DESIGN AND ANALYSIS OF MULTI BAND RECTANGULAR MICROSTRIP PATCH ANTENNA FOR C BAND AND X BAND APPLICATIONS

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ABSTRACT

Nowadays, due to a continuous growth in communication users, It is required to develop the antennas offering wide bandwidth. In this paper antenna described for the broadband finite ground plane. The antenna designed with 11.4051mm× 8.388mm radiating copper patch with ground plane design with 21.0051mm x17. 988mm. The primary radiating elements are rectangular microstrip patch antenna in the upper side with probe feed and use finite ground plane are inverted U shaped printed slot for four different frequency applications which is smaller in size compared to other available multiband antennas. From the result, it is observed that, the return loss of -15.71 dB is achieved at the first resonant frequency of 6.72414 GHz, -26.33 dB at the second resonant frequency of 8.27 GHz, -20.79 dB at the fourth resonant frequency of 11.38 GHz and -14.46 dB at the fifth resonant frequency of 14.48 GHz. This slot coupled microstrip patch antenna for satellite communication having a multi band operation covering C and X band along with wide bandwidth.

Indexing terms/Keywords

Rectangular Patch Antenna, Finite Ground Plane, broadband, Multiband, IE3D Software, Impedance Matching.

1. INTRODUCTION

Microstrip Patch Antenna

Microstrip patch antennas are a novel antenna that proposed topic with several applications in communication systems. Printed circuit technology has provided an edge for this class of cheapness that is small shape and MIC compatible antennas in the recent years. Feeding methods have been done to develop the wave characteristics of the antenna innovation inside the structured shape **[Liu, Yunlin, et.al. 2005**]. The main drawback associated with these antennas is excitation of surface lane waves and narrow frequency bandwidth. In this area, a reversed stacked antenna design is proposed to enhance the antenna bandwidth without producing additional plane waves in the structure. This design also allowed the antenna to operate in multiband and broadband as required by many wireless communication systems such as Bluetooth, RF-ID technology, satellite communication and radar communication **[Ray, K.P., et.al. 2003]**. In order to assemble the smallness necessities, the antennas which are working on communication terminals have to be a compact antenna such as microstrip patches. These types of antennas are very popular for the communication devices such as satellite communication,

radar, communication etc. The origin of Microstrip patch antennas begins with the use of planar microwave technologies such as microstrip and slotted lines **[Schell, A.C., 2001]**.
In its simple structure of a patch antenna consisting of a conducting layer on the upper plane of a dielectric substrate, and the other hand lowers the plane as shown in Fig.1.1.

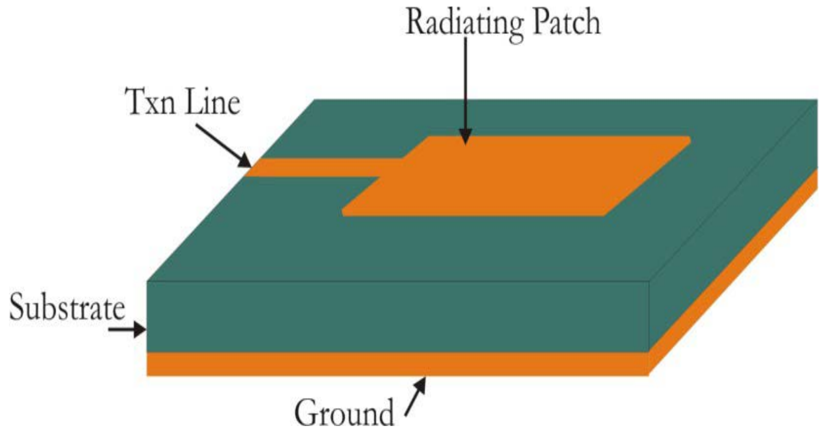

Figure 1.1 The common geometry of rectangular patch antenna. [Balanis, A., 1997]

This antenna is fed by strip line. The conducting patch radiates efficiently Thus, radiation arises from the fringing of electromagnetic fields connecting the upper layer and the lower layer. This patch is gaining in attractiveness for use in several present systems because of light mass, small size and small manufacture price. For this reason may be manufactured in huge numbers. It knows how to be simply incorporated with microwave integrated circuits (MICs) and may accomplish multi-band operation. These types of antennas have a number of drawbacks as compared to simple antennas and some drawbacks may be enumerated in, narrow bandwidth, small competence, small gain, and small power handling capacity.

