Journal of Positive School Psychology
2022, Vol. 6, No. 3, 4326 – 4332 http://journalppw.com

Slot Loaded Microstrip Triangular Patch Antenna for dual frequency applications in S band

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Abstract

Tuning of resonant frequency of microstrip patch antenna is an important aspect for practical applications within the application band. A simple dual frequency triangular patch antenna is designed which can be operated in L and S band. The antenna is initially designed for best performance in terms Return Loss values with optimized feed point location. The basic rectangular patch resonating within the band is further modified to triangular patch with insertion of slots, to investigate the shift in resonating frequency. Purpose of designing slot loaded antenna is to tune the antenna for single and/or dual frequency operation when required for various practical applications. Three triangular slots are inserted vertically across the radiating edge within the patch and one rectangular slit placed vertically 1mm distance from center towards another radiating edge.

Keywords— Dual frequency, L,S- band, Slot Loaded, Triangular patch.

INTRODUCTION

Microstrip patch antenna, highly used for communication purpose can provide wider bandwidth applicable in various frequency bands [2], [3], [7]. On the other hand, tuning resonant frequency of patch within the same band or other is an important design aspect [1], [4], [5] in terms of practical applications [6], [8]. In this report, path antenna has been fabricated on a copper clad FR4 substrate with a dielectric constant of 4.8 (ε_r) and substrate thickness of 1.5 mm (h). All the antennas designed in the present investigation are fed with coaxial probe feeding and simulations are carried out using CST microwave studio. Maximum Return Loss and VSWR for best matching with relocation of feed point for various structures at different frequencies has been investigated and results are analyzed. In conclusion, *the measured results indicate that the antenna resonates at two distinct frequencies, one is at 2.484 GHz and another is at 3.956 GHz with good return loss and the VSWR are within reasonable range, between 1.002 to 1.09.*

ANTENNA DESIGN

A simple rectangular microstrip patch antenna is designed using high frequency simulation software CST Microwave Studio which resonates at L and S- band. Dimension of the simple rectangular patch antenna has been put in Table 1 and Fig 2.shows the geometry of the simple patch.

Antenna parameters	**Values in mm**
Length of ground plane	48 mm

(Lg)	
Width of ground plane(Wg)	56 mm
Length of Rectangular Patch (Lp)	28 mm
Width of Rectangular Patch(Wp)	36 mm
Thickness of Substrate	1.5 mm
Dielectric constant of Substrate	4.8

Table1: Dimension of simple rectangular patch antenna

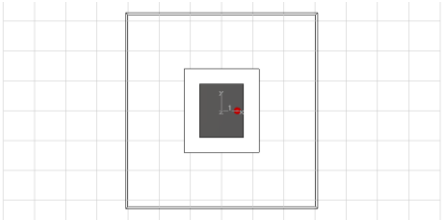


Fig 1: Simple Rectangular Patch Antenna

Feed point selection:

With the dimension summarized in Table1, feed point for best matching in terms of maximum Return Loss, value (S11 parameter) is investigated through repeated simulation. Feed point location from 0mm to 12mm with Return Loss (RL) value with frequency is plotted in Fig 2.

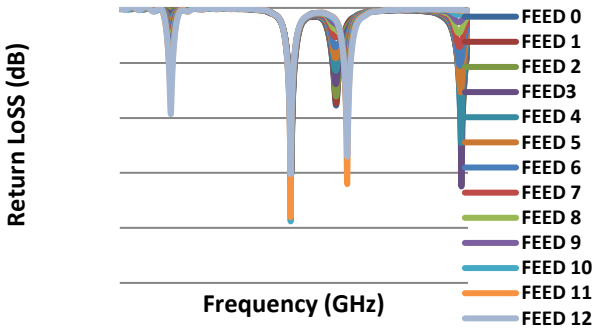


Fig: 2 Frequency (GHz) Vs, Return Loss (dB) of simple Rectangular Patch for different feeding points

From the above graph it has been observed that the RL is maximum (-38.822 dB) at the frequency 2.472 GHz and -32.472 dB at 3.948 GHz for the feeding point 10 mm and 3 mm along the X axis towards the radiating edges respectively. At the feeding point location 3mm, also shows the multi frequency responses within L, S band. For frequencies near 1.436 GHz, RL values below -20dB is observed and for another set of frequencies near 2.96GHz RL just above -30dB is observed. Further investigation is carried out for any shift of these frequencies by shaping the antenna into triangular shape without changing over all geometry of the antenna. Dimension of the modified antenna is summarized in Table2 and Fig 3 shows the geometry of the patch.

