Design of Multiband Antenna for Wireless Communications

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***Abstract*— Antennas play a major role in modern communication systems. Nowadays, mobile equipment is required to cover various communication services (Wi-Fi, Bluetooth, GPS, LTE and VOLTE) Each service is offered at different frequencies so a separate Antenna is used uniquely for every single application. In various mobile communication services, long-term evolution (LTE) is one of the widely used communication systems as a fourth-generation wireless service. Because each nation or wireless carrier uses different frequency bands, a multiband antenna is desirable. Moreover, the role of multiband antennas becomes more important because the carrier aggregation technique of LTE-Advanced communication system has been released.**

Proposed multiband antenna has to be operated over the quad-band in LTE/GSM/VOLTE services. It consists of antenna with Rectangular slots. The antenna operates at the high-frequency band covering GSM900 (900–1080MHz), LTE2300 (2305–2400MHz), VOLTE (800MHz, 1800MHz and 2300MHz) and WiMax (3500MHz).

The range of Ultra Wideband (UWB) is 3.1 GHz to 10.6 GHz, used for WiFi and WiMAX applications. To operate antenna in multiple selected frequencies, slotting has to be made on the patch with different positions and shapes. Now-a-days, the antennas used for Wi-Fi, WIMAX applications are operated at single frequency to operate an antenna at multiple frequencies, multiple antennas are required. Instead of using multiple antennas, by making a slot on patch, single antenna can be used to operate at more than one frequency, thereby enhanced bandwidth can be provided to Wi-Fi and WIMAX users. There are several unlicensed bands in ultra wide band range. The main goal of the research is to design an antenna which can operate at multi-bands and provide more bandwidth to Wireless users.

Here HFSS and IE3D Softwares is used for simulation.

***Keywords: Antenna, Multiband Antenna, Micro strip antenna, Slotting, HFSS software*, IE3D software.**

I.INTRODUCTION

The wireless communication devices such as mobiles, Bluetooth use worldwide Interoperability for Wi-Fi (wireless Fidelity), WIMAX (microwave acess), GSM(global system for mobile communication), LTE(long term evaluation) , VOLTE frequency bands. LTE is widely used as a fourth generation wireless services. As of now

conventional out designed is able to operate only in one frequency band. For multiple applications we need to design multi band antennas. Hence there is a need to design a multi band antenna which will work at multiple frequencies. Rapid growth in wireless technology lead awards configuration of gadgets with reduced size and multi functionality various. Wireless sensors are provided with various applications like GPS, GSM Wi-Fi, Wi Max, Bluetooth with different range of frequencies. As design of antenna plays a vital role in wireless communications devices, the requirement is to design an antenna which is small, light weights, in expensive and able to operate at various frequencies ranges.

Printed designs are well known because of their conformal aspects which allows simple combination with the planar PCB'S. A wireless communication devices provides the ability to integrate multiband operation. Therefore the need to design a multiband antenna is highly increased since it is attractive in any many commercial applications because a single radiator is capable to transmit and receive multiple frequencies. We use antennas in various applications like high performance Aircrafts, Space crafts, Satellite and Missile applications where size, weight, cost, performance, ease of installation and Aerodynamic profile are constraints. At present there are many other commercial and government applications such as mobile, radio, wireless communications with similar specifications. For such specifications microstrip antennas can be used. The idea of providing slotting to patch of antenna will make antenna to operate in multiple frequency bands [1]. Here we have used rectangular slots on patch of antenna for efficient excitation of the slot. The strip is either short circuited at the dielectric substrate to the edge of slot or strip line is ended in an open circuited substrate outside the edge of the cut slot [2].

The design of multiband antenna with slotting has been studied theoretically and experimentally by many researchers. The techniques used to compute this are based on transmission line model . The analysis is carried out in spectral domain found in [3-4]. In this to get the slot size, resistance observed at the field line is done in three possible ways [5]. One way is off centred feeding suggested by Yoshimoura. Another is turning of the slot by employing stabs as suggested by on Pozar [6]. The rectangular made antenna to operate in single and dual resonance frequency of operations on the patch is discussed in[7-8].