2. DESIGN METHODOLOGY AND SIMULATION OF ANTENNA STRUCTURE

The material with dielectric constant 4.4 (FR4 Epoxy) is used as a backplane conductor to form Microstrip antenna. and The heart of a microstrip patch antenna is the upper conductor. The patch of finite dimensions. The patch can be considered to be an open-ended transmission line of length and width. The amplitude of surface currents becomes significant when the signal frequency is close to resonance by taking only the fundamental mode into account. The resonant frequency can be calculated by

$$f_o = \frac{c}{2(L + 2\Delta L)\sqrt{\varepsilon_{reff}}}$$

Where ΔL is the equivalent length extension that financial records for the fringing fields at the two open ends and ε_{reff} Is the effective relative permittivity. A microstrip structure is not homogeneous because the electromagnetic field extends over the two media air and dielectric. Therefore wave propagation cannot be TEM. Since wave in two media travels with different velocities and the boundary conditions force nonzero transverse electric or magnetic components.

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TABLE 1: RECTANGULAR MICROSTRIP PATCH ANTENNA SPECIFICATIONS

	Magnitude	Unit
Dielectric Constant (ϵ_r)	4.4	-
Loss Tangent (tan ∂)	0.02	-
Thickness (h)	1.6	mm
Operating Frequency	8	GHz
Length (L)	8. 388	mm
Width (W)	11. 4051	mm
Ground Length (L_g)	17.988	mm
Ground Width (W_g)	21.0051	mm
Feed	Coaxial Feed	-

RMPA parametric analysis Width of metallic patch (W)

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where,
c = free space velocity of light
ε_r= Dielectric constant of substrate

Effective dielectric constant is calculated from:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{w}}}\right)$$

Length of metallic patch (L) $L = L_{eff} - 2\Delta L$,

$$\text{Where} \;\; \text{Leff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$

Calculation of Length Extension

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

If V_i is the amplitude of the incident wave and V_r that of the reflected wave, then the return loss can be expressed in terms of the reflection coefficient Γ as:

$$R_L = -20\log|\Gamma|,$$

and the reflection coefficient Γ can be expressed as:

$$\Gamma = \frac{V_r}{V_i}$$

For an antenna to radiate effectively, the return loss should be less than −10dB.

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3. RECTANGULAR MICROSTRIP ANTENNA WITH AND WITHOUT MODIFIED GROUND PLANE

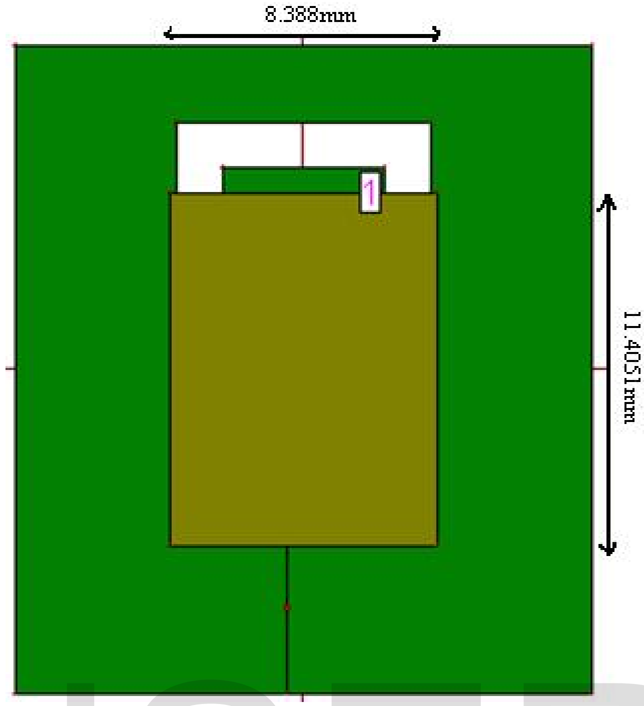

Figure 3.1. Upper Layer and Ground Layer Antenna

The configuration of the conventional printed antenna is shown in Figure 3.1 with L=8. 388 mm, W=11. 4051 mm, substrate thickness h = 1.6 mm, dielectric constant $\varepsilon_r = 4.4$. The coaxial probe - feed is located at y=W/2 =11. 4051/2=5.70255 mm and x=$\frac{L}{2\sqrt{\epsilon_r}}$ =2mm.

