CPW Triple Passband Filter using the Split-Modes of Stub Square Loop Resonators

Akshay Gupta
Subharti University Meerut

Amit Kumar
Subharti University Meerut

Kanika Goel
Subharti University Meerut

ABSTRACT
This paper presents a novel coplanar waveguide (CPW) dual pass band and triple pass band filter using the split-modes of the loaded stub square loop resonators. With the CPW feeding line, two micro strip stub resonators built on the rear sides are used to suppress resonance. We have designed our filter on the FR4 substrate (permittivity = 4.4 and loss tangent=0.02) with 20x50mm square and thickness 0f 1mm only. The modes splitting characteristics of the proposed structure are analyzed. A triple pass band filter covering center frequencies of 21.5 GHz, 26.7 GHz and 33.1 GHz or (K band range) is designed to verify the validity of the methodology. Good agreement for simulated results.

Keywords
Band-notched UWB antennas, coplanar waveguide (CPW) fed antennas, planar antennas, printed circuit board antennas, slot antennas, (UWB) antennas, triple pass band filter

1. INTRODUCTION
Now in wireless communication systems, filter with multiple passband have become one of the essential elements .For the initial investigations, dual passband filter is analysed more.

Another dual mode dual passband filter has been realized by using a stacked structure [5, 6]. Due to their configuration, these kinds of filters are not easy to fabricated. In this paper, a novel CPW dual passband and triple pass band filter is designed by using the split-modes of the stub square loop resonators. By loading stub in the proposed CPW square loop resonator, two degenerated modes could be simultaneously excited and they are split to produce two resonance frequencies. And then when two CPW square loop resonators are putting together with proper coupling, a dual passband filter would be achieved. Besides, in order to broaden the stopband and to design triple passband filter for high range of frequency(K band) by involving same structure in opposite side of the first square loop resonator and in this way we designed triple passband filter from this dual passband concept. Two micro strip stubs resonators are used. They are built on the rear side of the CPW structure. The characteristics of the proposed loaded stub CPW square loop resonator are analyzed.

The EM simulated results are offered to demonstrate the characteristics of the proposed triple passband filter covering center frequencies of 21.5 GHz, 26.7 GHz and 33.1 GHz.

2. FILTER DESIGN
2.1 CPW Square Loop Resonator with Loaded Stub
Figure 1 shows the proposed CPW square loop resonator. The structure is consisted of a CPW square loop and a stub. Such loop resonator will resonate if its electrical length is an multiple of the guided wavelength. When a discontinuity is introduced in loop, each resonance degenerates in two distinct modes.

The field solutions for the two degenerate modes of the square loop resonator are given by

$$E_z = \{AJ_n(kr) + BN_n(kr)\}\cos(n\phi)$$
$$H_r = \frac{n}{j\omega\mu_0 r}\{AJ_n(kr) + BN_n(kr)\}\sin(n\phi)$$
$$H_\phi = \frac{k}{j\omega\mu_0}\{AJ'_n(kr) + BN'_n(kr)\}\cos(n\phi)$$

and

$$E_z = \{AJ_n(kr) + BN_n(kr)\}\sin(n\phi)$$
$$H_r = \frac{-n}{j\omega\mu_0 r}\{AJ_n(kr) + BN_n(kr)\}\cos(n\phi)$$
$$H_\phi = \frac{k}{j\omega\mu_0}\{AJ'_n(kr) + BN'_n(kr)\}\sin(n\phi)$$

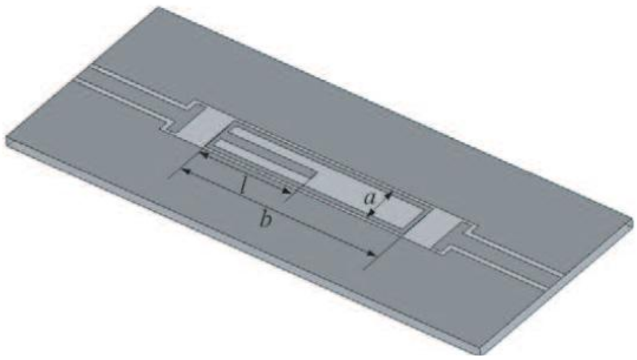

Figure 1 Square Loop Resonator

where A and B are constants, J_n is the Bessel function of order n, N_n is the Neumann function of order n, and k is the wave number. By adding an open loading stub to the square loop, resonance splitting of the degenerate modes would be observed. As the analysis when Á = 0, one of the two degenerate solutions goes to zero, and the phenomenon of resonance splitting would not achieve.When Á = π¼=4, the odd modes will split yet the even modes are not affected. That is due to for odd n both solutions exist and the resonances split, while for even n one of the solutions goes to zero and hence the resonances split do not appear.

