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Design and Simulation of Planar Monopole Antenna for UWB Applications

B. Lakshmi priyanka[1], G.Krishnaveni[2], Dr.B.Manimegalai[3]

PG Student, K.L.N College of Information Technology, Pottapalayam-630 611, Sivagangai, Tamilnadu, India[1]

AP/ECE, K.L.N College of Information Technology, Pottapalayam-630 611, Sivagangai, Tamilnadu, India[2]

AP/ECE, Thiagarajar College of Engineering, Madurai Tamilnadu, India[3]

Abstract-The objective of the project is to design and simulate the planar monopole antenna for UWB applications. The base of the proposed antenna is a diamond-shaped patch (DSP) that covers the ultra wide band (UWB) 3.1–10.6 GHz frequency range. It is shown that by removing the centre part of the DSP antenna, without distorting the UWB behavior. This will not affect the dimension of the base antenna. The used substrate is FR4 with relative permittivity of 4.4 and thickness of 1mm.The designed simple DSP - UWB antenna has a substrate size of 16*22mm^{2}and covers the frequency band 3.1–10.6 GHz which includes UWB. The antennas have omnidirectional and stable radiation pattern. Hence, a rectangular shaped ground plane is designed and will be simulated using ANSOFT-HFSS. The parameters such as return loss, VSWR and radiation pattern are taken.

Index Terms: Monopole antenna, ultra wide band (UWB) antenna, wireless communication frequencies.

I. INTRODUCTION

The ultra wideband (UWB) communication systems have received great attention from both the academic and the industrial sectors as a result of commercial systems such as indoor and hand-held wireless communication. UWB is short distance radio communication technologies that can perform high-speed communication with speeds of more than 100 Mbps. Modern communication systems require a single antenna to cover Several allocated wireless frequency bands. Moreover, design of a multi-band antenna which also covers the UWB range without deteriorating the UWB performance is of high interest

The objective of this project is to design and simulate a small-size microstrip-fed UWB base diamond-shaped-patch (DSP) antenna for multi band applications using ANSOFT – HFSS. The performance and behavior of the antenna is analyzed using the results obtained from the simulation process.

The scopes defined for this project are as follow

- Understanding the antenna concept.
- Designing the microstrip patch antenna to operate at UWB frequencies.
- Performs simulation using ANSOFT / HFSS software.
- Obtain results and graphs from the simulation.
- Analyzing the performance of microstrip patch antenna.

The project begins with the understanding of the uwb technology. This includes the property studies such as the radiation pattern, input impedance, return loss, VSWR, etc. the related literature reviews includes understanding the previous works done. The design of the microstrip patch antenna starts with calculating the dimensions of the patch using the formula. This will determine the size of the microstrip patch antenna. The next step is to design the ground plane.

The software used for designing and simulation is ANSOFT -HFSS. Then the measurement was taken and the graphs are plotted to analyze the performance of the microstrip patch antenna.

II. RELATED WORK

I have observed that the size and shape of the rectangular microstrip planar monopole antennas have

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significant impact on the antenna gain. By shaping the rectangular microstrip in UWB, I have increased the gain of a rectangular microstrip antenna for as much as -10 dB. Theoretical results are will be verified by measurements. The computed results presented above were it will be verified by experimentally. The enhancement of the antenna gain with the rectangular microstrip, with respect to the gain for the rectangular plate. The gain enhancement is presented as a function of frequency. Were this infers that the observed paper uses UWB band and the proposed system is designed with UWB band.