Table 2: Specification of Simple Triangular Patch Antenna

Antenna parameters	**Values in mm**
Length of ground plane (Lg)	48 mm
Width of ground plane(Wg)	56 mm
Length of Rectanguar Patch (Lp)	28 mm
Width of Rectanular Patch(Wp)	36 mm
Thickness of Substrate	1.5 mm
Dielectric constant of Substrate	4.8
(Co-Ordinates of the points of the triangle (in mm) of Triangular Patch	(14,18) (14,-18) (-14,0)

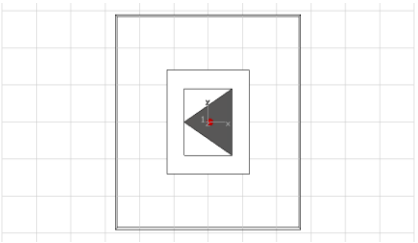


Fig 3: Simple Triangular Patch Antenna

Feed point relocation of the antenna is carried out (0mm to 11mm) with repeated iteration to obtained best matching in terms of maximum RL value (Fig 4) and values are put in Table3

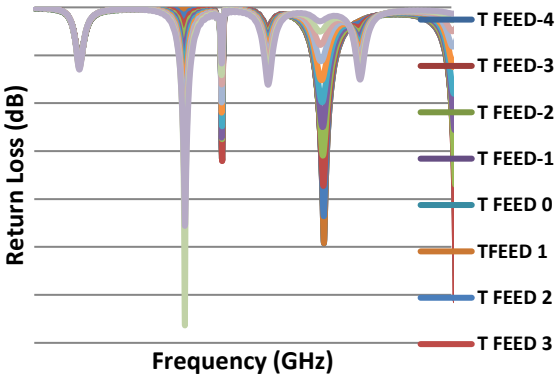


Fig 4: Frequency (GHz) versus Return Loss (dB) of the triangular patch antenna at different feeding points

Table 3: Frequency (GHz) versus RL (dB) of the triangular patch antenna at different feeding point locations.

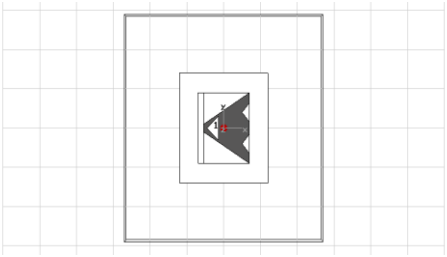
Feed point location (In mm)	Frequency (GHz)	Return Loss(dB)	Frequency (GHz)	Return Loss(dB)
FEED 0	2.352 ***3.084***	-15.904 ***-24.11***	***4.036***	***-22.39***
FEED 1	2.352 ***3.084***	-15.904 ***-24.611***	4.036	-22.391
FEED 2	2.352 3.08	-14.975 -21.639	4.032	-27.890
FEED 3	2.352 3.076	*-16.02* -18.775	***4.032***	***-30.633***
FEED 4	2.348 3.072	-13.375 -15.246	4.028	-18.515
FEED 5	2.348 3.068	-13.489 -12.287	4.02	-12.61
FEED 6	2.352 3.06	-12.48 -9.57	4.012 4.312	-8.794 -15.659
FEED 7	2.08 2.348	-9.94 -10.988	4.004 4.316	-5.96 -18.03
FEED 8	2.08 2.348	-13.722 -9.927	4.004 4.316	-4.09 -18.27
FEED 9	2.08 2.384	-19.777 -8.041	3.334 4.316	-3.63 -16.44
FEED 10	***2.084*** 2.348	***-33.189*** -7.082	3.34 4.312	-6.676 -13.236
FEED 11	2.084 2.348	-22.80 -5.857	3.344 4.3	-10.42 -7.5
FEED - 1	2.352 ***3.084***	-15.904 ***-24.611***	4.036	-22.391
FEED-2	2.352 ***3.084***	-14.975 ***-21.789***	***4.036***	***28.116***
FEED - 3	2.352 3.08	-16.025 -18.640	4.032	-30.634
FEED - 4	2.352 3.072	-13.712 -15.246	4.028	-18.515

From the Table 4 it has been observed that change of RL values with slight shift of resonant frequencies for this modified antenna is observed as highlighted in Table 3.

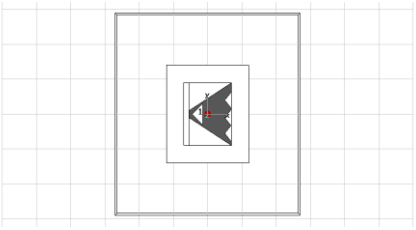
DESIGN OF SLOT LOADED TRIANGULAR PATCH ANTENNA

The simple triangular patch has been modified by introducing triangular slots and rectangular slit on it with simulations using CST microwave studio. The different structures has been shown below for various shape of slots and slit introduced on it for best result with different feeding point (structures 1 to structure 10) and the **structure 8** showed the best result i.e. maximum return loss (- 61.375 dB) at frequency 2.484 GH has been obtained.

