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Comparative Analysis of Different Angles of CPW- Fed UWB Rectangular Slot Triangular Patch Antenna

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Abstract: In this paper, a (coplanar waveguide) CPW- fed triangular patch antenna designed at 3GHz frequency with different angles is analysed. The dimension of proposed antenna is 70mmx70mmx 2mm with FR4 substrate having dielectric constant $\epsilon_r = 4.4$. The proposed antenna is designed and simulated through HFSS v 12.1 software and results of different shapes of TPA (Triangular Patch Antenna) are analysed and compared. The different angles of proposed antenna are 60^0-60^0-60^0,45^0-45^0-90^0,30^0-60^0-90^0,30^0-30^0-120^0, 15^0-75^0-90^0,25^0-65^0-90^0 Impedance band width of 12.1GHz (17.9GHz-30GHz) is achieved which covers the frequency range of IEEE K band(18GHz-27GHz) and (Voltage Standing Wave Ratio) VSWR≤ 2 has a wider range in all the proposed design. The proposed antenna design can be used for K band applications, in satellite communication field.

Keywords: TPA, UWB, Micro strip patch antenna, CPW**,** Impedance Bandwidth

I. INTRODUCTION

In the recent year, there is tremendous growth of small and broad bandwidth antennas design in research areas. The main limitation of micro strip antennas of narrow bandwidth has been eliminated through the use of slots in antenna design, as in the proposed antenna design rectangular slot is designed and it has wide range of bandwidth.CPW fed design is an alternative to micro strip and strip line that places both signal and ground currents on the same layer. There is little fringing field in air space, the coplanar waveguide exhibits low dispersion. The main structure of CPW fed design is shown in figure 1

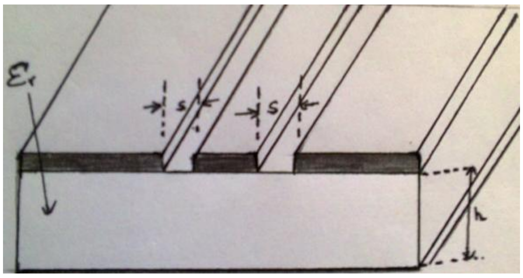

Fig. 1 Basic CPW configuration

This figure shows the basic CPW configuration which shows the ground is above the substrate at certain height 'h' and 'w' is the width of feed line 's' is the feed gap between ground and width line, 'h' is the height of substrate.ε_r is the relative permittivity of material used in substrate.

Mainly patch antennas are flat surfaced antennas and are based on printed circuit technology. There is great advantage in designing such antennas which are compact and yields low manufacturing cost and has higher reliability. Today various shapes of antenna are designed and simulated but the most simulated designs are rectangular, circular and thin strips. [1] Later on there is tremendous growth in antenna technology and now triangular patch shaped antennas are in demand as these antennas has compact shapes and give better performance in broadband antenna design. In this paper various angles of triangular patch antennas are analysed and simulated.

Among the shapes that attracted much attention lately is the triangular shaped patch antenna [2-8] this is due to their small size compared with other shapes like the rectangular and circular patch antennas. As UWB is a short range unlicensed wireless communication system which has a potential to offer a high capacity with low power than the current wireless systems for short range applications. In general, the wideband in CPW-fed slot antenna can be achieved by tuning their impedance value.

Even though large impedance bandwidth could be obtained by using various techniques, but they are quite complicated. In planar slot antennas two parameters affect the impedance bandwidth of the antenna, the slot width and the feed structure. The wider slot gives more bandwidth and the optimum feed structure gives the good impedance matching [9].

The proposed antenna design is compact, small in size and simple design due to less number of design parameters.

In survey of various papers recently several interesting designs of the slot antenna with different geometric configurations for the bandwidth enhancement and the size reduction have been widely studied [10, 11].

In this paper an attempt has been made to enhance the impedance bandwidth with TPA (Triangular Patch Antenna).CPW fed antennas due to attractive features

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draws attention of many industries in wireless communication systems and gives the height of achieving low cost antenna with small and compact sized shapes. This needs accuracy in deciding the various parameters of an antenna like the operating frequency and the minimum return loss vales with higher gain and directivity.

II. PROPOSED ANTENNA DESIGN

The proposed antenna design consists of different shapes of triangular patch antenna Figure 2 shows the dimensions of proposed antenna and these measurements are same for all the six designs only differ in side lengths of different triangles shapes.

