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Stepped Cut Four Corners Microstrip Patch Antenna to enhance Bandwidth at 7.5 GHz for Wireless Communications

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Abstract : ***This paper presents the bandwidth enhancements in a microstrip line feed patch antenna by the use of selective stepped cuttings at four corners.This paper addresses the performance comparisons of three different patch antennas.The first is a conventional rectangular patch over Rogers RT Duroid 5880 substrate operating at 7.5GHz, In the second stage the patch antenna possesses a step at the corners and as a result the designed antenna operates at 7.8GHz with minimum return loss and with increased band width of 63.61%.The third structure that is being proposed maintain more steps at the corners and operates at 7.5GHz with minimum return loss and bandwidth increase of 74.98% is achieved.***

Keywords;Bandwidth,Returnloss,MicrostripPatch antenna, Microstrip line feed.

I.Introduction

Microstrip patch antennas are very well known due to their low profile structure.The advantages of the Microstrip patch antennas being light in weight,small in size,low cost,ease of installation and integration with other circuits makes them suitable for wireless communications.However, the antenna inherent narrow bandwidth is one of their major demerits.Therefore there is a need to enhance the bandwidth of the patch antenna for wireless applications.This paper investigates a technique which can enhance the bandwidth of microstrip patch antenna without altering the dimensions and shape of the substrate and the conducting ground plane.

II.Microstrip patch antenna design

In this paper the practical width(w) of the conventional patch antenna operate at 7.5GHz with Rogers RT Duroid 5880 substrate of dielectric constant ε_r=2.2 can be determined using the equation below [1]

$$w = \frac{c}{f_o\sqrt{\frac{\in_{r+1}}{2}}};$$

where f_o is the operating frequency of the antenna and c=3*10^8 m/sec.

The effective dielectric constant ε_{reff} of the patch antenna with substrate height H=0.794mm can be determined from the equation above[1]

$$\in_{reff} = \frac{\in_{r+1}}{2} + \frac{\in_{r-1}}{2\sqrt{1+12\frac{H}{w}}}$$

and the extension of length ΔL is determined by using the equation[1]

$$\Delta L = 0.412\left(\frac{\in_{reff}+0.3}{\in_{reff}-0.258}\right)\left(\frac{\frac{w}{H}+0.264}{\frac{w}{H}+0.8}\right)$$

and the length L of the antenna becomes[1]

$$L = \frac{C}{2 f_o\sqrt{\in_{reff}}} - 2\Delta L$$

Table1:Design parameters of Microstrip patch antenna

Parameter	value
Width of the patch w	12.45mm
Length of the patch L	16mm
Height of the substrate H	0.794 mm
Dielectric constant of the substrate ε_r	2.2

