A DESIGN OF A RECTANGULAR PATCH ANTENNA WITH EQUILATRAL TRIANGULAR SLOT

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ABSTRACT

In the modern world of technology, antenna has gained popularity because it provides a wireless connectivity to the electronic devices with irrespective of its location. Antenna is the only elements which converts electrical sig nal-to-electromagnetic signal and vice-versa. This paper explains how to create a equilateral triangular slot on a rectangular microstrip patch antenna. Here parameters are calculated with the help of a C program for rectangular patch. We have tried to enable the dual-connectivity between LTE operating bands below 6GHz frequency and NX air-interface between bands ranges from 6Ghz to 100.Ghz.

Keyword: *-Microstrip patch antenna, Microstrip feed line, Return loss, Bandwidth, VSWR, Resonant Frequency, LTE operating bands, NX air-interface, C software, HFSS.*

1. INTRODUCTION

In the technological world, antenna has been one of the major attraction field for the researcher. It is the only element which is capable of converting the electrical signals-to-electromagnetic signal and vice-versa. It provides a wireless connectivity to the electronic device with irrespective of its location. With the advancement in the field of wireless technology, the need of light weight and miniature size antennas become's major req uirements of today's world. Microstrip antenna is the most popular antenna in this category. Microstrip antenna is similar to a radio antenna with a low profile that can be fabricated on flat surface. This antenna has some major advantages over other antenna such as low profile, low weight, simple fabrication process with low manufacturing cost, polarization diversity and can be easily modified and customize. LTE operating bands (frequency) are available at below 6 GHz frequency where as NX interface frequencies are available from 6 GHz to 100Ghz [5]. 6 GHz is the only frequency which is common between LTE operating bands and NX air interface, only frequency which can provide dual connectivity between them from their frequency distribution [5]. In this paper, we have tried to increase the band width of the microstrip antenna by creating a equilateral triangular slot on a rectangular microstrip patch antenna [4]. A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The top and side view of a rectangular MSA (RMSA) is shown in figure 1[1].

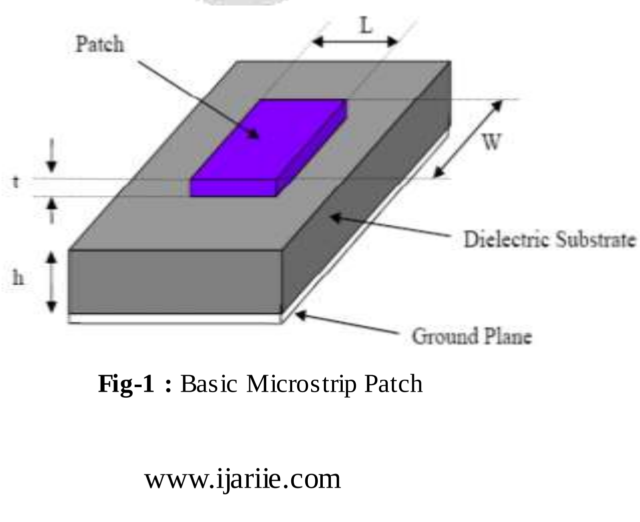

Fig-1 : Basic Microstrip Patch

Here, the feeding technique used is the microstrip feed line. In this technique connecting strip line is directly connected to the edge or side of the microstrip patch. The conducting strip is comparatively very small in width compared to the patch. Its advantage is that it can be fabricated on the same substrate for providing the planar structure. Fig-2 shows the microstrip patch antenna with microstrip feed line[1].

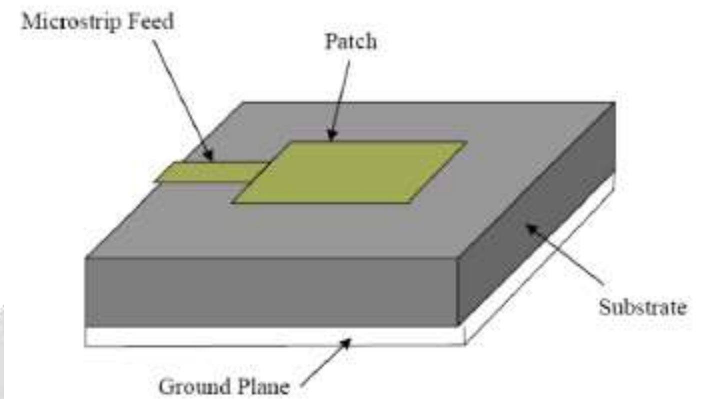

Fig-2 : Microstrip Feed Line

2. DESIGN EQUATION

A) Calculation of rectangular patch[1]

Step-1 Calculation of Width (w)

For good radiation efficiency, practical width is more important and width is calculated by

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

Where c is a velocity of light in free space.