The proposed antenna is designed and simulated to operate in multiple frequency bands by etching the slot on the patch. The simulations are performed using commercial Electromagnetic softwares HFSS for microstrip antenna with substrate Rogers 5880 and IE3D for multiband antenna for FR4 substrate.

II. DESIGN SPECIFICATIONS

To design a multiband antenna using transmission line model we need frequencies = 900MHz, 1.8GHz, 2.4GHz, 3.5GHz Dielectric constant (ϵ_r) = 4.4 , Height of substrate=1.5mm.

1. Width of the Patch

$$W=\frac{C}{2f\sqrt{\frac{\epsilon_r+1}{2}}}=38.1\text{mm}.$$

Where, C=Free space velocity of light.

$= 3\text{x}10^{10} cm.$

$\epsilon_r =$ Dielectric constant of substrate.

2. Effective dielectric constant of the rectangular micro strip patch antenna (ϵ_r)

$$\epsilon_{eff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2}=4.1.$$

3. Effective length (L_{eff})

$$L_{eff}=\frac{C}{2f_0\sqrt{\epsilon_{eff}}} = 30.9\text{mm}.$$

4. Actual length of the patch (L)

$$L=L_{eff} -2\Delta L = 28.5\text{mm}.$$

5. Calculation of Length Extension

$$\frac{\Delta L}{h}=0.412\frac{(\epsilon_{eff}+0.3)}{(\epsilon_{eff}-0.258)}x\frac{(\frac{w}{h}+0.264)}{(\frac{w}{h}+0.8)} = 0.67$$

Ground plate calculations:

1. Length (L_g) = 6h+L=38.56mm.
2. Width (W) =6h+W=47.1mm.

Feed point location(x):

Here coaxial probe feeding technique is used

$R_{in}=R_e sin^2(\frac{\pi x}{L})$

R_{in} =Input impedance 50Ω

$R_e=\frac{1}{2(G_s+G_m)}$

G_s=Slot Conductance

G_m=Mutual Conductance

R_e=200Ω (approx 199Ω)

X =6.70mm.

III. ANALYSIS OF RECTANGULAR MICRO STRIP PATCH ANTENNA AND MULTIBAND ANTENNA:

The Rectangular Micro strip Patch Antenna is designed on Rogers 5880 substrate where as for multiband antenna we have used FR4 substrate. Parameters specifications of rectangular micro strip patch antenna and multiband antenna are shown above.

(i) Design of Rectangular Patch Antenna

HFSS Software is used to design and simulate Patch antenna. The designed rectangular patch antenna with probe feed is shown in figure 1.

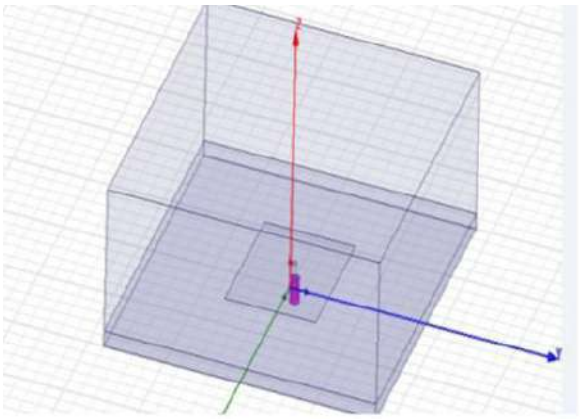

Figure 1: Designed Rectangular Patch Antenna.

(ii) Design of Multiband Antenna

Multiband antenna is designed and simulated using IE3D software. To get an antenna to be operated in Multiple frequency bands we need to provide slotting on patch. Here we have used Rectangular slots.