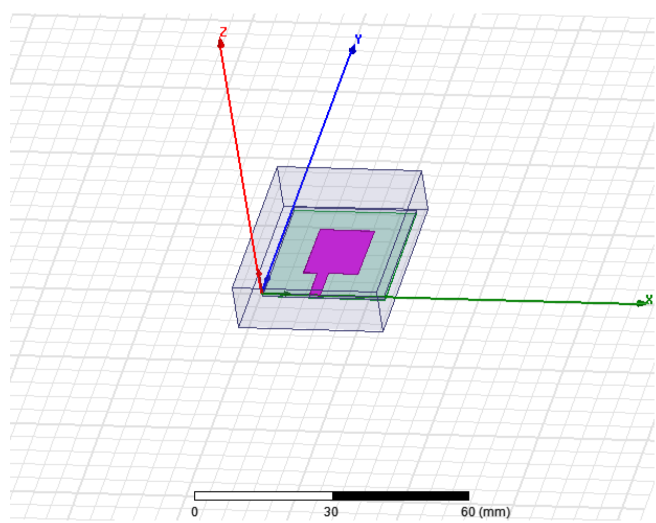


Fig (a) conventional microstrip patch antenna

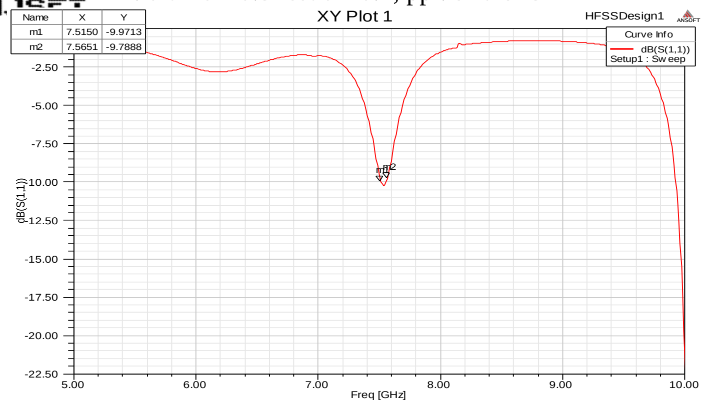
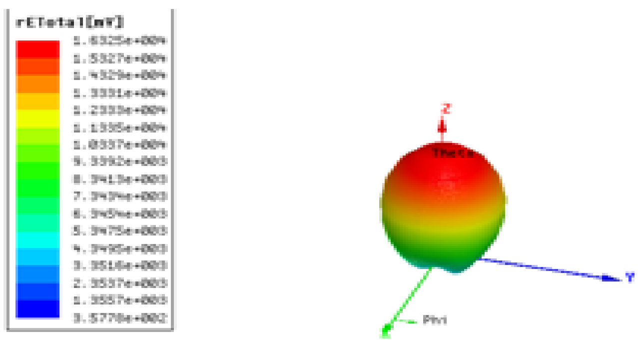
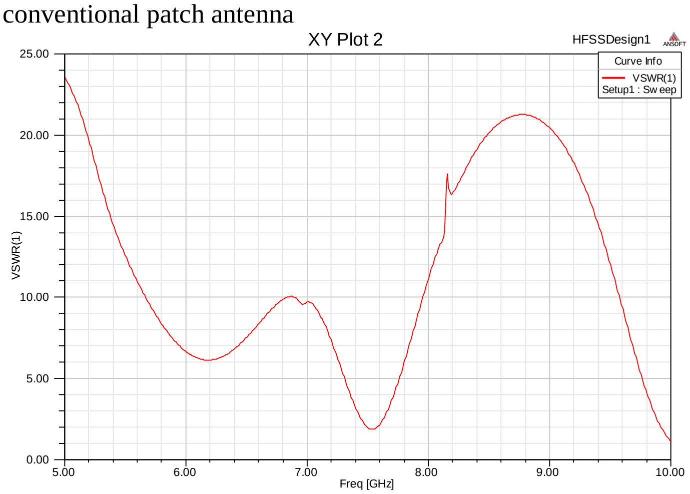


Fig (b) simulated graph of return loss for conventional microstrip patch antenna



Fig(c):3dimensional Radiation pattern of the conventional patch antenna



Fig(d) Simulated VSWR pattern

III.Simulated results of conventional patch antenna

In this paper the conventional patch antenna has been simulated using Ansoft High frequency structure simulator (HFSS)[2]. Fig(b) shows the return loss value equal to -10.24dB and 40.1MHz bandwidth at 7.5GHz frequency , radiation pattern and VSWR characteristics are shown fig(c) and (d) respectively

IV.Single step cut microstrip patch antenna

This antenna is as shown in fig(e) below only the shape of the patch is changed when compared to the conventional patch antenna.This antenna has a step at the corners[3].However the dimensions of the substrate and the ground are unchanged.