Bandwidth Improvement using Slot Coupling

The patch and slots are separated by an air gap and a material with low dielectric constant. There are two types of slot. If the slot measurement lengthwise is comparable to the half of the wavelength of the antenna it is called as the resonant slot. If lesser length slots are used, it is called as the non resonant slot.

Impedance Matching Analysis

Impedance Matching was originally developed for electrical power, but can be applied to any other field where a form of energy is transferred between a source and a load. Impedance Matching issues can be analysed as trajectories on the Smith Chart, where the addition of a series or shunt component moves the total impedance along constant impedance, admittance, or resistance circles. If the task is to match the specific impedance to a reference impedance (generally to 50 Ω), then the target of the impedance matching is to arrive at the centre of the Smith Chart by moving along the arcs from the initial point. If the task is to provide impedance matching to impedance other than the reference impedance, then the end point of the matching trajectory must be the conjugate of the target impedance. The closer an Impedance Matching trajectory comes to the edge of the Smith Chart, the narrower the bandwidth. Maximum bandwidth for a given matching network can be obtained by keeping the trajectories short, well away from the edges of the Smith Chart, and as close as possible to the real axis.

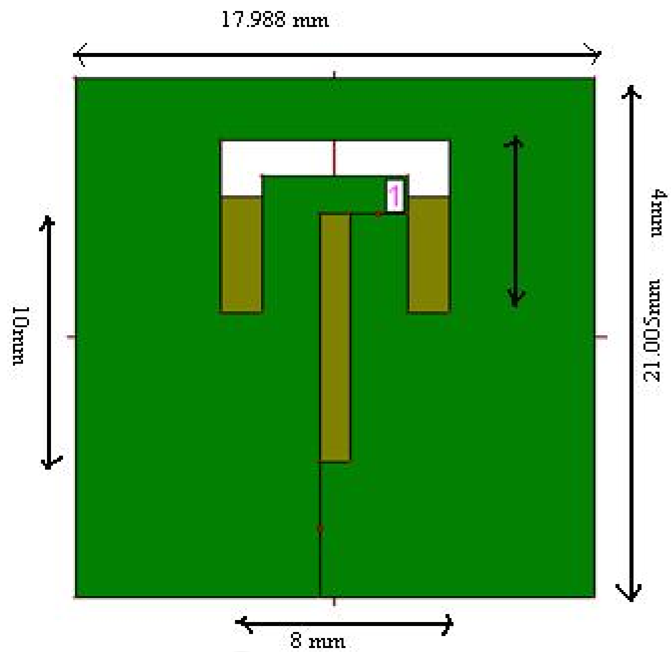

Figure 3.2. Ground Layer of Antenna

Ground Plane Design

L_g=6h+L=6x1. 6+8.388=17.988mm, W_g=6h+W=6x1. 6+11.4051=21.0051mm.