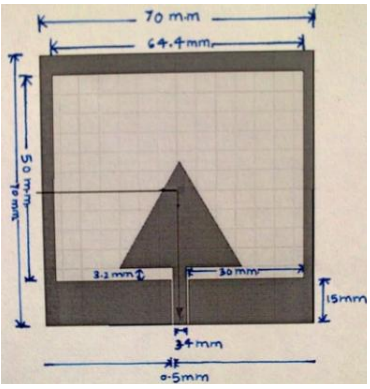
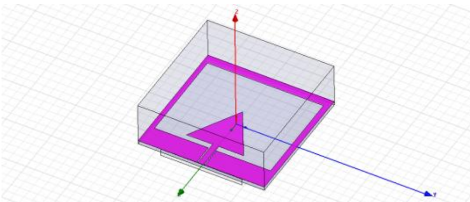
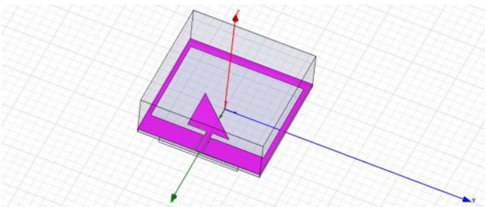


Fig. 2 Proposed antenna design

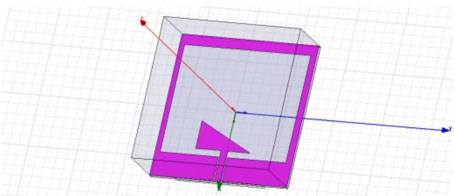
For the proposed antenna dimensions are analysed through above figure, gap between the ground plane and width of CPW feed line is 0.5mm, this length should be taken to be small as possible, width of CPW feed line is 3.4mm.These figures are analysed by simulating at different values but the optimum results are obtained through these dimensions but the results can be improved further in future work. Now the six proposed designs are shown in the following figures with different angles.



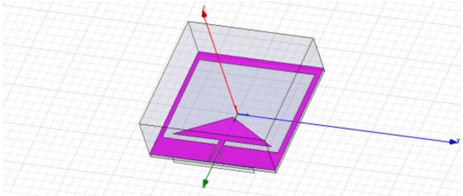
(a)



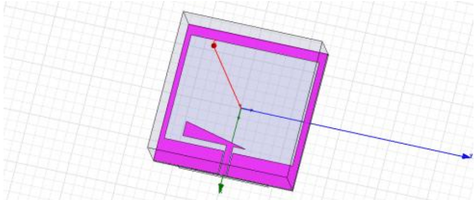
(b)



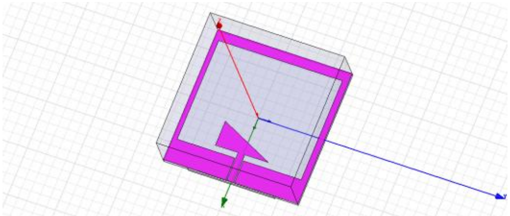
(c)



(d)



(e)



(f)

Fig.3.Proposed antenna designs with different angles (a) 60^0-60^0-60^0 (b) 45^0-45^0-90^0 (c) 30^0-60^0-90^0 (d) 30^0-30^0-120^0 (e) 15^0-75^0-90^0(f) 25^0-65^0-90^0

Using the cavity model and assuming perfect magnetic side walls the side lengths of TPA can be obtained through following equations [12-14]:

For the 60^0-60^0-60^0 TPA:

$$f_{m,n} = \frac{2c}{3a\sqrt{\epsilon_r}}\sqrt{(m^2 + mn + n^2)} \quad (1)$$

For the 45^0-45^0-90^0 TPA:

$$f_{m,n} = \frac{c}{2a\sqrt{\epsilon_r}}\sqrt{(m^2 + n^2)} \quad (2)$$

For the 30^0-60^0-90^0, 15^0-75^0-90^0, 25^0 - 65^0-90^0 TPA:

$$f_{m,n} = \frac{c}{a\sqrt{3\epsilon_r}}\sqrt{(m^2 + mn + n^2)} \quad (3)$$

For the 30^0-30^0-120^0TPA:

$$f_{m,n} = \frac{2c}{a\sqrt{3\epsilon_r}}\sqrt{(m^2 + mn + n^2)} \quad (4)$$

Where, $f_{m,n}$ is the resonant frequency of an antenna and c is the velocity of light in free space, m and n are integers (mode indices) and ϵ_r is the substrate relative permittivity. Assuming $\epsilon_r = 4.4$ and dominant mode (TM_{10} mode) resonant frequency of 3GHz, the side lengths can be calculated and are listed in a tabular form in table 1 as shown below.

