

CORNER TRUNCATED MICROSTRIP PATCH ANTENNA

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ABSTRACT

A square Microstrip patch antenna at frequency of 3.4 GHz is designed in this paper. This structure will give linear polarization. We have truncated the opposite corners from square patch antenna to achieve circular polarization. Microstrip feed line is used in this design. Ansoft HFSS is used to design this structure.

Keywords: Microstrip Patch Antenna, Microstrip Feed Line, Ansoft HFSS

INTRODUCTION

Micro-strip patch antennas have always been an attractive choice for the researchers, especially in the field where cheap, low profile, light weighted and easy to fabricate structures are desired such as in Wireless or Mobile communication. Microstrip patch antennas used because of its various advantages like compatibility with integrated circuits, conformal configuration, light weight, easy to fabricate and so on. Microstrip patch antennas usually designed with linear polarization but in some applications such as satellite communication circular polarization is desired because circularly polarized antennas are very insensitive to transmitter and receiver orientation. A micro-strip patch is one of the most widely used radiators for circular polarization generation. A microstrip patch antenna which is linearly polarized may be easily converted in to circularly polarized patch antenna after some modifications in the shape of structure and after cutting slots in the structure.

In the work presented in this paper a microstrip patch antenna is designed at the frequency of 3.4 GHz and this structure will produce linear polarization. The opposite corners of the structure are truncated as a result of which the linear polarization of the antenna is converted in to circular polarization. In this way circular polarization is achieved.

Polarization diversity of reception is also very important to counter the effects of fading in communication, especially in mobile communication.

Table 1 shows the design parameters of simple micro-strip patch antenna without truncated opposite corners.

II.THE ANTENNA STRUCTURE

The structure of the antenna is shown in figure.1 and various dimensions of the patch antenna are given in Table

S.no.	Parameter	Value
1.	Frequency	3.4 GHz
2.	Dielectric constant of substrate	Duroid (tm) 2.2
2.	Width of patch	23.82 mm
3.	Length of patch	23.82 mm
4.	Width of quarter wave transformer	1.144 mm
5.	Length of QWT	20.8325 mm
6.	Width of 50 ohm transmission line	4.84 mm
7.	Length of 50 Ω TL	20 mm
8.	Polarization	Linear

Table 1 various dimensions of Patch antenna

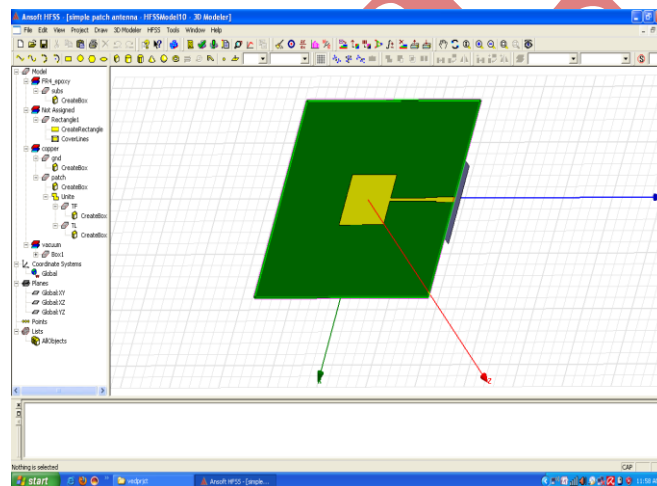


Fig.1. Micro-strip Patch Antenna at 3.4 GHz

The patch antenna was designed on the basis of transmission line model (TLM). The width of the patch is calculated first, given by the formula,

$$W = \frac{c}{2f} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

where ϵ_r the dielectric constant of substrate, W is the width of the patch and H is the height of the substrate.

The patch we have used in this model is square patch, so the length and the width both are the same. The dimensions of the patch are extended to account the fringing effect; the extension is given by,

$$\Delta L = 0.412 h \frac{(\epsilon_{eff} + 0.3).(W / h + 0.264)}{(\epsilon_{eff} - 0.258).(W / h + 0.8)} \quad (2)$$

Since the length of patch has been extended by Δ on each side of the patch, the effective length is given by,

$$L_{eff} = \frac{c}{2f\sqrt{\epsilon_{eff}}} \quad (3)$$

Patch resonant length L is given by,

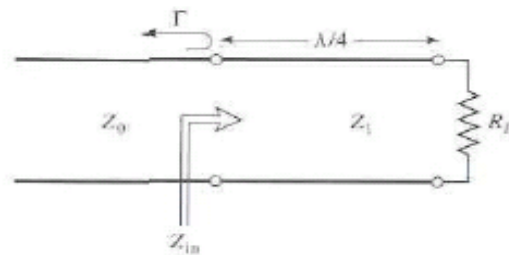
$$L = L_{eff} - 2\Delta \quad (4)$$

Using the values given by TLM approximation, parameters for the antenna were calculated for 3.4 GHz. The dielectric substrate Duroid ($\epsilon_r = 2.2$) with height $h = 1.57$ mm is used.