Step-2 Calculation of Effective dielectric coefficient (e_{reff})

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

Step-3 Calculation of Effective Length (L_{eff})

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Step-4 Calculation of the Length extension (ΔL)

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

Step-5 Calculation of actual Length of Patch (L)

$$L = L_{eff} - 2\Delta L$$

Step-6 Calculation of the Ground Plane Dimension (L_g and W_g)

$$L_g = 6h + L$$

$$W_g = 6h + W$$

OR

Program: - Write a C program to calculate the dimensions for rectangular patch [2].

```
#include <stdio.h>
#include <conio.h>
#include<math.h>
void main()
{
float c=30000000000.0,f,Er,h,Ereff,delL,a,b,l,Lg,Wg,W;
clrscr();
printf("Enter the value of frequency in hertz (decimal) - ");
scanf("%f",&f);
printf("Enter the value of height in mm (decimal) - ");
scanf("%f",&h);
printf("Enter the value of dielectric substrate in decimal - ");
scanf("%f,&Er);
w=c/(2*f*(pow(((Er+1)/2),0.5)));
a=h/w;
b=w/h;
Ereff=((Er+1)/2)+(((Er-1)/2)*(1/sqrt(1+(12*a))));
Leff=c/(2*f*sqrt(Ereff));
delL=0.412*h*(((Ereff+0.3)*(b+0.264)/((Ereff-0.258)*(b+0.8)));
l=Leff-(2*delL);
Lg=(6*h)+l;
Wg=(6*h)+w;
printf("\nEreff = %f",Ereff);
printf("\nLeff = %f",Leff);
printf("\nl = %f",l);
printf("\nLg = %f",Lg);
printf("\nWg = %f",Wg);
getch();
}
```

B) Calculation of triangular slot[3]

Step-1 Calculation of Side of triangle (a)

$$a = \frac{2c}{3f_r\sqrt{\varepsilon_r}}$$

Step-2 Calculation of Effective Dielectric Coefficient (ε_{reff})

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{4}\left[1 + 12\frac{h}{a}\right]^{-\frac{1}{2}}$$

Step-3 Calculation of Effective Length (a_{eff})

$$a_{eff} = a - h(\varepsilon_{reff})^{-\frac{1}{2}}$$

Step-4 Subtraction of triangular patch from rectangular patch using Boolean subtraction to create a triangular slot in rectangular patch in HFSS.

3. CALCULATED PARAMETERS

TABLE-1: Design specification for equilateral triangular slotted microstrip rectangular patch antenna

SR. NO.	PARAMETERS	DESIGNED VALUE
1	Resonant Frequency (f_0)	6 GHz
2	Dielectric Constant (ε_r)	4.4
3	Substrate Height (h)	2.4mm
4	Patch Length (l)	11.11mm
5	Patch Width (w)	15.21mm
6	Substrate Length (L_g)	23.11mm
7	Substrate Width (W_g)	27.21mm
8	Side of a equilateral triangle (a)	3.46mm

4. DESIGN IN HFSS [4]

Step-1 Draw a cube1 having a length and width equal to the substrate length (L_g) and substrate width (W_g) as shown in table1 with height of 0.5mm.

Step -2 Draw a cube2 having a length, width and height equal to the substrate length (L_g), substrate width (W_g) and substrate height as shown in table1.

Step-3 Select the dielectric constant (ε_r) 4.4 for cube2.

Step-4 Draw a cube3 (patch) and cube4 (feed line) having a height of 0.05mm and select copper (Cu) material for both cube3 &4.

Step-5 Give the length and width dimensions of patch as shown in table1 to the cube3.

Step-6 Draw a 2 equilateral triangle with 3.46mm as a side of it.

