WIDE BAND DUAL FREQUENCY CIRCULAR SLOT ANTEENA WITH RECTANGULAR STUB AT X AND KU BAND

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Abstract:

The paper presents design and study of the performance of simple circular slot antenna, fed by microstrip line. The dual frequency response having center frequency of 10.58 GHz is observed by using 0.2m.m wide rectangular stub connected with microstrip line. The effect of bandwidth enhancement studies on the return loss performance (-10db) by changing the substrate thickness and substrate material is also being carried out.

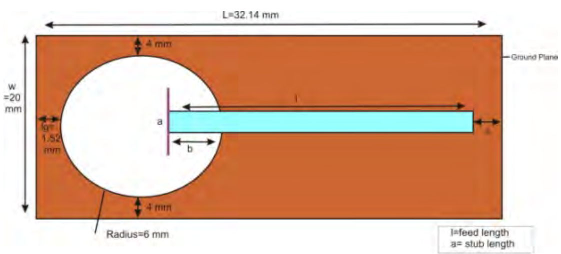
Keywords: Dual frequency antenna , use of stub, circular slot antenna, thickness effect of dielectric substrate, microstrip antenna

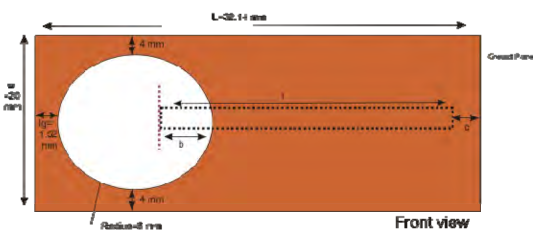
1. Introduction

2. Dual frequency microstrip antenna becoming very popular day by day for its various applications [1-2]. One such application is in MIMO Rader [3-4]. Many methods are used so far for the realization of dual frequency microstrip antenna, like use of different structures in same microstrip antenna using printed circuit technology [5],wide band dual frequency operation can be achieved by L shaped slots [6],or U shaped slots[7], and also dual band operation can be produced by different types of defective ground structure(DGS)[8] ,But here authors have considered the effect of stub, which increase the bandwidth of microstrip antenna by 3 to 4%. Also introduction of stub improves VSWR and return loss of dual frequency antenna. Also authors have repeated the same study with different substrate thickness and with substrate materials like RT/DUROID 5880, 5870 and benzocytobutane.

2. Structure

The structure of circular slot antenna with rectangular stub is shown in fig1(a), where the rectangular substrate having 32.14 mm length and 20 mm width. A microstrip line having an impedance of 50 ohm and having line width of 2 mm isX20 mm with $_r$=2.2,lost tangent=.001 is taken. Antenna is tested for different thickness from 1.58 mm to 1.1 mm. A circular slot of radius 6 mm at ground plane is also taken in one side according to 1(b)





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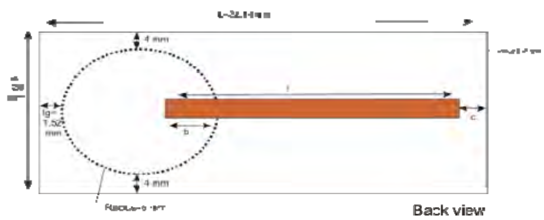

Fig.1(a).(b).(c). Proposed Antenna Structure.

3. Results and discussion

Using method of moment based IE3D simulator the result has been taken with b=1.76 mm c=2 mm. These had been done with and without stub. When a stub is not used the lower resonance frequency shown its high return loss value, where as in the case of higher resonance frequency the return loss is considerably poor performance. Using the stub of variable length the return loss performance in case of higher resonance frequency is considerably improved. The optimum performance is shown in fig 2, where the stub width of .2 mm and length of 5 mm is taken. The optimum length for stub a=6 mm exhibit it fair return Loss performance as shown inTable 1

Table 1. Variation of Bandwidth and Return loss with Stub length

Sub length	f_r(in GHZ)	%B.W	f_1(in GHZ)	f_2(in GHZ)	Return loss in db(f_1)	Return loss in db(f_2)
0 m.m	10.61	39.49	9.46	12.10	-39.54	-13.8
2 m.m	10.62	40.11	9.44	12.12	-34.24	-14.89
4 m.m	10.62	41.52	9.41	12.15	-26.95	-20.20
4.5 m.m	10.62	41.9	9.39	12.16	-25.70	-22.80
5 m.m	10.61	42.22	9.36	12.16	-24.54	-28.41
6 m.m	10.58	42.81	9.31	12.18	-22.7	-28.61

3.1. Bandwidth improvement

The band width improvement is also very significant with respect to the stub length. When the stub is not present the % bandwidth is 39.49%which increases up to 42.81% using the stub effect (given in table 1 and fig 2).