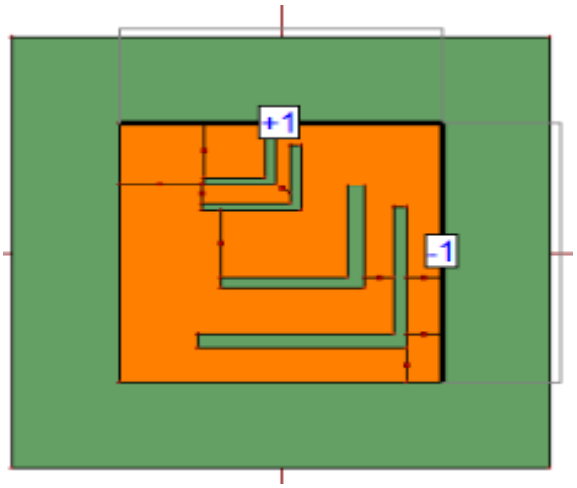

Figure 2: Designed Multiband Antenna

IV.SIMULATED RESULTS

(i) Rectangular Patch Antenna

Return loss: After simulation, the return loss of Rectangular patch antenna is shown in figure 3.At 2.4GHz, obtained return loss is -37dB, Bandwidth=150MHz .

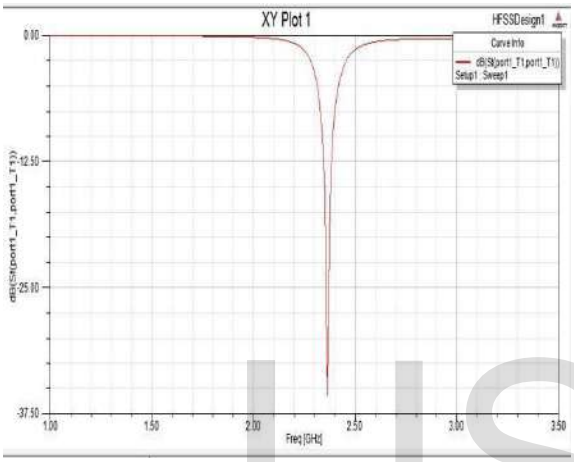

Figure 3: Return loss for Rectangular Patch.

Gain: The simulated gain of the Rectangular patch antenna is 4.4dBi is shown in Figure 4.

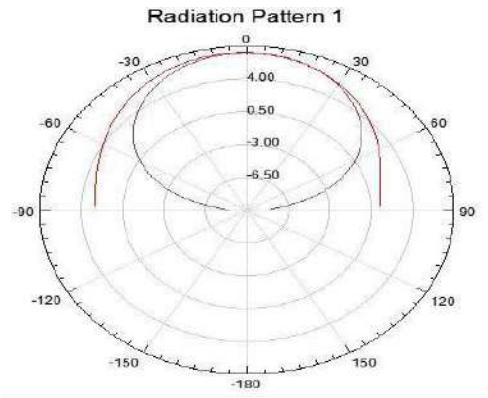

Figure4:Gain of Rectangular Patch Antenna

(ii) Multiband Antenna

Return loss: After simulation, the return loss of Rectangular patch antenna is shown in figure 5.At 0.9GHz, 1.8GHz, 2.4GHz, 3.5GHz obtained return loss is -31dB.

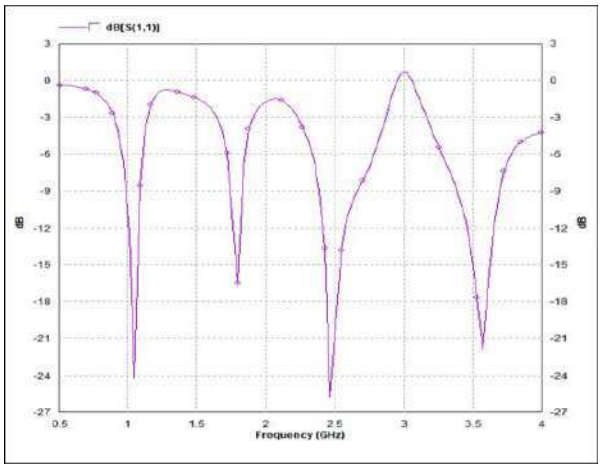

Figure5:Return loss of Multiband Antenna.

