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Design of Miniaturized Multi Band Stub Slot Antenna for Wimax Application

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ABSTRACT: In this paper, the design of a multiband antenna for wireless carrier is proposed. The proposed antenna comprises on FR-4 substrate feed patch, an inverted T-shaped stub and two E-shaped stubs for Worldwide Interoperability for Microwave Access (WiMAX). In proposed system to overcome limitation of several slots, Several stubs are used. We are using two feed patch in which first feed patch are generated at the frequency of 3.27-3.97 GHz for the WiMAX system. By using secondary feed patch last band is generated, 4-4.2 GHz for C bands.The proposed system is designed using EM simulation tool HFSS (High frequency structure simulator).

KEYWORDS: Isolation, Return loss, Directivity, Reflection coefficient.

I. INTRODUCTION

Integrated Multiple wireless carrier demand is increased into single standard of multiband antenna to accommodate new service. For the requirement of high gain and directional radiation, feed patch or microstrip antenna is employed. Meta-materials is used in fabrication of such types of antenna for increasing attenuation. For reducing the size of antenna many design are implemented by maintaining good performance. WiMAX and LTE became popular in high capacity standard communication by making the frequency ratio of the multi-band system even greater than before. Hence so, the design of multi-band antennas becomes more challenging task.

Even slot antenna design have low profile with wide bandwidth and low cost PCB substrates but it is challenging in reducing its structure.In the single-feed design, there are generally two approaches towards multi-band polarization radiation: stacked patch design and single-layer design.For a single-layer design, patch and slot configurations have been used to excite two orthogonal resonant modes with 90 degree phase difference between them.To obtain tri-band operation stacked patches with a coaxial feed are used. In, a multi-band dual-sense circularly polarized slot antenna is obtained by loading the original antenna structure by stub-like slots.

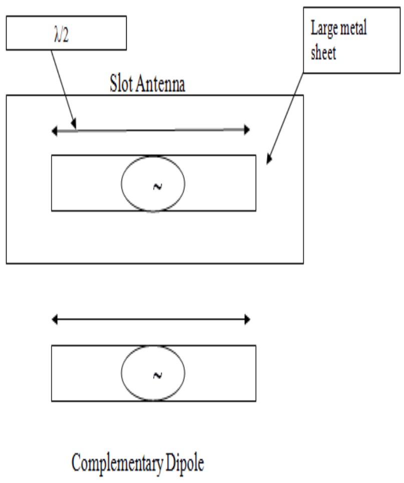

Fig. 1 Structure of Slot antenna

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II. RELATED WORK

In a Compact Multiband Open-Ended Slot Antenna [6] for Mobile Handsets,the space occupied by this antenna is 10 42.5 mm^2. It has two printed open ended slots they are T-shaped slot and E-shaped slot created by etching the ground plane. Small dimension is obtained by bending antenna into various shapes. A micro-strip feed line is used for feeding purpose. It supports five resonant frequency GSM900/DCS1800/PCS1900/UMTS and 2.4 GHz based WLAN.In A Mode-Based Design Method for Dual-Band and Self-Diplexing Antennas Using Double T-Stubs Loaded Aperture, E-field distribution and cut-off frequency of individual band of the individual modes in a T-stub loaded aperture, we selected two proper modes for the antenna designed for dual-frequency operations. At two different frequencies, the antenna exist identical radiation characteristics including the polarization, the pattern shape, and the gain level. A rectangular aperture loaded with double T-stub is deployed in this design. Two types of dual-band antenna and self-Diplexing antenna, In this self-Diplexing antenna achieves better port isolation. Its FR4 substrate dimension is 10×42.5 mm^3.

Kin-Lu Wong, Wei-Yu Chen and Ting-Wei Kang [2] designed a small area of 15×31 mm^2. A small size printed planar inverted-F antenna works at one-eighth wavelength mode and is formerly used for WWAN operation.Penta-band WWAN operation is attained in this system. In High-gain dual-WLAN-band dual-loop antennas for MIMO access-points coined by Saou-Wen Su and Fa-Shian Chang [4] for multiple inputs multiple output system. Main feature of this antenna is producing high gain. It consists of three dual-loop antennas which are in medium dimension of $10 \times 20 \times 40$ mm^3. This antenna consists of small inner loop and large outer loop. These loop working at 1.0 wavelength resonant mode. The arrangement of antenna is in a sequential rotating order with inclination angle 120 degree. Impedance matching is attained at certain fixed frequency band and also depends on width size of feeding and grounding section. High gain and directional radiation results in well port isolation. The envelope correlation is very less in this antenna.