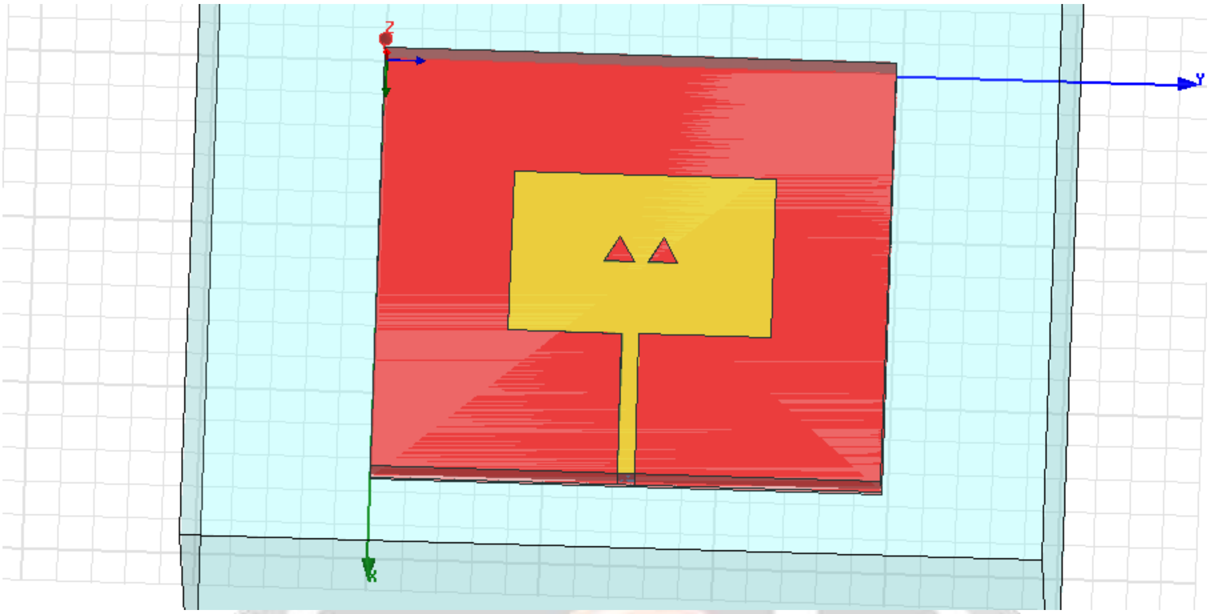

Fig-3 : Top view of the microstrip antenna

Step-7 Arrange the cubes and triangles as show in the figure-3.

Step-8 Perform the Boolean function between cube3 and both the triangle to get figure is show in figure-3.

Step-9 Choose other parameters or function as required.

4. RESULTS

4.1 Return loss and bandwidth

The bandwidth of antenna can be calculated from return loss versus frequency plot. The bandwidth of the rectangular antenna is 200 MHz at resonant frequency is 6GHz and above 1GHz at frequency 8.4 GHz.