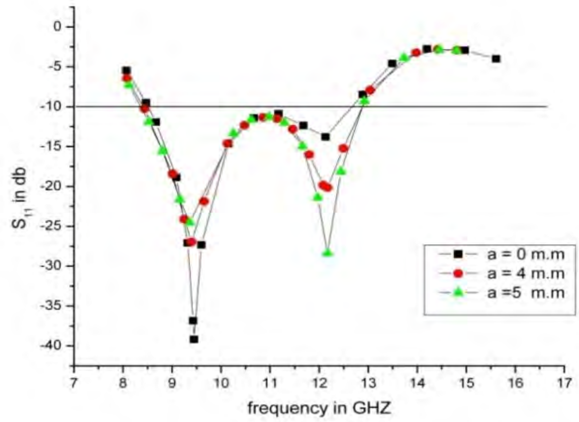

Fig2. Return loss performance for varying stub length at h=1.58 mm.

3.2 Improvement in VSWR

VSWR is nearest to 1 in both the upper resonance frequency as well as lower resonant frequency with the stub. Hence stub is not used. VSWR of upper resonancefrequency is goes up as shown in fig 3.

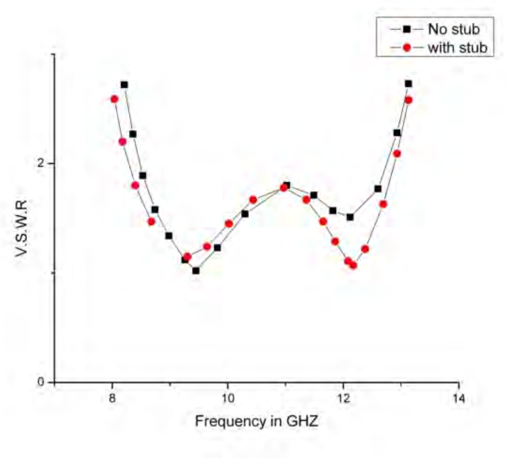

Fig 3: VSWR performance at h=1.58 mm

3.3 Thickness effect

The effect of thickness using the substrate material Roger RT/DUROID 5880 with a dielectric constant of 2.2 is being considered here. The effect can be clearly shown in fig 4. Entire effect as per table 2(a), 2(b) and fig 4 has been carried out for the stub length a=4 mm. The thickness is varied from 1.58 mm to 1 mm. which shows the return loss performance of upper resonant frequency (exit in Ku band) improved continuously, where as the lower resonance frequency (which exist in x band).Return Loss performance is fairly good. However the %bandwidth remains almost same throughout the variation of substrate thickness.

Table 2. Variation of bandwidth with substrate thickness

Thickness in m.m	f_r(in GHZ)	%Bandwidth	f_1(in GHZ)	f_2(in GHZ)
1.58	10.62	41.33	9.49	12.16
1.4	10.8	41.11	9.64	12.37
1.3	10.91	41.18	9.82	12.49
1.2	11.05	40.72	9.98	12.6
1.1	11.51	41.44	10.8	12.88

Table 2(b):Variation of Return loss with substrate thickness

Thickness in m.m	f_1(in GHZ)	f_2(in GHZ)	Return loss in db(f_1)	Return loss in db(f_2)
1.58	9.49	12.16	-24.75	-19
1.4	9.64	12.37	-26	-18.04
1.3	9.82	12.49	-27.1	-18
1.2	9.98	12.6	-32.91	-16.6
1.1	10.8	12.88	-30.93	-50.1

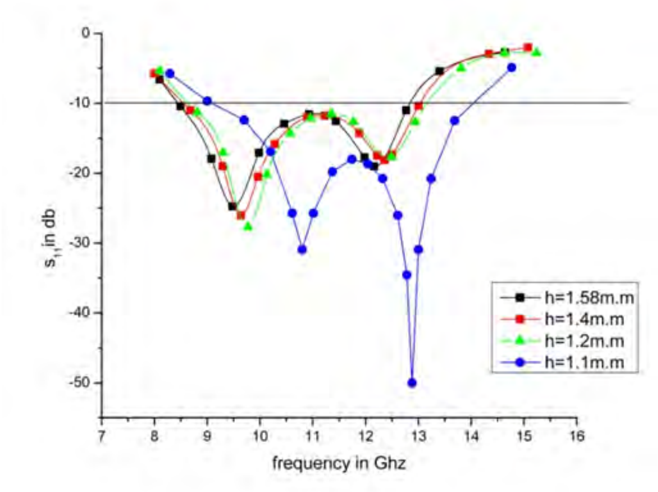

Fig 4: Return Loss performance with respect to thickness effect.

3.4 Effect of substrate material

The return loss performance is analyzed for three different types of available substrate material with constant thickness =1.58 mm. The material is Roger RT/DUROID 5880; Roger 5870 and Benzocyctobuten with ε_r are 2.2, 2.33, 2.4& 2.6 respectively. The Return loss is shown in fig 5. As the dielectric constant of substrate material increases the lower resonant frequency return loss performance is almost similar, whereas for the higher resonant frequency return loss performance degraded.