In a Compact Micro-strip Slot Triple-Band Antenna for WLAN/WiMAX Applications, a slot is made in ground plane using the etching technique [11]. A feeding is provided with coaxial coupling technique. It contributes three impedance bandwidth of 600 MHz centered at 2.7 GHz, 430 MHz centered at 3.5 GHz, and 1300MHz centered at 5.6 GHz. In Compact Tri-band Square-Slot Antenna With Symmetrical L-Strips for WLAN/WiMAX Applications[12], a square slot and symmetrical L-strip are innovated in this antenna. It looks minimized in size and simple structural configuration. It comprises a substrate and a ground plane. It is one sided antenna because a ground plane and feed are kept in same side of substrate. The dimension of this antenna is 28×32 mm^2. The square slot is designed with step by step procedure for individual bands works properly.

In Compact UWB Printed Slot Antenna[13] with Extra Bluetooth, GSM, and GPS Bands, octagonal shaped slot is introduced and fed by a beveled and stepped rectangular patch cover UWB band. Three inverted U-shaped strips generate other frequency range. A printed multiband slot antenna for LTE/WLAN applications [2], uses quarter wave radiation mode and U-shaped patch to minimize the size of the antenna. It has substrate size of 46.8×10 mm^2 they proposed the multiband antenna to work under LTE bandwidth. The operating bands of LTE are (700MHz– 2600MHz) and WLAN are (2.45 GHz – 5.5 GHz).

III.PROCESS METHODLOGY

The Creation of physical model is initial task in an HFSS that a user wishes to analyze.HFSS using 3D modeler is created in this model. The 3D model is parametric for a user to create a structure with regard of geometric dimensions and material properties. A parametric values is very useful when dimensions are not known or design is to be varied.

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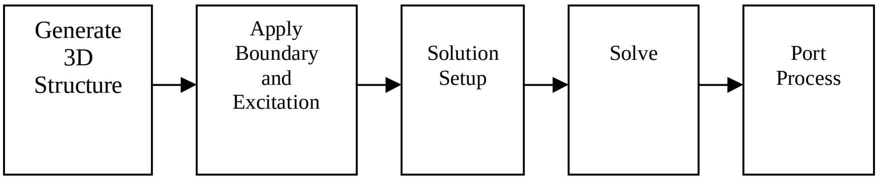

Fig.2 Flow model

The imported structures do not retain any history in the created model, so they will not be parameterizable upon import. If parameterization of the structure is desired, a user will need to manually modify the imported geometry so that parameterization is possible.The next flow is assignment of boundaries. The assigned Boundaries are applied to created 2D (sheet) objects or specific surfaces of 3D objects.In HFSS Boundaries have a impact provides a solution for the users.

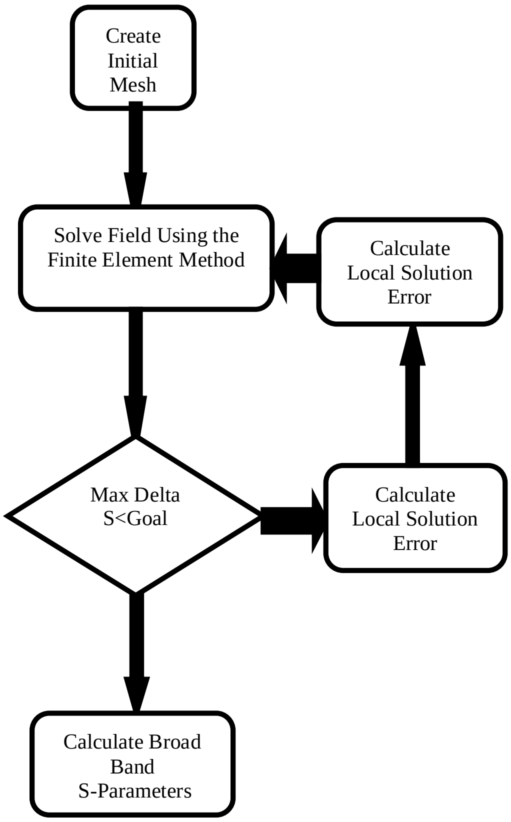

Fig.3 Process Model

After the boundaries have been assigned, the excitations ports should be applied. Once boundaries and excitations have been created, the next step is to create a solution setup. While selecting a solution frequency, the desired convergence criteria, the maximum number of adaptive steps to perform, a frequency band over which solutions are used.

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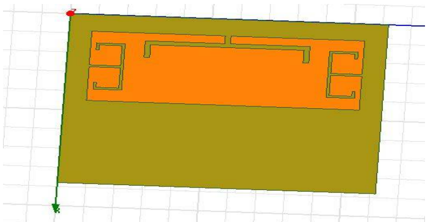

Fig.4 Two E shaped Stub

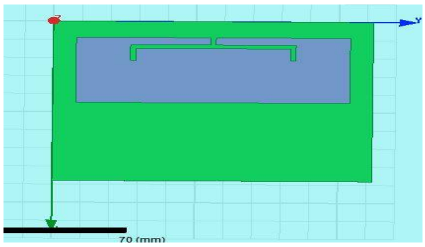

Fig.5 Inverted T shaped Stub

When the initial four steps have been completed by an HFSS and it is ready to be analyzed. The time required for an analysis is highly dependent upon the model geometry, the solution frequency, and available computer resources. Once the solution has finished, a user can post-process the results. Post processing of results can be as simple as examining the S-parameters of the device modeled or plotting the fields in and around the structure.