Gain: The simulated gain of the Rectangular patch antenna is 2dBi at 900MHz, 4.2dBi at 1.8GHz, 4.9dBi at 2.4GHz and 5.1dBi at 3.5GHz is shown in Figure 6.

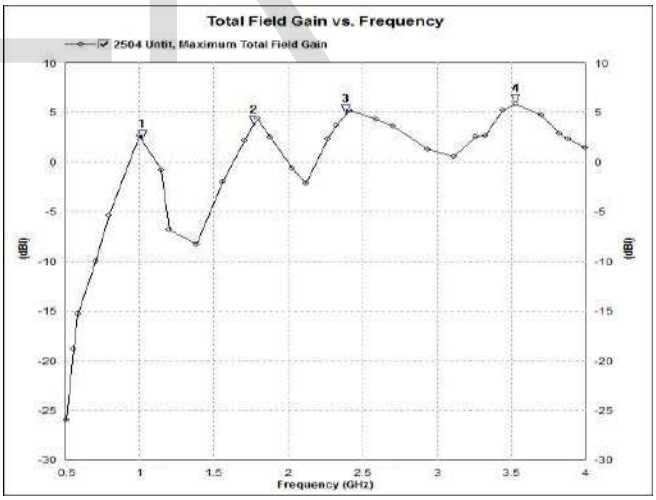

Figure 6:Gain of Multiband Antenna

The results obtained for both Antennas with and without Meta materials are compared in table 1.

Table 1: Comparison of Results

Parameters	**Rectangular Patch Antenna**	**Multiband Antenna**
Frequency	2.4GHz	900MHz,1.8GHz, 2.4GHz,3.5GHz.
Substrate	Rogers5880	FR4
R/L	-37dB	-25dB,-21dB, -24dB,-16dB
Gain	4.4dBI	2dBI,4.2dBI, 4.9dBI,5.1dBI
Polarization	Linear	Linear
Impedance	50Ω	50Ω

CONCLUSION AND FUTURE SCOPE

Conclusion

Thus the design of Microstrip antenna and Multiband antenna which can be used for wireless applications is considered. To design multiband antenna using IE3D software and same could be fabricated and simulated by Fractal antennas but there is a limitation due to the diodes configured in fractal antennas. This designed antenna operates in multiple frequencies which can be used for multiple applications at a time. For example: GSM (900MHz),Voice Over LTE (1800MHz),WIMAX (3.3–3.6 GHz), which can get conflict with single antenna for each application . Here the rectangular patch antenna is simulated in HFSS and multiband antenna is simulated in IE3D separately. Thus concluded that multiband antenna had better gain at all the frequencies. The propose antenna is operating at high frequencies to get the antenna to be operated at low frequency ranges we can have this MPIFA with additional branch line.So that antenna will be capable of operating in more frequency ranges then we can use a single antenna instead of multiple antennas for various applications.

The cause of deviation in the parameter of these slots are studied for antenna characteristics like return loss, VSWR, radiation pattern, current distribution, Efficiency, gain and directivity are simulated.

Future Scope

The antenna can be made to operate in more frequency bands by changing position, size, shape of slotting. If we use Planar Inverted Folded Loop antennas we can operate in Hepta bands. In future use folded loop antenna for better results.

V. REFERENCES

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He designed 8x8 Micro strip Patch Antenna Array for Winf Profiler Radar, operating at 430 MHz at National Atmospheric Research Laboratory, Gadanki, Department of Space, and ISRO. This Radar has been installed at Cochin, Kerala for weather forecast.

He is presently working as Assistant Professor in department of ECE since 2011. He published more than 12 papers in reputed international journals. Presented 2 papers in IEEE international conferences and 5 papers in National conferences. His Research areas of interest are design and simulation of Multi-band Antennas, Electrically small Antennas, Image and Video Processing, communication Networks.