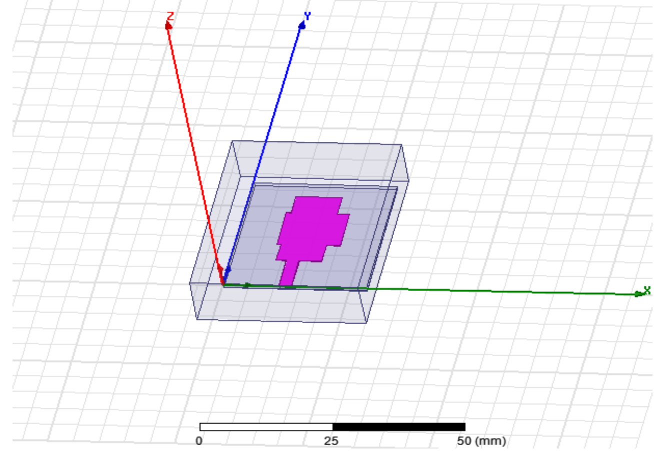


Fig (e) Single step cut microstrip patch antenna

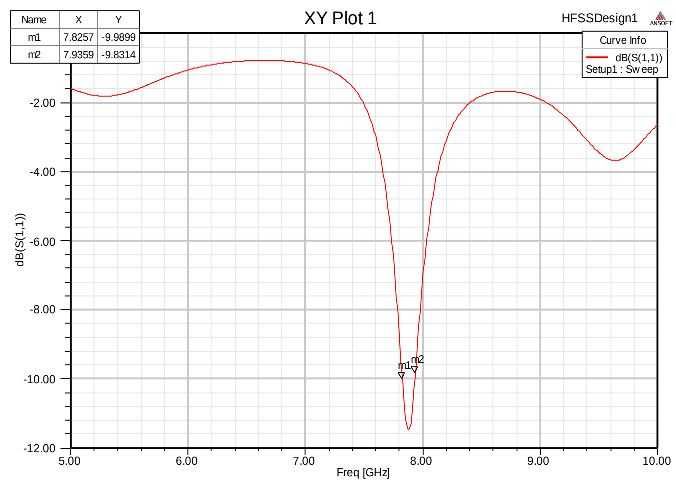


Fig (f) Simulated graph of return loss for single step cut microstrip patch antenna

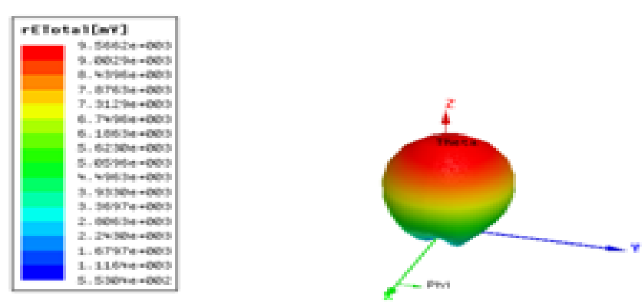


Fig (g) 3dimensional radiation pattern of the single step microstrip patch antenna

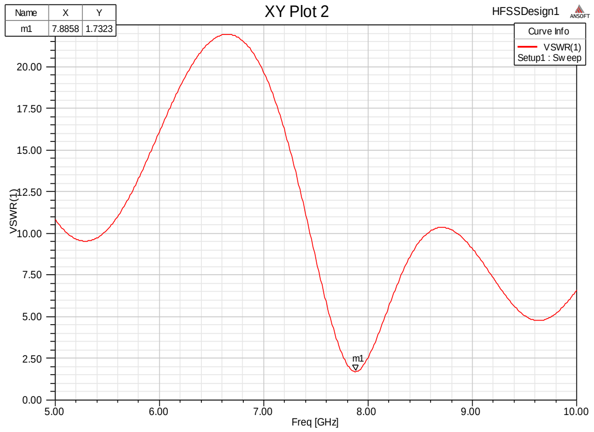


Fig (h) simulated VSWR Pattern

V.Simulated results of single step cut microstrip patch antenna

Simulated results of the antenna is shown in fig(f) which have -11.46dB return loss with increased bandwidth upto 110.2MHz at 7.8GHz frequency which is 63.61% more than the conventional patch antenna. Radiation pattern and VSWR characteristics are shown in fig(g) and (h) respectively.

VI.Multi step cut microstrip patch antenna

This antenna is as shown in fig(i) below .This proposed antenna contains multiple number of steps at the corners[3] and the dimensions of the substrates and ground planes are unchanged.