IV.DESIGN SPECIFICATIONS

The three parameters for the design of a rectangular Microstrip Patch Antenna:

- Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately. The Mobile Communication Systems uses the frequency range from 2100-5600MHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 2.4 GHz.
- Dielectric constant of the substrate (ε_r): The dielectric material selected for our design which has a dielectric constant of 2.45. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.
- Height of dielectric substrate (h): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.58 mm.

Hence, the essential parameters for the design are:

f_o = 2.46 GHz
ε_r = 2.45
h = 1.6 mm

The width of the Microstrip patch antenna is given as:

$$w = \frac{c}{2 f_o \sqrt{\frac{\varepsilon_r + 1}{2}}} = 48mm$$

The effective dielectric constant is

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{w}\right)^{\frac{-1}{2}} = 2.4$$

$$f_o = \frac{c}{2L_e\sqrt{\varepsilon_r}} = 2.46GHz$$

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The effective length is:

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{eff}}} = 41mm$$

The actual length is obtained by:

$$L_e = L + 2\Delta L$$

Where,

$$L_e = 41mm,$$

Hence ,

$$L = 39mm$$

The length extension is:

$$\frac{\Delta L}{h} = 0.412\left(\frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{w}{h} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{w}{h} + 0.8\right)}\right) = 0.506mm$$

In this design, the ground plane dimensions would be given as:

$$L_g = 6h + L = 6(1.5) + 39 = 48 \text{ mm}$$

$$W_g = 6h + W = 6(1.5) + 48 = 57 \text{ mm}$$

V. SIMULATION RESULTS

The software used to model and simulate the Microstrip patch antenna is HFSS software. HFSS is a full-wave electromagnetic simulator based on the method of moments. It analyzes 3D and multilayer structures of various shapes. It can be used to calculate and plot the return loss and directivity as well as the radiation patterns.

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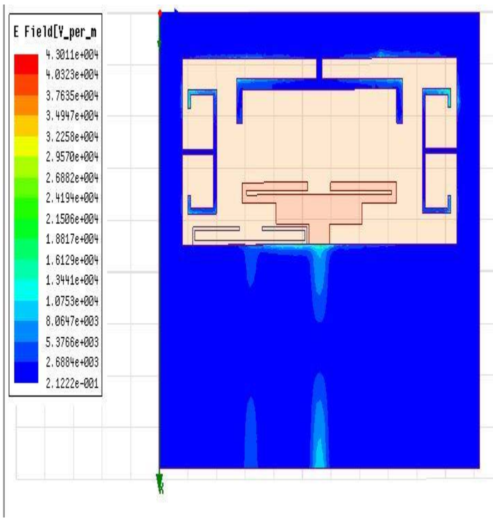