III. GENERAL CHARACTERISTICS OF MICROSTRIP PATCH ANTENNA

Microstrip patch antenna was first designed in the year Bob Munson in 1972. One of the most useful antennas at microwave frequencies (*f* > 1 GHz). It consists of a metal "patch" on top of a grounded dielectric substrate. The patch may be in a variety of shapes, but rectangular and circular are the most common. The patch acts approximately as a resonant cavity (short circuit walls on top and bottom, open circuit walls on the sides). In a cavity, only certain modes are allowed to exist, at different resonant frequencies. If the antenna is excited at a resonant frequency, a strong field is set up inside the cavity, and a strong current on the (bottom) surface of the patch. This produces significant radiation (a good antenna)

The formulas used in the design of microstrip patch antenna are given below, The expression for ε_{reff} is given as;

$$\varepsilon_{reff} = (\varepsilon_{reff} + 1)/2 + (\varepsilon_{reff} - 1)/2[1+12h/W]^{-1/2} \quad \text{..........................(1)}$$

Where
ε_{reff} = Effective dielectric constant
ε_r = Dielectric constant of substrate
h = Height of dielectric substrate
W = Width of the patch

The dimensions of the patch along its length have now been extended on each end by a distance ΔL;

$$\Delta L=0.412h(\varepsilon_{reff} + 0.3)(W/h + 0.264)/((\varepsilon_{reff} - 0.258)(W/h + 0.8)) \quad \textbf{.....................(2)}$$

The effective length of the patch L_{eff};

$$L_{eff}=L+2\,\Delta L \quad \textbf{............ (3)}$$

Resonance frequency f_o, the effective length is given by ;

$$L_{eff}=c / (2f_o \sqrt{(\varepsilon_{reff})}) \quad \textbf{.................. (4)}$$

Resonance frequency for any TM mode is;

$$f_o = c/(2\sqrt{(\varepsilon_{reff})}[(m/L)^2 +(n/W)^2]^{1/2} \quad \textbf{...................(5)}$$

Where m and n are modes along L and W respectively.

For efficient radiation, the width W is given as;

$$W= c/(2f_o \sqrt{((\varepsilon_r+1)/2)}) \quad \textbf{...........................(6)}$$

IV. MODE OF OPERATION OF MICROSTRIP PATCH ANTENNA

The UWB systems can be divided into two categories;

DS-UWB
MB-OFDM

V.DESIGN OF MICROSTRIP PATCH ANTENNA

A microstrip patch antenna is one whose main body is composed of two or more sections in which one of the two sections is mounted over the other. The bottom larger one may also serve as a supporting stem of an antenna so as to provide an enhanced antenna system with a common ground plane.

To design the DSP UWB antenna, DSP antenna with inserting notched region in the middle part.

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DESIGN FOR DSP UWB ANTENNA:

Given

Frequency fr = 9GHz

Substrate name: FR4

Substrate size : $16*22*1\ mm^3$

Loss tangent=0.02

ε_r =4.4

Microstrip-fed line =1.86 mm

Characteristic impedance =50Ω

DESIGN:

From the formula

$W = (C/2f0\sqrt{(\varepsilon r+1)/2})$

Length L=Leff-2ΔL

Resonant frequency:

The wavelength is,

$$\lambda g = \lambda/\sqrt{\varepsilon_{reff}}$$

λ is the free space wavelength,

ε_{reff} is effective permittivity

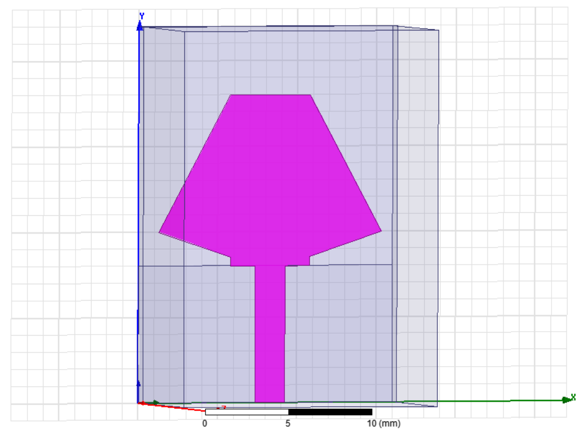

fig 5.1: DSP UWB antenna without inserting notched region

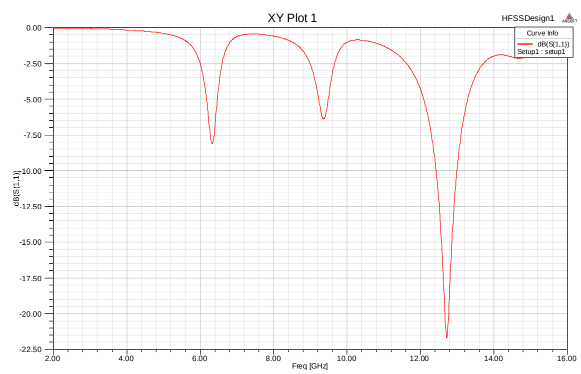

Figure 5.2 Return Loss

From the return loss graph it is seen that in frequency at 12.8 GHz it has a value of return loss is -21.52dB

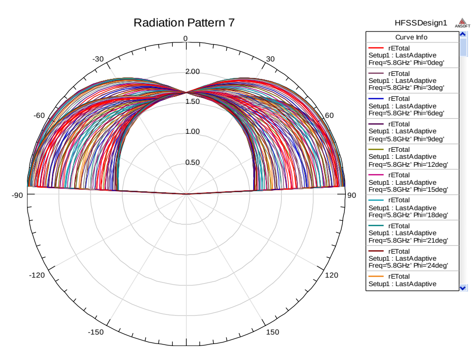

Figure 5.3 Radiation pattern

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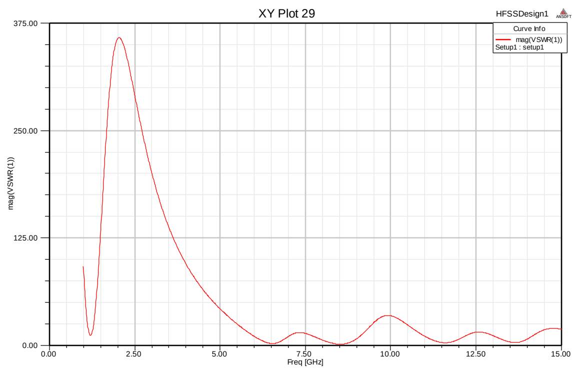

Figure 5.4 VSWR

From the VSWR graph it is seen that in frequency at 6.5GHz the value of VSWR is 1

VI. DESIGN FOR DSP ANTENNA WITH INSERTING NOTCHED REGION

Design:

From the formula

Thus, a rectangular section along the axis of the DSP antenna can be removed as shown in Fig.4.1 (b) without affecting the overall antenna impedance and radiation characteristics leading to the UWB antenna

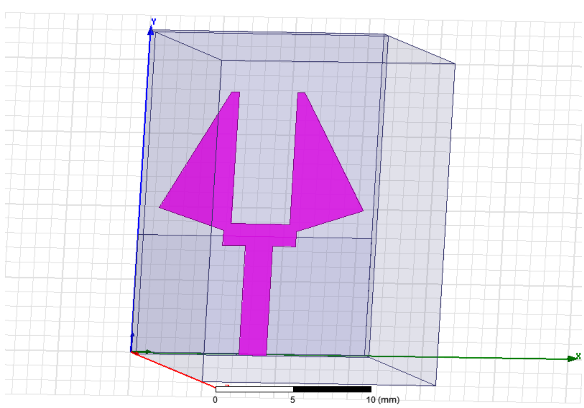

fig 6.1: DSP UWB antenna with inserting notched region

Given

Frequency fr = 9GHz

Substrate name: FR4

Substrate size : 16*22*1 mm^3

Loss tangent=0.02

ε_r =4.4

Microstrip-fed line =1.86 mm

Characteristic impedance =50Ω

GROUND PLANE DESIGN:

Perfect E plane is choose, then set;

Axis =z

x=16mm

y=7.8mm

To create the rectangle.