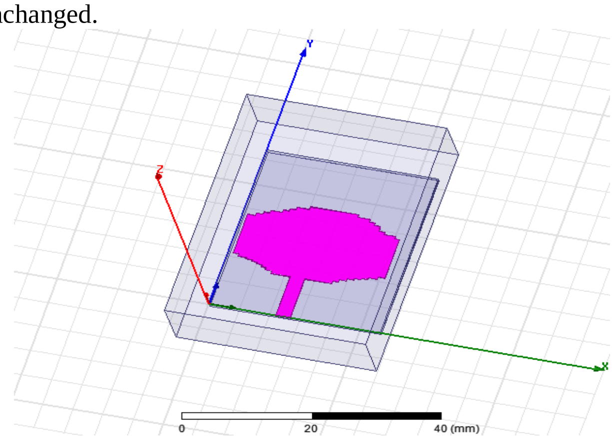


Fig (i)Multi step cut microstrip patch antenna

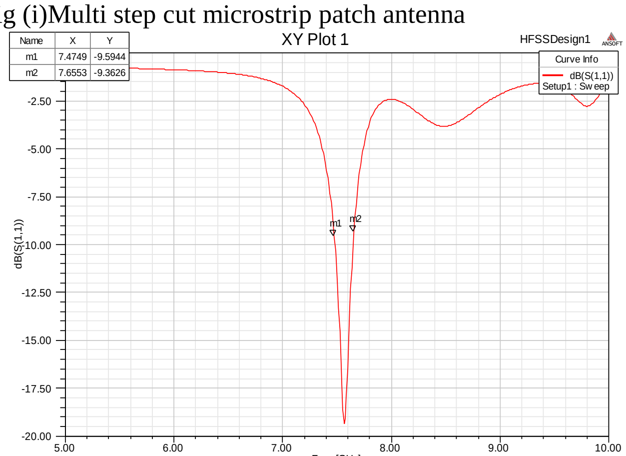


Fig (j)Simulated graph of return loss for multistep cut microstrip patch antenna

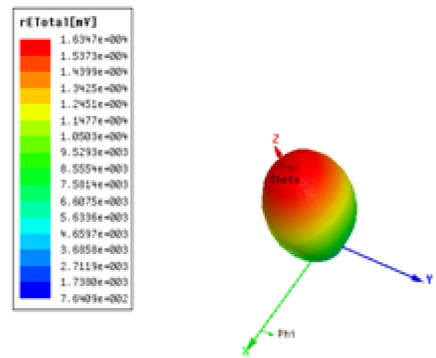


Fig (k) 3 dimensional radiation pattern of the multi step cut microstrip patch antenna

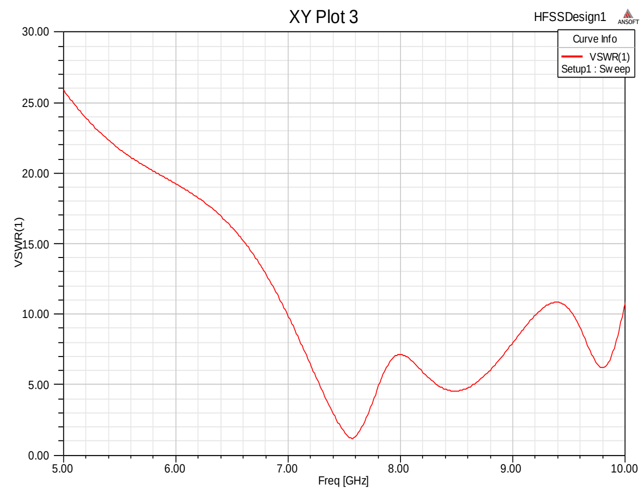


Fig (l) Simulated VSWR pattern

VII.Simulated results of multi step cut microstrip patch antenna

Simulated results of the antenna are shown in fig(j) which have -19.3dB return loss with increased bandwidth upto 160.3MHz at 7.5GHz frequency which is 78.98% more than the conventional patch antenna.Radiation pattern and VSWR characteristics fig(k) and (l) respectively

Table 2 comparison between the simulated results of the three antennas

Parameter	Conventional microstrip patch antenna	Single step cut microstrip patch antenna	Multi step cut microstrip patch antenna
Bandwidth	40.1MHz	110.2MHz	160.3MHz
Return loss	-10.24dB	-11.46dB	-19.30dB
Resonant frequency	7.5GHz	7.8GHz	7.5GHz
VSWR	1.8	1.7	1.2

VIII.**Conclusion**

Bandwidth of step cut microstrip patch antenna has been enhanced to 63.61% in the first stage and in the second stage where the number of steps at the corners are increased resulting in further bandwidth enhancement to 74.98% and makes the proposed patch antenna suitable for wireless applications.As, mentioned earlier this technique has its advantages such as the dimenions of the substrate and the ground plane are unaltered.

IX.References

[1].C.A.Balanis (2005).Antenna theory:analysis and design(3rd edition).by John Wiley &Sons,Inc.

[2].Ansoft HFSS version 13.0.

[3].Alishir Moradikordalivand and Tharek A.Rahman,"Broadband modified rectangular microstrip patch antenna using stepped cut at four corners method,"Progress in Electromagnetics Research,Vol. 137, 599-619,2013.

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