Table- 1 Side lengths of proposed antenna

Shape	Side length a(mm)
60^0-60^0-60^0	31.782
45^0-45^0-90^0	23.836
30^0-60^0-90^0	27.524
15^0-75^0-90^0	27.524
25^0- 65^0-90^0	27.524
30^0-30^0-120^0	55.048

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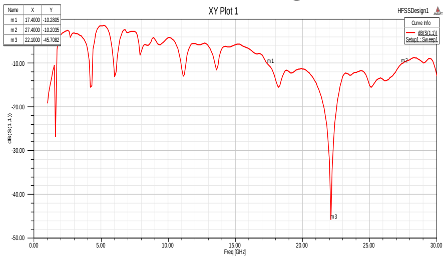
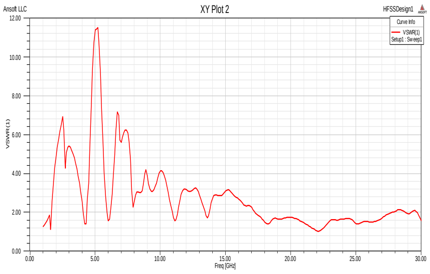
III. SIMULATED RESULTS OF PROPOSED ANTENNA DESIGN

Now the simulated results of six proposed antenna designs have been shown in following figures which include the return loss curve and VSWR curve respectively for each design.

Simulated Result of 1st antenna design



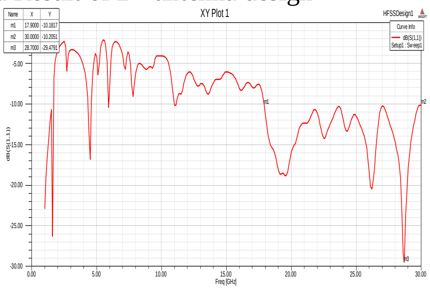
(a)



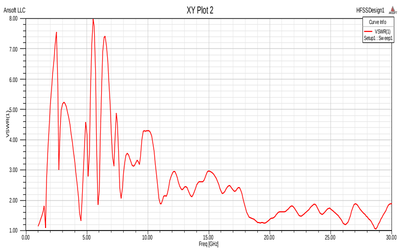
(b)

Fig.4. Simulated results of 60^0-60^0-60^0 TPA design (a)Return loss curve (b) VSWR curve

Simulated Result of 2nd antenna design



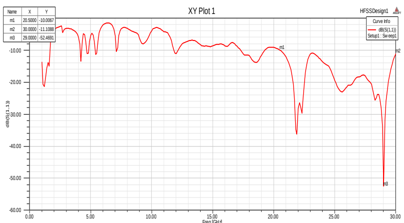
(a)



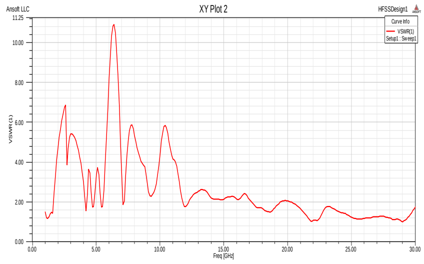
(b)

Fig.5. Simulated results of 45^0-45^0-90^0 TPA design (a) Return loss curve (b) VSWR curve

Simulated Result of 3rd antenna design



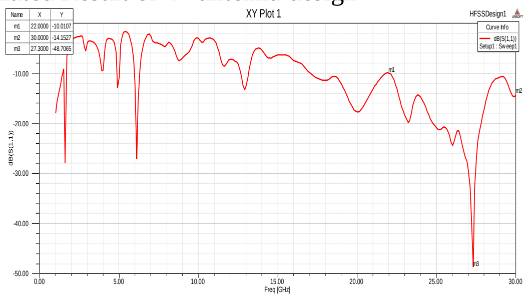
(a)



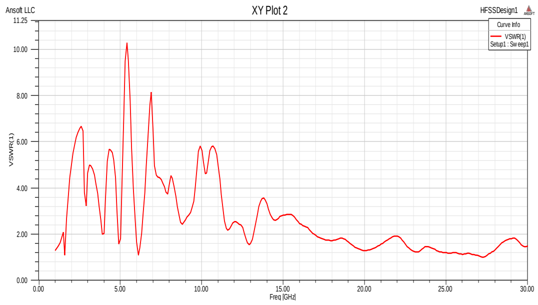
(b)

Fig.6. Simulated results of 30^0-60^0-90^0 TPA design (a) Return loss curve (b) VSWR curve