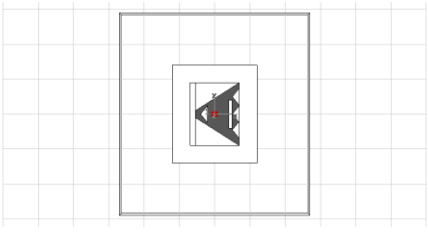
Few of the designed structures are shown below **(triangular antenna with slot and slit) -**



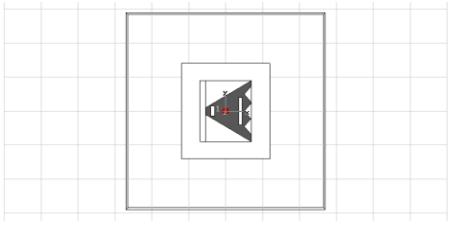
Structure: 1



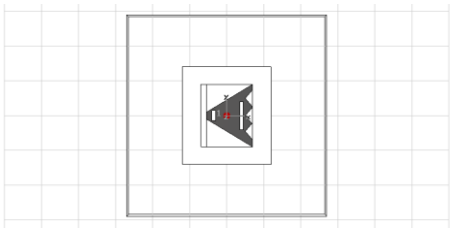
Structure: 2



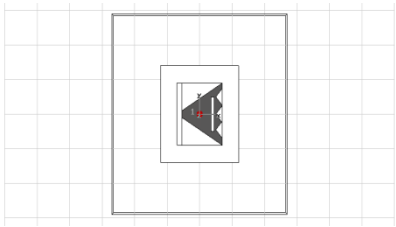
Structure: 3



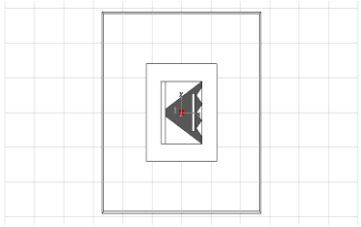
Structure: 4



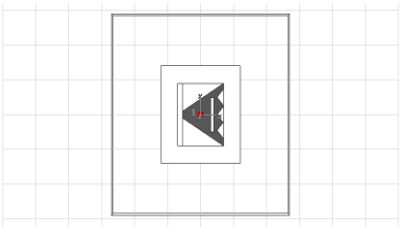
Structure: 5



Structure: 6



Structure: 7



Structure: 8

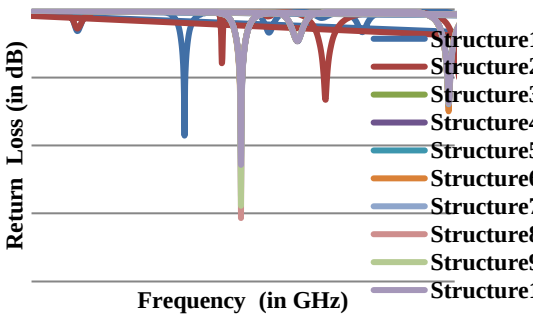


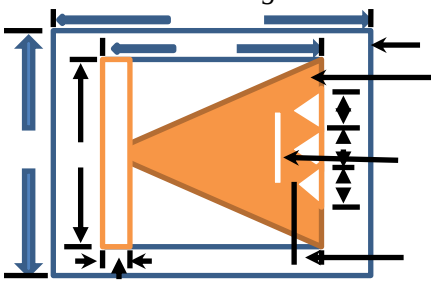
Fig. 5: Frequency (in GHz) Versus Return Loss (in dB) of different structures (1-8)

Table 5: Frequency (GH) Vs. Return Loss (dB) for different Structures

Structures	Frequency (GHz)	Return Loss (dB)	Frequency (GHz)	Return Loss (dB)
Structure 1	2.084 2.348	-37.124 -7.137	4.3	-12.621
Structure 2	2.348	-15.83	3.084 4.028	-26.593 -19.57
Structure 3	2.484	-43.942	3.956	-27.057
Structure 4	2.484	-36.392	3.96	-26.877
Structure 5	2.484	-45.01	3.956	-28.692
Structure 6	2.484	-35.929	3.956	-29.984
Structure 7	2.484	-54.955	3.956	-27.90
Structure 8	***2.484***	***-61.375***	***3.956***	***-27.392***
Structure 9	2.484	-57.777	3.956	-27.441
Structure 10	2.484	-45.729	3.956	-27.381

From the above Table 5, it is has been observed that for the structure 8, maximum RL value of -61.375 dB is found at the frequency 2.484 GHz., and another return loss is -27.392 dB at the higher frequency 3.956 GHz and also it is observed that it gives dual frequency responses. However, for structures 1 and 2 (without slit), antenna behaves as multifrequency antenna.