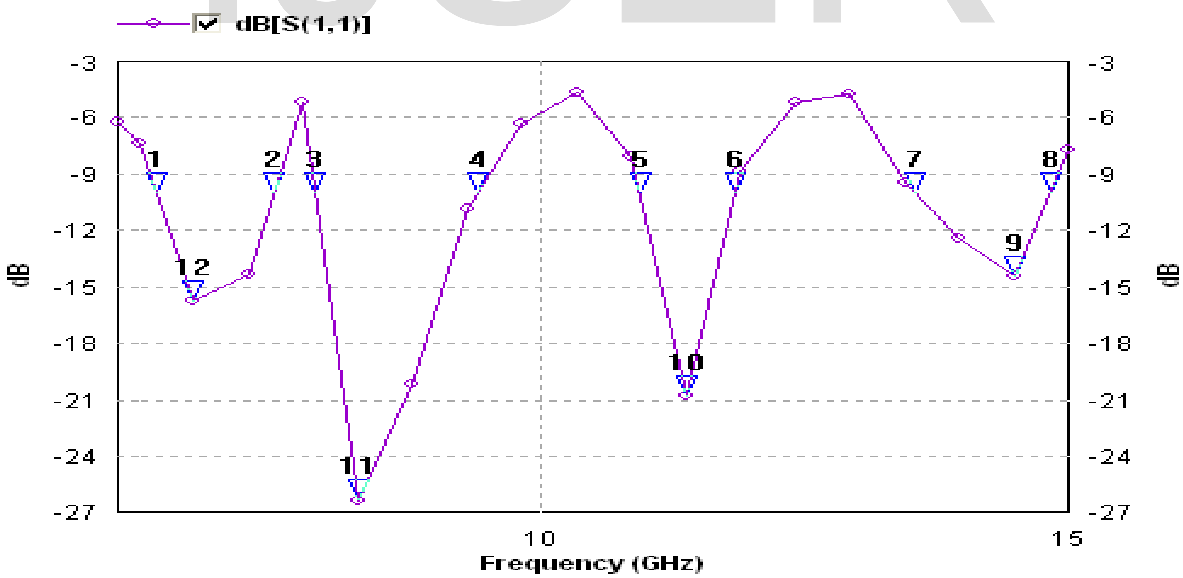

Figure 3.3. Return Loss of Broadband Multiband Antenna

In fig 3.3 shows the point 12,11,10 and 9 are return loss at different frequencies with impedance matching Enforce matching to 50ohms at the 1-port circuit is connected to a series L=0.568194(nH) then a shunt C=0.295294(pF) at frequency 6.72414GHz.Enforce matching to

50ohms at the 1-port circuit is connected to shunt C=0.14148(pF) then a series L=0.713651(nH) at frequency 7.241GHz. Enforce matching to 50ohms at the 1-port circuit is connected to shunt C=0.117969(pF) then a series L=0.302038(nH) at frequency 8.276GHz.Enforce matching to 50ohms at the 1-port circuit is connected to a shunt C=0.108948(pF) then a series L=0.374275(nH) at frequency 14.48GHz.