Here the parameter of the square loop are *a* = 4mm and *b* = 19 mm. It shows that when *l* = 0 mm, just the same as the situation of *Á* = 0, there is no resonance splitting. When the length *b* of square loop keeps constant, the bandwidth of each passband would be adjusted by varying the length it shows that not enough suppression at the higher frequency of the second passband is achieved. The reason is that it is influenced by the first even mode resonance. For broadening the stopband of the proposed filter and improving the selection of the second passband, two microstrip stubs at the bottom layer with capacitive coupling to the top CPW structure are introduced. With the microstrip stub *lm*=13.0m, *lm* = 0mm, *b* = 9:5 mm, *l* = 6:2 mm, *wm* = 0:5mm a dual passband filter with wider stop band and higher selection would be obtained.

But our aim is not to design the dual pass band filter our aim is to design the triple pass band filter but this dual passband filter design gives us a better idea to do so.

2.2 CPW Triple Pass Band Filter Design

As we got idea from above dual pass band filter we have designed one more resonator on other side to produce the more filtering in different frequency range of K band (20 to 40GHz). This have dimensions same as above but only difference is that now we are using two square loop resonator with same dimension. This triple pass band filter is designed on a substrate with a relative dielectric of 4.4 and a thickness of 1 mm. the input/output impedance of the feeding line is identical to 50- corresponding to the coplanar waveguide which has a central strip width *w* = 1:6mm and a slot width *g* = 0:5 mm. Using the commercial software Ansoft HFSS based on the finite element method, the desired physical dimensions of the proposed filter are determined. After simulation, the final optimized parameters of the filter are as follows: *a* = 3 mm, *b* = 10:5 mm, *l* = 5:8 mm, *s* = 1:6 mm, *s*1 = 0:15 mm, *lm* =13.0 mm, *wm* = 0:6 mm, *w*1 = 0:5 mm, *w*2 = 1 mm, and *w*3 = 0:58 mm. Figure 2 shows the photograph of the designed CPW tripple pass band filter with dimensions of 20x50mm square. Figure 2,3 shows the top, bottom view of proposed filter respectively.

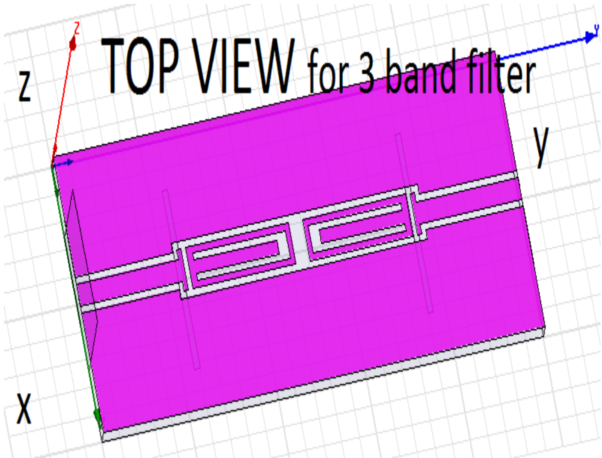

Figure.2 top view of three band pass filter

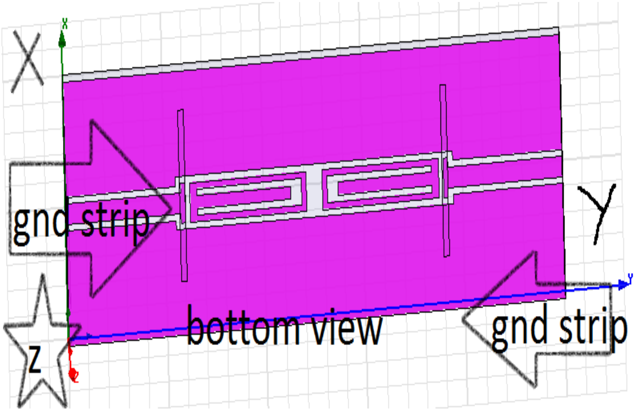

Figure.3 bottom view of three band pass filter

3. SIMULATED RESULTS FOR K BAND TRIPPLE PASS BAND FILTER

3.1 S11 at Center Frequencies of 21.5 GHz, 26.7 GHz and 33.1 GHz

Reflection coefficient S_{11} are shown in figure 11 for first, second and third bands are as follow for all three bands the S_{11} is less than -10 db which shows that our filter is working properly and we will be able to work this project in K BAND range of frequency which is 20GHz to 40 GHz.