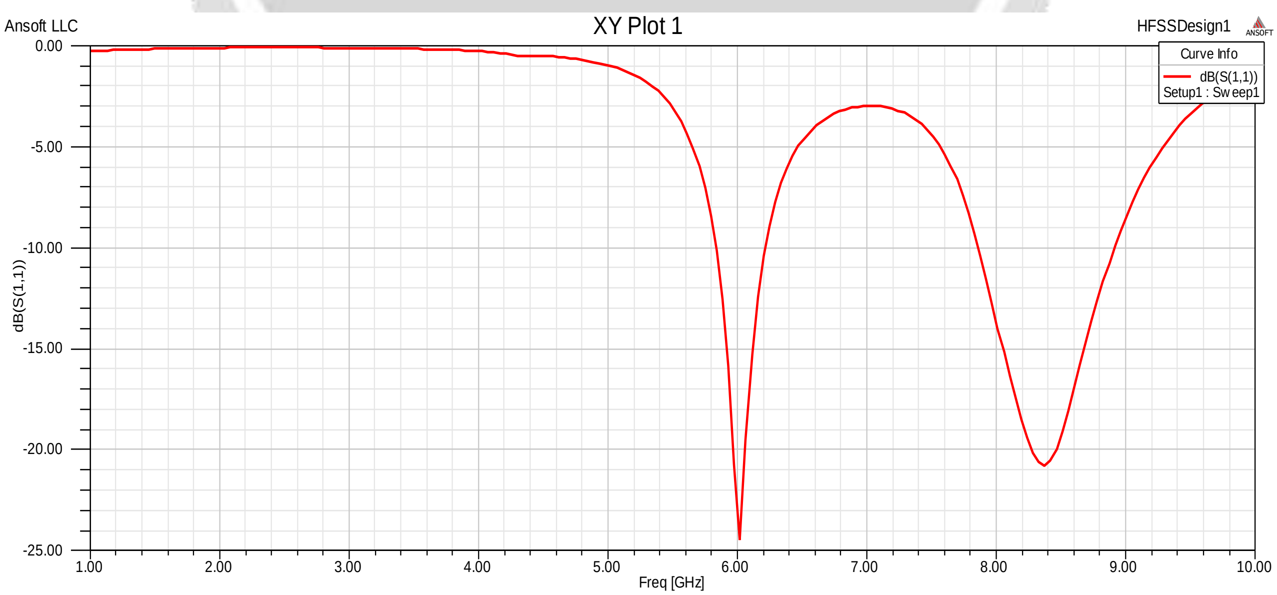

Fig-4 : Return loss and bandwidth of the antenna

4.2 Voltage Standing Wave Ratio (VSWR)

The VSWR is slightly above 1 at resonant frequency 6 GHz and also the VSWR is between 1-2 at 8.4 GHz.

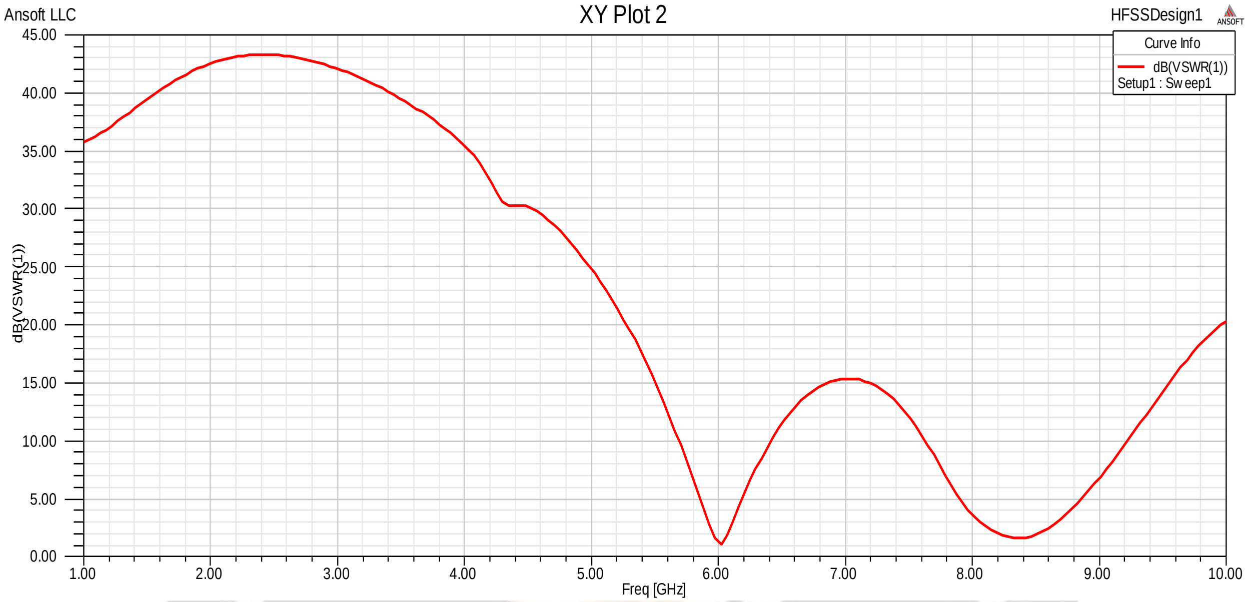

Fig-5 : VSWR of the antenna

5. CONCLUSIONS

This paper shows the 40% increase in the bandwidth of antenna at center frequency 6 GHz and also creates the additional bandwidth of more than 1 GHz at frequency 8.4 GHz.

6. FUTURE WORKS

To combine the bandwidth of resonant frequency (6Ghz) and secondary frequency (8.4 GHz) at resonant frequency (6 GHz).

7. REFERENCES

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