Simulated Result of 4th antenna design



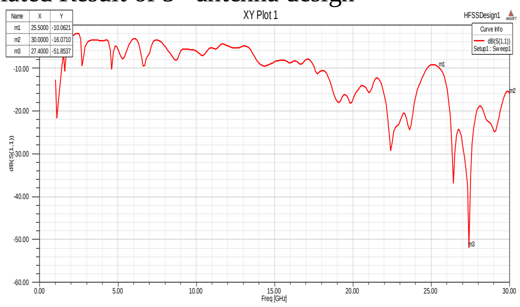
(a)



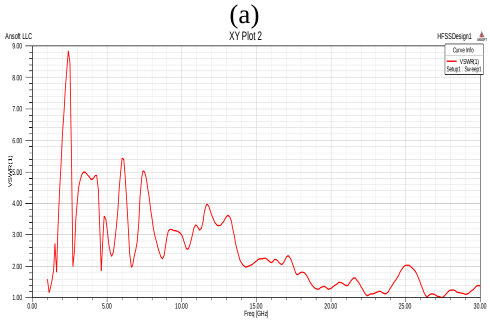
(b)

Fig.7. Simulated results of 30^0-30^0-120^0 TPA design (a) Return loss curve (b) VSWR curve

Simulated Result of 5th antenna design



(a)



(b)

Fig.8. Simulated results of 15^0-75^0-90^0 TPA design (a)Return loss curve (b) VSWR curve

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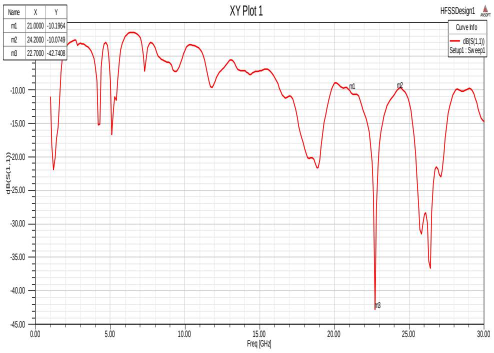
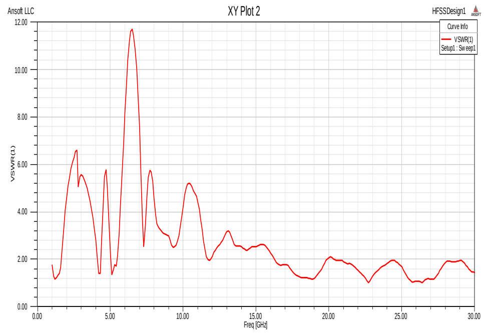
Simulated Result of 6^{th} antenna design



(a)



(b)

Fig.9. Simulated results of 25^0- 65^0-90^0 TPA design
(a) Return loss curve (b) VSWR curve

Above figures shows the clear picture of samples of return loss values and VSWR curve which are the important parameter in antenna designing, it can be analysed that minimum return loss obtained in 30^0-60^0-90^0 is -52.4691 dB and the maximum in case of 45^0-45^0-90^0 is -29.4791 dB and the maximum impedance bandwidth of 12.1Ghz is obtained in 45^0-45^0-90^0 with percentage bandwidth of 50.52% and it gives a tremendous increase in bandwidth required in various wireless communication field.

The return loss and band width of different antenna design is summarised in tabular form as shown in table 2:

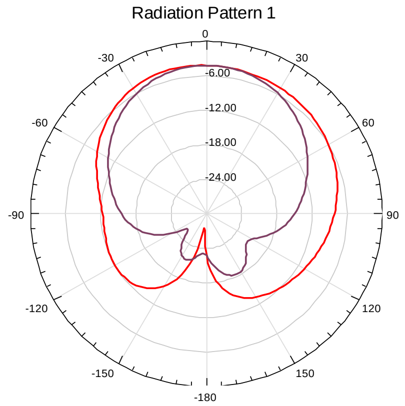
Table-2 Simulated Results of Proposed Antenna

Shapes	Return loss(dB)	Band width(GHz)
60^0-60^0-60^0	-45.7082	10 GHz(17.4-27.4)
45^0-45^0-90^0	-29.4791	12.1GHz(17.9-30)
30^0-60^0-90^0	-52.4691	9.5GHz(20.5-30)
15^0-75^0-90^0	-51.8537	4.5GHz(25.5-30)
25^0- 65^0-90^0	-42.7408	3.2GHz(21-24.2)
30^0-30^0-120^0	-48.7065	8GHz(22-30)

So, the comparative analysis can be done through the above table as there is wide bandwidth obtained in each case, minimum return loss is achieved in case of 30^0-60^0-90^0 and maximum in case of 45^0-45^0-90^0 but it gives the maximum impedance bandwidth, VSWR≤2 goes for wide frequency range in each design. Radiation pattern simulated at 3GHz for each TPA and is almost have bidirectional property.