Geometrical dimension of the structure 8 is shown in Fig 6



To carry on further investigating, structure 8 with maximum RL value and behaving as dual

frequency antenna, feed point relocations in step of 1 mm along the +ve and –ve X axis has been performed and the result are shown below in the Fig 7 and tabulated in Table 6.

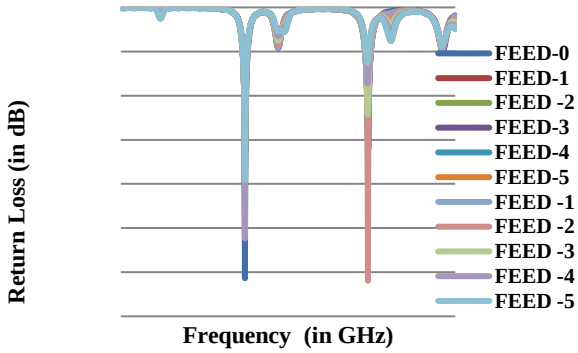


Fig: 7: Frequency (in GHz) vs. Return Loss of different feeding point of the antenna of **structure 8(0 to 5mm, +ve, -ve X-axis)**

Feeding Point Location (in mm)	Frequency 1 (in GHz)	Return Loss (in dB)	Frequency 2 (in GHz)	Return Loss (in dB)
0	***2.484***	***-61.38***	***3.956***	***-27.392***
1	2.484	-42.29	3.956	-30.43
2	***2.848***	***-40.08***	***3.956***	***-39.46***
3	2.848	-38.35	3.951	-23.54
4	2.848	-51.62	3..92	-17.02
-2	***2.484***	***-38.99***	***3.956***	***-61.930***
-3	2.488	-32.78	3.952	-30.55
-4	2.484	-52.33	3.952	-17.227
-5	2.848	39.112	3.948	-12.60

Table 6: Frequency (GH) Vs. Return Loss (dB) for different feed point location

From the above Table, 6 it has been observed that maximum Return Loss (RL) with dual frequency responses are found at frequency 2.484 GHz and 3.956 GHz for the three different individual feeding point locations are at 0 mm, 2mm , and at -2 mm along the X axis for the slot antenna structure 8. Also it is found that the VSWR for these frequencies are around 1. The value of VSWR at different frequencies and for the different feeding point locations are shown in the Table 7.

Table: 7: Frequency (GHz) Vs. Return Loss (dB) with their respective VSWR

Feeding Point Location (in mm)	Frequency1 (GHz)	RL 1 (dB)	VSWR1	Frequency2 (GHz)	RL2 (dB)	VSWR2
-2	**2.484**	**-38.99**	**1.023**	**3.956**	**-61.93**	**1.002**
0	**2.484**	**-61.38**	**1.002**	**3.956**	**-27.392**	**1.09**
2	**2.484**	**-40.08**	**1.02**	**3.956**	**-39.46**	**1.002**

In the above Table 7, each individual feed point location and the Frequency (GHz) Vs. Return Loss (dB) with its respective VSWR for these frequencies are summarized. Plot between frequency vs. RL with its VSWR in each frequency is shown separately in Fig 8, Fig 9, Fig 10, Fig 11, Fig 11,Fig 12 and Fig 13 respectively.

