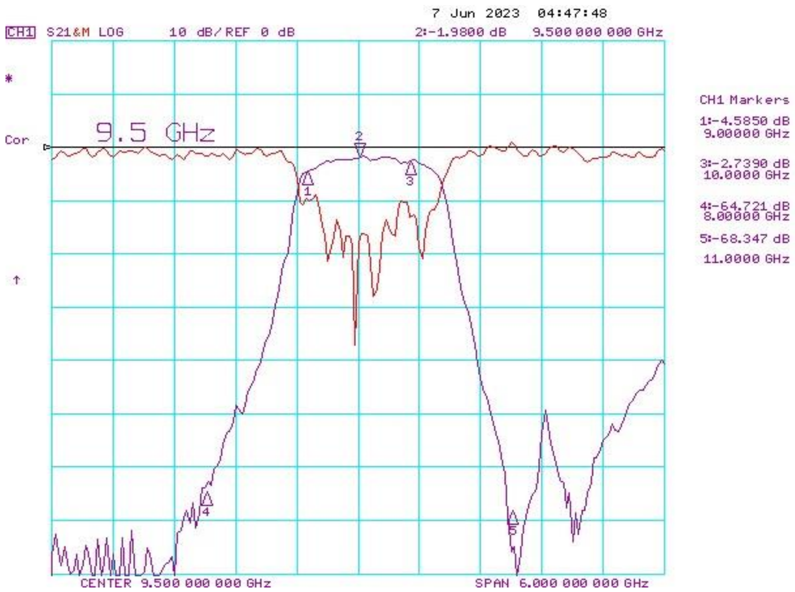
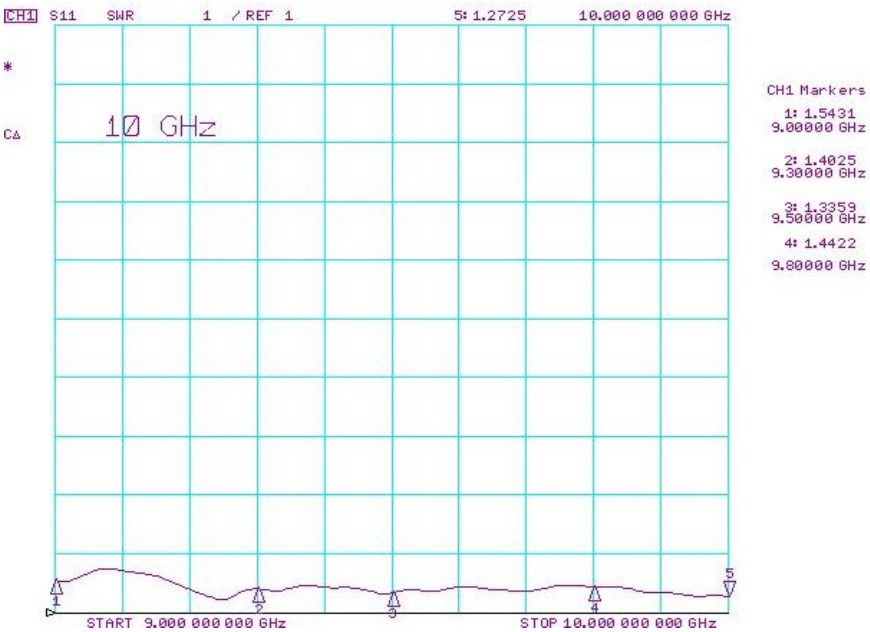


Figure 4: Simulation results of 9-10 GHz microstrip band pass filter. (a) S parameters, (b) VSWR

After the simulation is done in ADS software, the designed bandpass filter is fabricated. The fabrication results are verified in the Network analyser. Figure 5 shows the results of the fabricated microstrip bandpass filter. The simulation and actual filter results are approximately same. The insertion loss at the centre frequency is -2dB and at the total bandwidth is 1dB ripple. The reflection coefficient is below -10dB. The rejection of the unwanted band of frequency is approximately below 70dB which is verified 1 GHz away from the pass band frequency. The VSWR is between 1.2 -1.5



5(a) S parameters



5(b) VSWR

Figure 5: Fabrication results of 9-10 GHz microstrip band pass filter

II. CONCLUSION

It was observed that the band pass filter is designed at the centre frequency of 9.5 GHz with wide bandwidth i.e., 1 GHz. Some of the parameters that need to be tuned according to the requirement of the filter. To increase the bandwidth, the width of the resonator has to decrease. The rejection point depends upon the length of the resonators. The band pass frequency is shifting according to the total width of resonator. These are changes that are done to design this filter. The comparison of fabrication results and simulation results are discussed.

REFERENCES

[1]. Basith Adli, Rina Mardiati, " Design of Microstrip Hairpin Bandpass Filter for X-Band Radar Navigation"2018 IEEE 978-1-5386-6163-5/18/$31.00

[2]. Gaurav Chaitanya, "Design and analysis of Hairpin Microstrip band pass filter" 2015 International journal of innovative research in Electrical, Electronics, Instrumentation and control Engineering, DOI10.17148/IJIREEICE.2015.3512.

[3]. T Hariyadi et al, " Design and Simulation of Microstrip Hairpin Bandpass Filter with Open Stub and Defected Ground Structure (DGS) at X-Band Frequency" 2017, IOP Conference Series: Materials Science and Engineering, Volume 306, 2nd International Conference on Innovation in Engineering and Vocational Education25–26 October 2017, Manado, Indonesia.

[4]. David Pozar, " Microwave Engineering, 4th Edition" 2011.