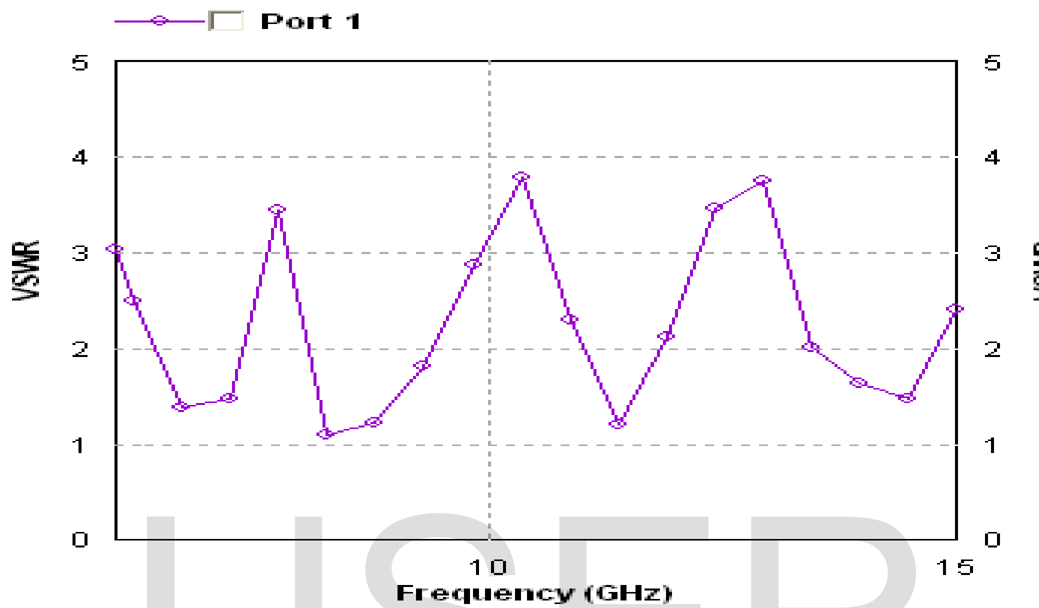

Figure 3.4 Graph of VSWR of Multiband Antenna

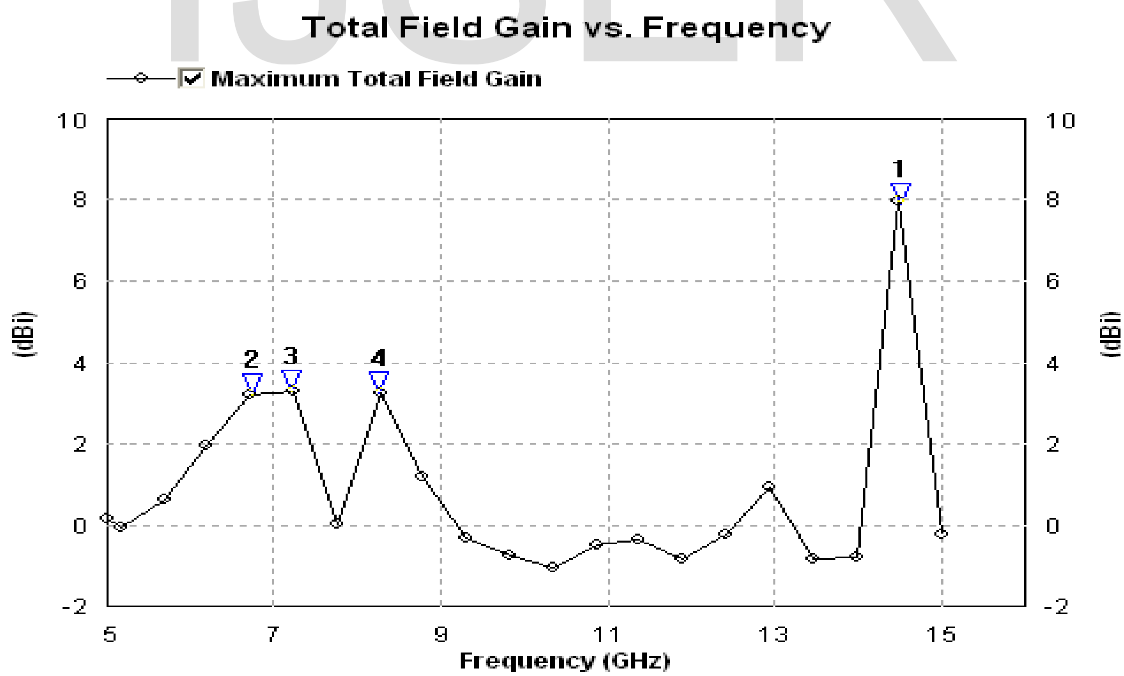

Figure 3.5 .Graph of Total Field Gain Vs. Frequency of Multiband Antenna

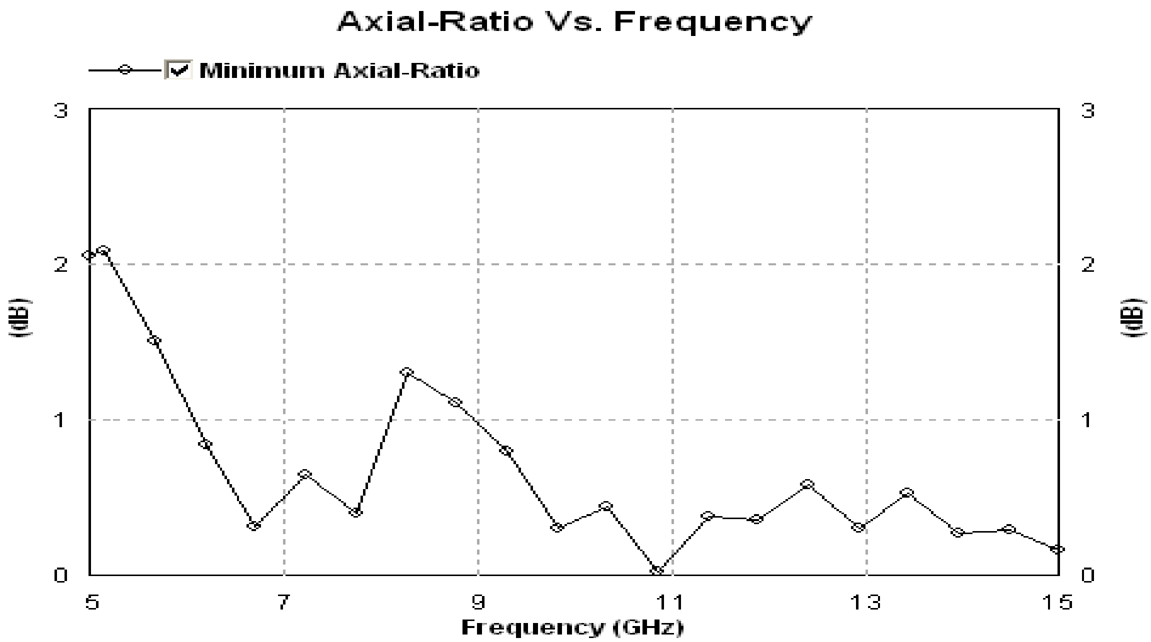

Figure 3.6. Graph of Axial Ratio Vs. Frequency of Multiband Antenna

axial ratio: ratio of maximum to minimum power contained in the field components of the polarization ellipse The axial ratio is the ratio of orthogonal components of an E-field. A circularly polarized field is made up of two orthogonal E-field components of equal amplitude (and 90 degrees out of phase). Because the components are equal magnitude, the axial ratio is 1 (or 0 dB).