1. First band 20.5GHz to 22.5GHz with band gap of 2 GHz.
2. Second band 24.6GHz to 28.8GHz with band gap of 4.2 GHz.
3. Third band 32.2GHz to 34.2GHz with band gap of 2.2 GHz.

First, second and third band have center frequency of 21.5 GHz, 26.7 GHz AND 33.1 GHz, respectively. The reflection coefficient s_{11} for all three bands are given in graph below, here m1, m2, m4, m7 shows the resonance at their center frequencies.$S_{11}$is shown in figure 4.

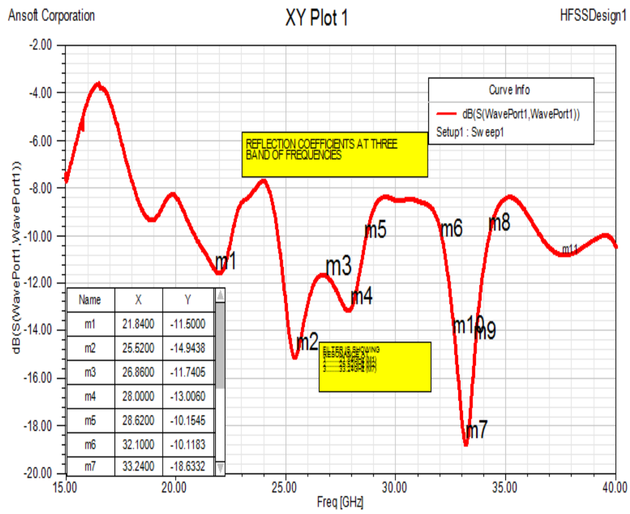

Figure 4 Reflection Coefficients S_{11}

3.2 VSWR at Centered Frequencies of 21.5 GHz, 26.7 GHz and 33.1 GHz

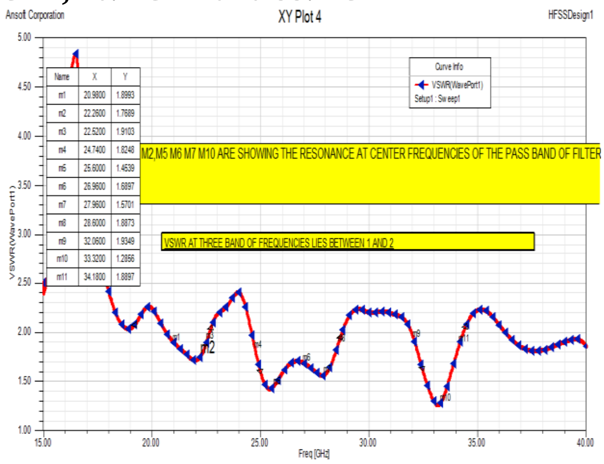

Figure 5 VSWR in all three bands

In above graph 5 VSWR is denoting that better power is transmitting at third band at center frequency of 33.2GHz, but results are not too much better at first and second bands. The values are between 1 and 2 which is better for our filter.

4. CONCLUSION

In this paper, a novel CPW dual passband filter using the split-modes of loaded square loop resonators is modeled in the theory and verified by the experiment. And two microstrip stub resonators are applied to suppress the higher resonance. By simply increasing the width w_m=.6 mm of both the srips and keeping all the parameters as we have used for the dual pass band filter that is a = 3 mm, s = 1:6 mm, $w1$ = 0:5 mm, $w2$ = $w4$ = 1mm and $s1$ = 0:15 mm. When the w_m increases, the center frequencies of the dual pass band slows down smoothly with rarely influence on the bandwidth of each. And finally we can have one more band at the center frequency of the 33.1GHz.But all the center frequencies were changed.

After doing this all the center frequencies are change so we have just gave the way to produce the three band pass filter design. Further we can also use this design but changing the coupling technique means we can use different 2 slow wave structure that shown in figure 4, to produce the different results and better also.

5. IMPROVEMENT

As discussed above this design also can be advanced further for the band rejection around those frequencies which we have notched in our proposed antenna. We can vary the dimensions of stub and ground microstip which produces the sudden variation in the results or S_{11} and vswr also. We have used w_m more than 0.6mm so we found that it may possible that our this filter will notch other band of frequency also which is better one for our filter.

6. ACKNOWLEDGEMENT

The authors would like to thank for this paper to Mr.Tejveer Singh my project guide and Er.Amit Kumar my batch mate from subharti university who guided me a lot for doing so.

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