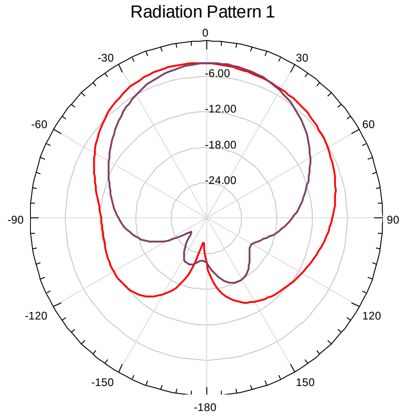
Now the radiation patterns are shown in following figures for the respective antenna design, which are almost with bidirectional properties.

Radiation pattern of 1^{st} antenna design



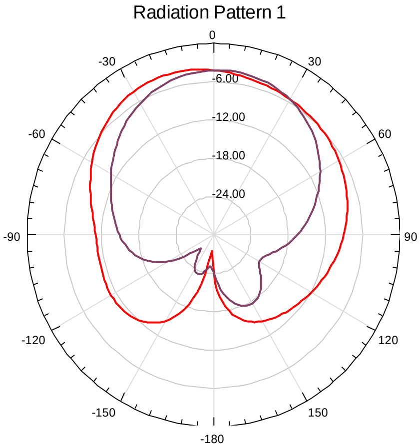
(a)

Radiation pattern of 2^{nd} antenna design



(b)

Radiation pattern of 3^{rd} antenna design



(c)

Fig10. Radiation pattern (a) 60^0-60^0-60^0
(b) 45^0-45^0-90^0 (c) 30^0-60^0-90^0

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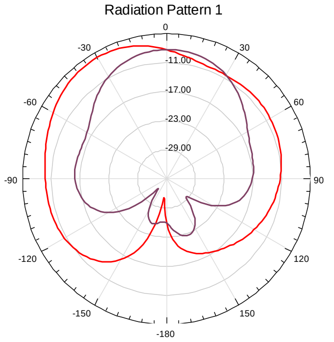
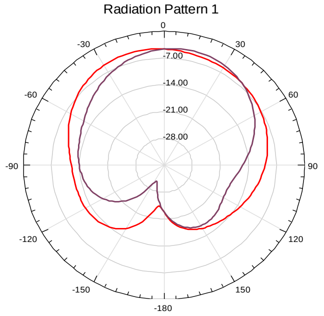
Radiation pattern of 4th antenna design



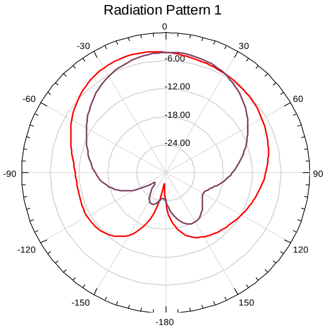
(d)

Radiation pattern of 5th antenna design



(e)

Radiation pattern of 6th antenna design



(f)

Fig11. Radiation pattern

(d)30^0-30^0-120^0 (e) 15^0-75^0-90^0 (f) 25^0-65^0-90^0

These figures shows the one of the important parameters of antenna design with radiation patterns of different antennas simulated at 3Ghz .These patterns are analysed on the basis of gain obtained, also the functioning of antenna depends on radiation efficiency which can be analysed on the basis of these radiating patterns. Table 3 shows the radiation efficiency of all the six antenna designs.

Table 3 Radiation efficiency of proposed antenna designs

Proposed Antenna designs	Radiation efficiency (%)
60^0-60^0-60^0	84.8
45^0-45^0-90^0	85.6
30^0-60^0-90^0	82.4
15^0-75^0-90^0	84.8
25^0- 65^0-90^0	81.8
30^0-30^0-120^0	79.5

IV. CONCLUSION

For the proposed antenna minimum return loss is -52.4691dB for 30^0-60^0-90^0 having bandwidth of 9.5GHz and VSWR$\leq$2 for the frequency range of 1-1.6GHz,4.2GHz,4.7-4.8GHz,5.4-5.5GHz,7.1GHz,11.8 12.2GHz,17.2-19.4GHz and 20.3-30GHz.For each case this VSWR value is obtained for different frequency ranges. Maximum radiation efficiency obtained is 85.6% in case of 45^0-45^0-90^0. Basically the proposed antenna design can be used in K band applications in radar and satellite communication field. Also four designs 60^0-60^0-60^0 TPA, 45^0-45^0-90^0TPA, 25^0- 65^0-90^0 TPA, 30^0-30^0-120^0TPA covers the frequency of L band (1GHz to 2GHz) and these can be used in military and digital audio broadcasting.

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