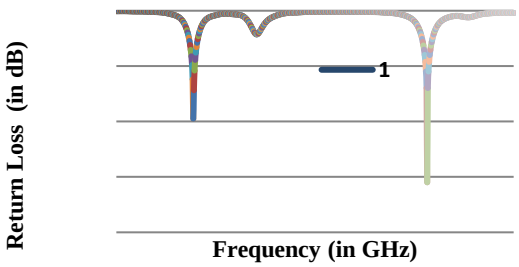


Fig: 8: Frequency (in GHz) vs. Return Loss at feed point -2mm

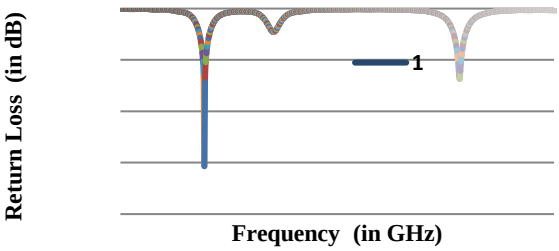


Fig: 9: Frequency (in GHz) vs. Return Loss at feed point 0mm

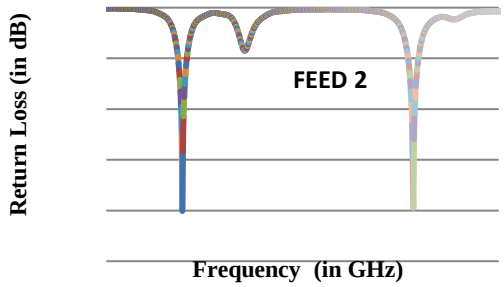


Fig 10: Frequency (in GHz) vs. Return Loss at feed point +2mm

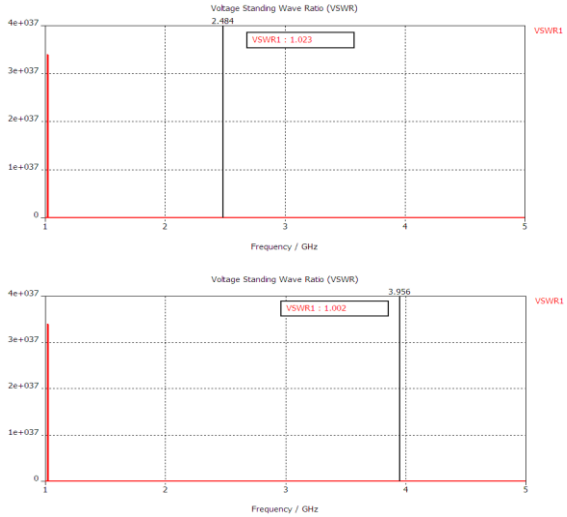


Fig 11: VSWR at frequency 2.484 GHz and 3.956 GHz for feeding point – 2mm along X axis

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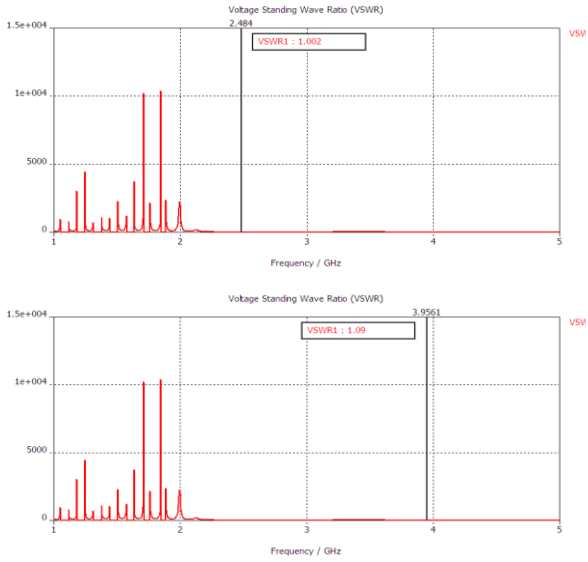

Fig12: VSWR at frequency 2.484 GHz and 3.956 GHz for feeding point at center (0,0)

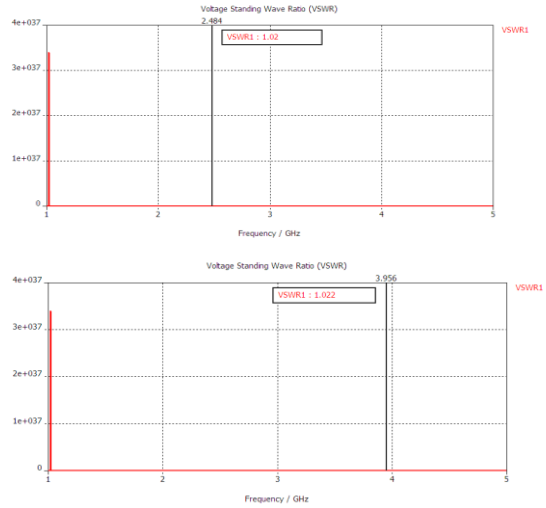

Fig 13: VSWR at frequency 2.484 GHz and 3.956 GHz for feeding point 2mm along X axis

From the investigation carried out, it is found that the proposed antenna responded the dual frequency responses with best Return Loss (RL) and acceptable VSWR at frequencies 2.484 GHz and 3.956 GHz for any one of the feeding point locations at -2 mm, at centre (0,0) and 2 mm along the X axis towards the radiating edge. Required frequency can be selected for applications in L and S band with the optimized feed point location which has been carried out in the work presented. The slot loaded antenna can act as potential candidate for applications in L and S band.

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