Lg=8mm

Lf=8mm

Wf=1.86mm

DSP PATCH DESIGN:

Perfect E patch is choosing, then set;

Axis =z

x=5mm

y= -10mm

To create the patch.

a1=14mm

a2=5mm

b1=2mm

b2=8mm

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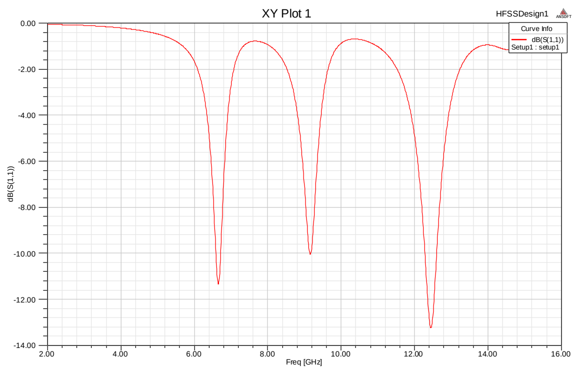

Figure 6.2 Return Loss

From the return loss graph it is seen that in frequency at 6.8GHz it has a value of return loss is -11.02dB.,9GHz it has a value of -10dB. and 12.3GHz it has a value of -13.3dB

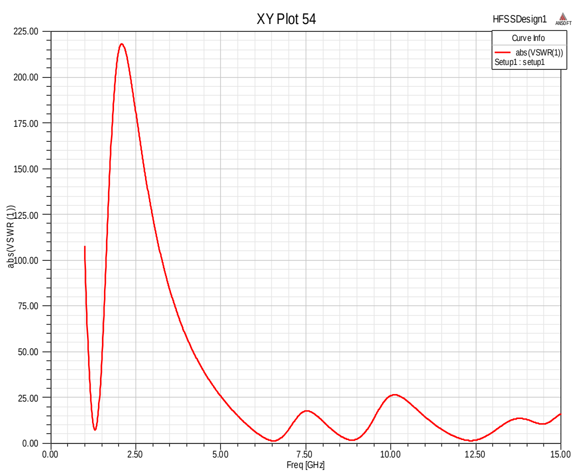

Figure 6.3 VSWR

From the VSWR graph it is seen that in frequency at 6.5GHz the value of VSWR is 1.

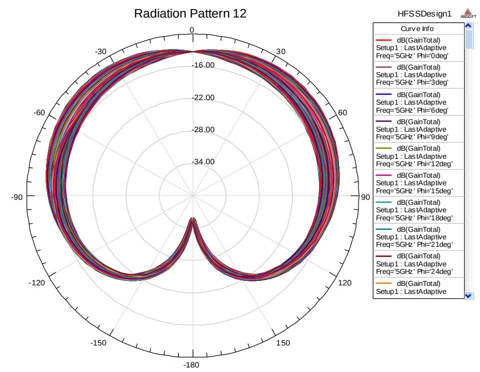

Figure 6.4 Radiation pattern

VII. RESULT DISCUSSION:

Frequency	VSWR	Return Loss	Impedance Bandwidth
9.3 GHz	1	-10dB	9.3-10.3GHz
6.8 GHz	1	-11.0dB	6.8-9.2 GHz

VIII. CONCLUSION

Thus the design and simulation of microstrip patch array antenna was successfully designed and analysed using Ansoft/Ansys HFSS. The diamond shaped patch antenna covers the UWB frequency range. ANSOFT-HFSS software is used to analyze the performance of the designed antenna. Designed a rectangular microstrip patch antenna that operates in UWB frequencies. i.e., 3.1-10.6 GHz frequencies. From observing the return loss, vswr, radiation pattern graphs it is very clear that this antenna works on the designed UWB frequency range. Thus the planar monopole rectangular microstrip patch antenna works in the designed UWB frequency

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range. When this antenna is implemented it could be used to transmit or receive signals simultaneously in UWB frequency range. and design a small-size microstrip-fed UWB base diamond-shaped-patch (DSP) antenna for quad band application and to achieve the UWB frequency band is left for future work.

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