Table 3: Variation of return loss of Secondary resonance frequency with different dielectric

Type of subtrate Material	r	F_2(in GHZ)	Return loss in db(f_2)
Roger RT/DUROID 5880	2.2	12.18	-25.85
Roger 5870	2.33	11.92	-16.94
Ptfe	2.4	11.8	-16.04
Benzocyctobuten	2.6	11.61	-13.8

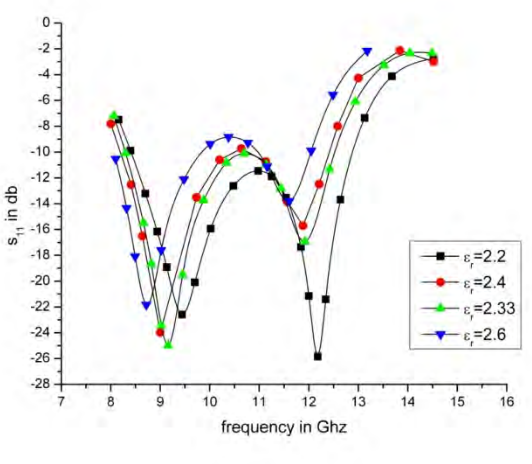

Fig 5 : Return Loss performance for different dielectric.

3.5 Discussion on proposed antenna

According to the above analysis in all respect, the good agreement for the best return loss performance as well as high percentage bandwidth performance , the proposed antenna with thickness h=1.11 mm with ε_r=2.2 and effective stub length a=4 mm.

3.6 Radiation pattern

Fig 6 (a) & (b) shows the radiation pattern characteristic of proposed antenna for both copolar and crosspolar characteristics.

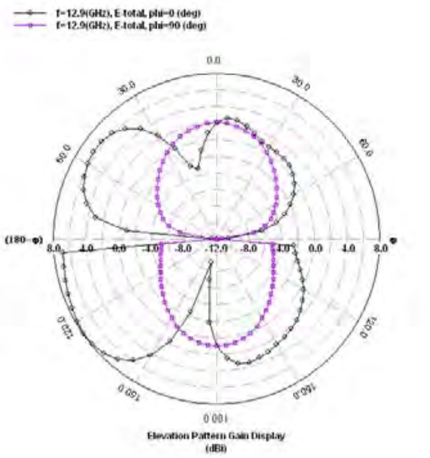

Fig 6(a): Radiation pattern for f_1=10.8 GHZ

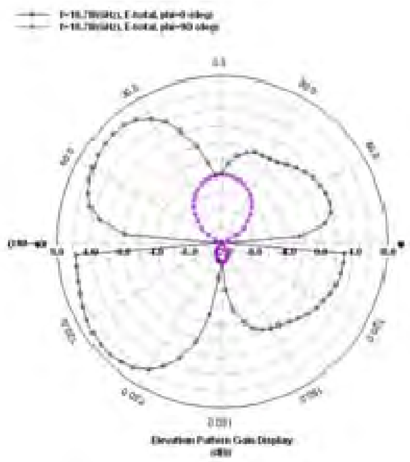

Fig 6 (b): Radiation pattern for f2=12.9 GHZ

3.7 Directive gain

The variation of gain characteristics of proposed antenna is from 3.79dbi to 7 dbi in between 8 GHZ to 14 GHZ is taken.

The stable gain is achieved with the variation of less than 2.54 dbi in between operating bandwidth 8.33 GHZ to 12.86 GHZ as shown in fig7.

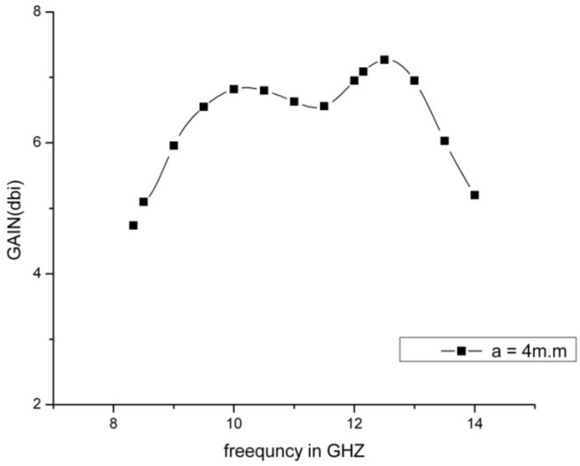

Fig 7: Peak Gain performance of proposed antenna

4. Conclusion

A dielectric analysis with proposed antenna shows that increase of stub length for fixed width improves the bandwidth by about 3 to 4% and return loss of second resonance frequency being increase considerable.

Variation of substrate thickness does not affect the bandwidth so much but improves the return loss for the second resonance frequency.

5. References

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