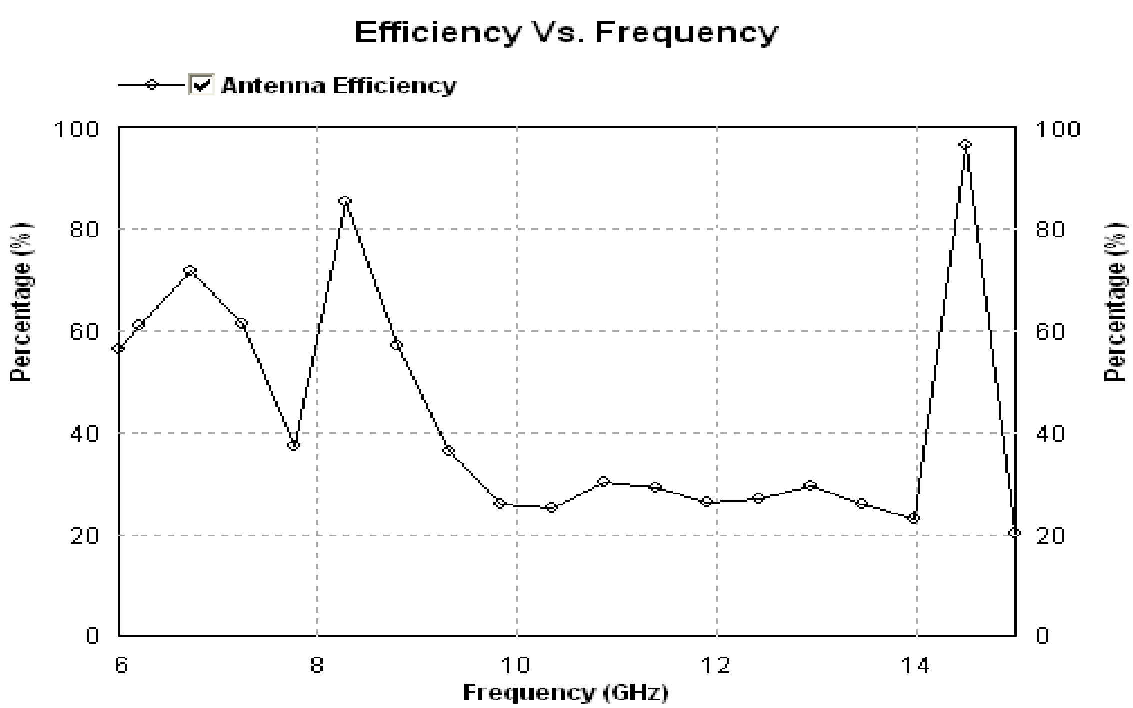

Figure 3.7. Graph of Efficiency Vs. Frequency of Multiband Antenna

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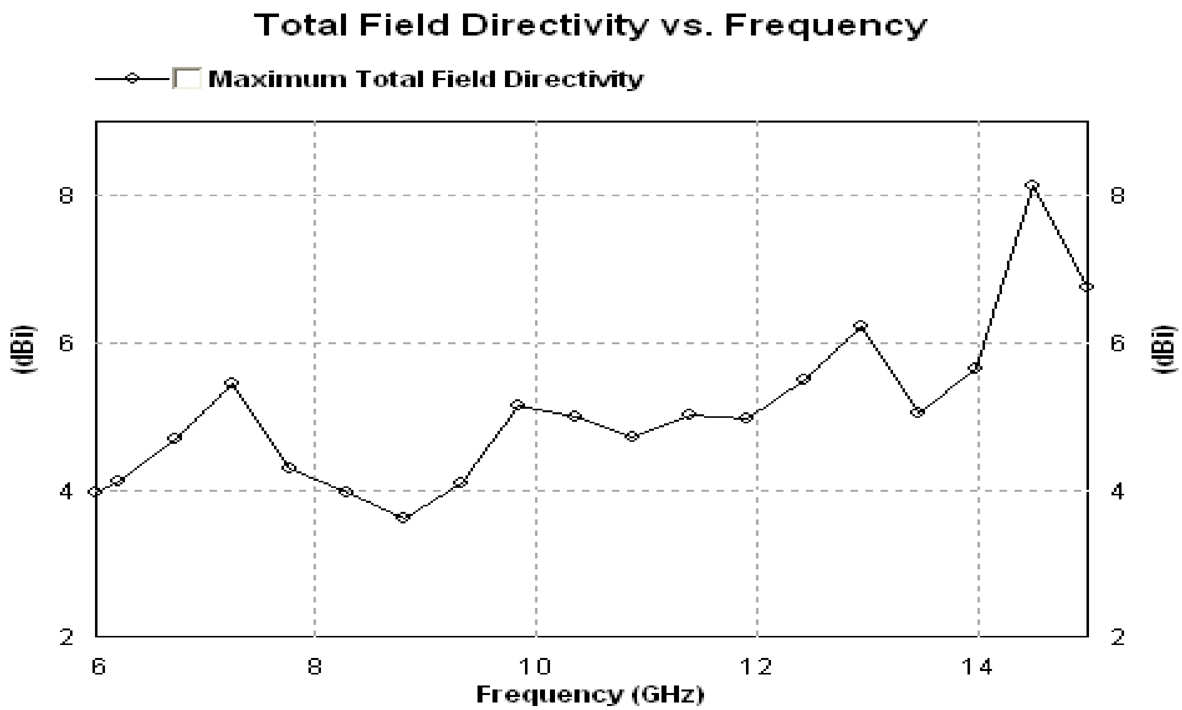

Figure 3.8. Graph of Total Field Directivity Vs. Frequency of Multiband Antenna

4. OUTCOMES AND DISCUSSIONS:

From the Simulation result of Antenna, it is observed that, the impedance bandwidth (VSWR ≤ 2) below -10 dB return loss obtained are 1.11885GHz, 1.53012GHz, 0.908GHz and 1.2886GHz. The multiband antenna consists of a single layer patch antenna with two parallel slots Inverted U- shaped designed in Ground Plane. The result shows that the return loss of is achieved at the first resonant, -15.71dB frequency of 6.72414GHz, -14.39dB at the second resonant frequency of 7.24GHz, -26.33dB dB at the third resonant frequency of 8.27GHz, -20.79dB at the fourth resonant frequency of 11.38GHz and -14.46dB dB at the fifth resonant frequency of 14.48GHz. From the Simulation result of compact multiband antenna of xial Ratio, total field gain, antenna efficiency, and VSWR are shown in Figure 4.6,4.5 4.7 and Figure 4.4. IE3D is employed to analyze the antenna and simulated results in return loss, axial ratio, total field gain, and VSWR plot is presented.

5. CONCLUSION

A slot coupled microstrip patch antenna for broadband applications at C and X band, which may be useful for the current miniaturized wireless communication system. This modified antenna to have characteristics of multi band operation, enhance bandwidth, along with reduce size and meandered gain, which is used for C and X band applications. Excellent agreement the simulation results are obtained.

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