Quarter wave transformer is a very useful and practical circuit for impedance matching and it also provides a simple transmission line circuit that further illustrates the properties of standing waves on a mismatched line.

When it is desired to match a load resistance R_L with a feed line of characteristic impedance Z_0 , a piece of lossless transmission line of characteristic impedance Z_1 and $\lambda/4$ length is used to connect them, so to make the reflection coefficient $\Gamma=0$ looking into the $\lambda/4$ matching section. The matching impedance Z_1 is given by the expression.

$$Z_1 = \sqrt{Z_0 * R_L} \quad (5)$$



Quarter wave transformer

The length of the transformer is $\lambda/4$, which gives length 20.8325. The width of the conductor is given by the formula

$$\frac{w}{h} = \frac{8 \exp(-A)}{\exp(2A) - 2} \quad (6)$$

for $Z_0(\epsilon_r)^{1/2} > 89.91$, that is $A > 1.52$ and for $Z_0(\epsilon_r)^{1/2} \leq 89.91$, that is $A \leq 1.52$

$$\frac{w}{h} = \frac{2}{\pi} \left\{ B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r} \left[\ln(B - 1) + 0.39 - \frac{0.61}{\epsilon_r} \right] \right\} \quad (7)$$

Where,

$$A = \frac{Z_0}{60} \left\{ \frac{\epsilon_r + 1}{2} \right\}^{1/2} + \frac{\epsilon_r - 1}{\epsilon_r + 1} \left\{ 0.23 + \frac{0.11}{\epsilon_r} \right\} \quad (8)$$

The width of 50-ohm transmission line is calculated by eq. (7) and we get 4.84mm.

The dimensions of the ground plane were taken according to the lengths of the patch, the quarter wave transformer and the 50-Ohm transmission line. So the length of the ground plane, we calculated is given by;

$$L_g = L + L_{QWT} + L_{TL} \quad (9)$$

Where L is the length of the patch, L_{QWT} is the length of the quarter wave transformer; L_{TL} is the length of the 50-Ohm transmission line.

The Patch antenna and the ground plane are made of copper sheet; the thickness of copper sheet is taken to be 0.1 mm. The antenna is fed RF signals ranging from 2 to 5 GHz, at the port with the help of a waveport as shown in fig.1. The antenna without truncated opposite corners has linear polarization. S-parameter plot of without truncated corners patch antenna is shown in figure given below

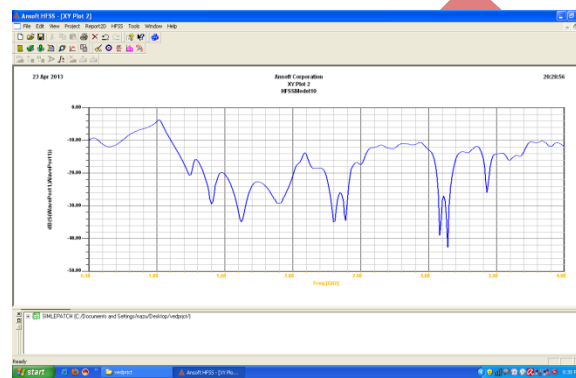


Fig.2 S-parameter plot of simple patch antenna

Next step is to change the polarization of this antenna from linear to circular. For this purpose, opposite corners of the patch are truncated. The dimensions of the truncated corners being calculated according to the following equation

$$\text{Length } a = \text{length of patch} / 5 \quad (10)$$

The design of opposite corner truncated micro-strip patch antenna is shown in figure 3.

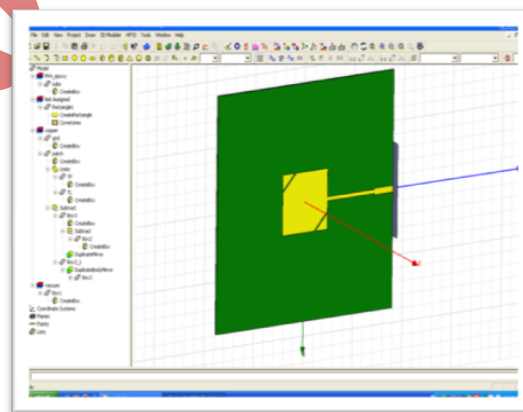


Fig.3. Opposite corners truncated patch antenna

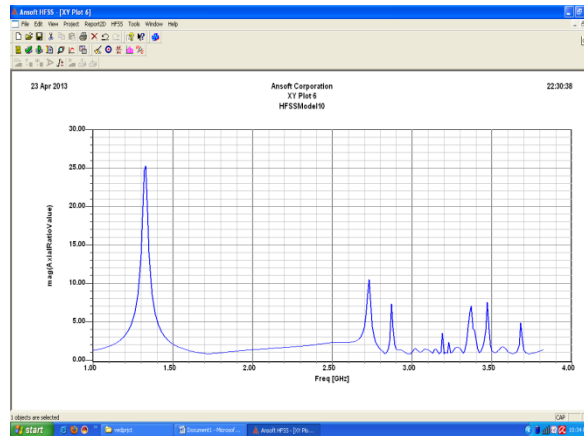


Fig.4 Axial ratio plot of opposite corners truncated

This truncated opposite corners changes the polarization of the antenna from linear to circular this circular polarization can be verified by plotting the axial ratio as shown in figure3. For circular polarization the axial ratio should be 1. The axial ratio of corner truncated patch antenna is 1.01. The axial ratio plot of opposite corner truncated antenna is shown in figure 4.

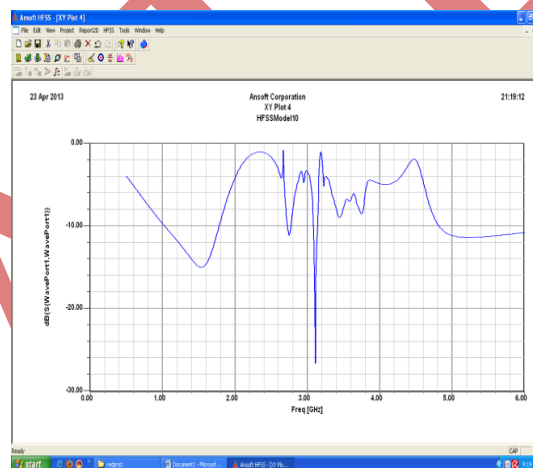


Fig 5. S11 plot of opposite corners truncated antenna

As desired the polarization of this antenna has now changed to circular because of the truncated corners but the resonant frequency is changed because of truncating the corners of the patch, s-parameter plot showing the resonant frequency of corner truncated microstrip patch antenna.

III. RESULTS & ANALYSIS

Software and settings

This circularly polarized antenna was simulated on EM solver Ansoft HFSS (High Frequency Structure Simulator), the radiations were measured with the help of an infinite sphere setup in far field. The RF signals were setup from 3 GHz to 5 GHz, simulated adaptively.

Analysis of results

The simulation results are shown in figures below; from figure 2. it can be observed that the reflection coefficient S_{11} for linearly polarized antenna without any truncation showing resonance at frequency 3.3 GHz. Figure 4 shows the axial ratio for opposite corners truncated antenna, as desired its magnitude is 1.01, which shows that this antenna possesses circular polarization.

Figure 5 shows s-parameter plot of corner truncated patch antenna its resonant frequency has changed after truncating the corners that is 3.15 GHz.

The 3D Gain polar plot for linearly polarized patch was shown in figure 6, for circular polarization and polarization tunable patch antenna, the 3D Gain polar plot is shown below in figure 7.

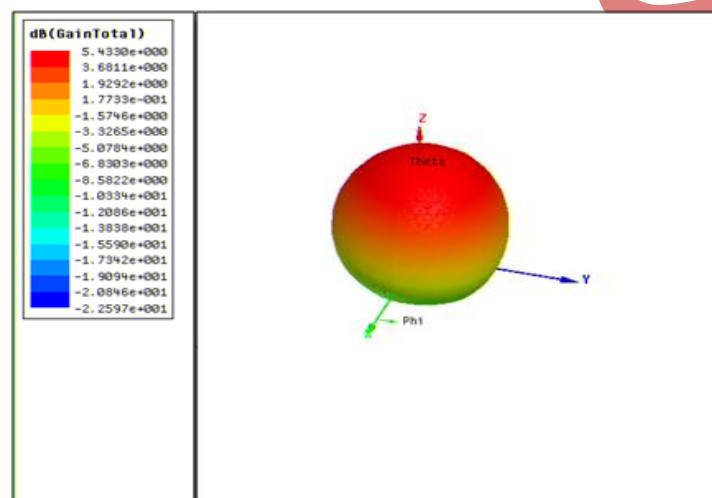


Fig.6 Gain of simple microstrip patch antenna

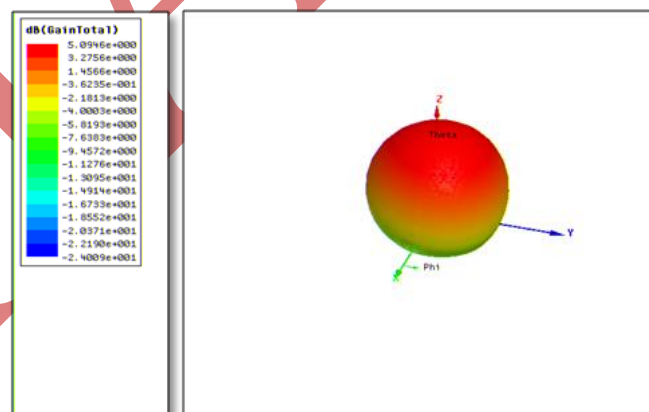


Fig.7 Gain of corner truncated patch antenna

These results were compared with theoretical ones, for the structure good agreement between simulated and experimental results were achieved.

IV. CONCLUSION AND FUTURES COPE

The proposed antenna is suitable for use in communication, defense applications, surveillance and countermeasures.

ACKNOWLEDGEMENT

The authors are thankful to DEAL (Defense Electronics Applications Laboratory), Dehradun for extending their laboratory to use Ansoft HFSS.

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