Fig.6 E-field distribution on slotted side at 2.46 GHz

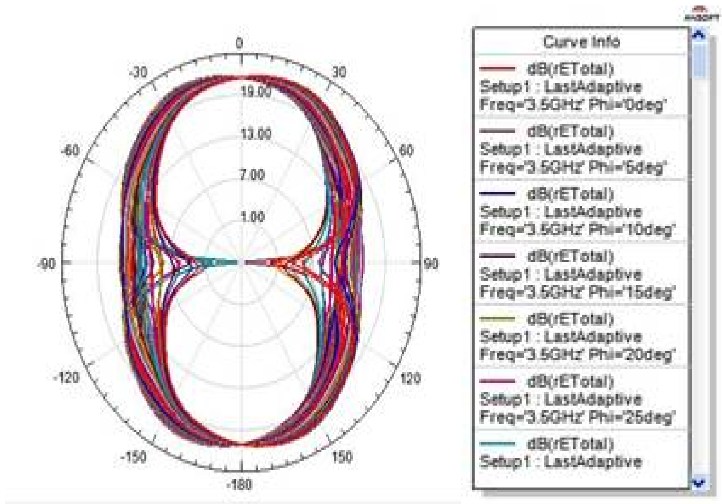

Fig.7 Directivity at 2.46 GHz

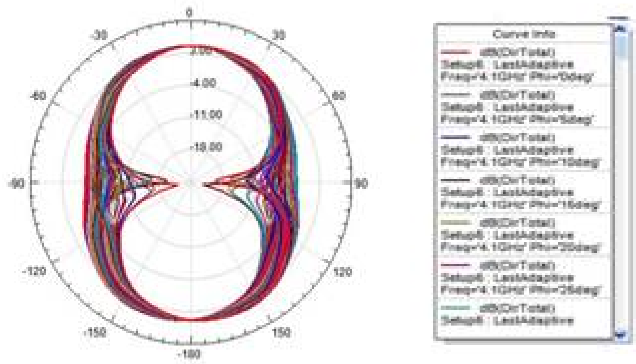

Fig.8 rETotal at 2.46 GHz

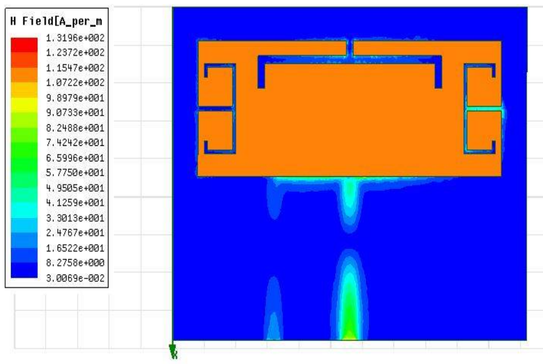

Fig.9 E-field distributed on slotted side at 4.1 GHz

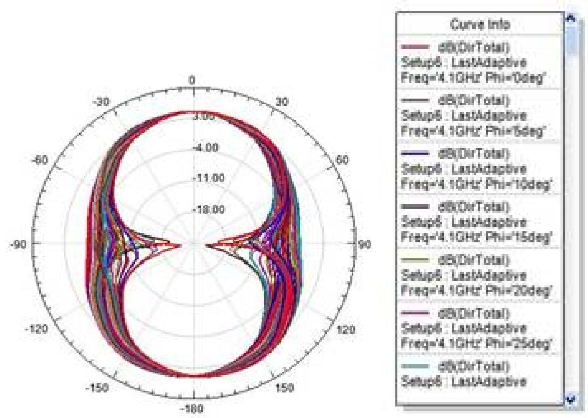

Fig.10 Directivity at 4.1 GHz

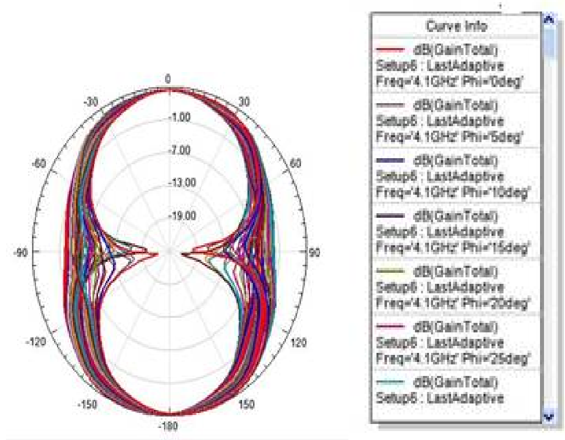

Fig.11 rETotal at 4.1GHz

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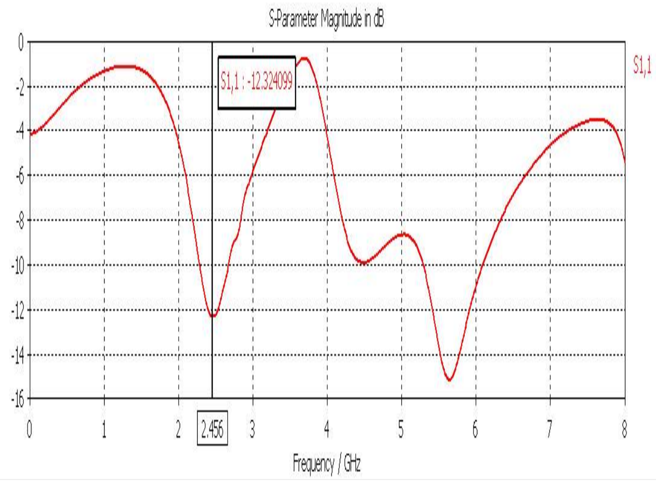

Fig.12 Return Loss for 2.46 Ghz And 5.64 Ghz

VI. COMPARISION RESULTS

Bands	Band 1	Band 2	Band 3	Band 4
Frequency Range (GHz)	1.575-1.66	2.39-3.0	3.25-3.65	4.8-5.7
Return Loss (dB)	- 20	-16.8	-13	- 19.5
Gain (dB)	3.55	3.93	5.02	4.86
Directivity (dB)	3.7	3.45	5.20	5.25
Bandwidth (MHz)	90	610	400	900

Table 1. Comparision table for different band of frequency.

VII. CONCLUSION

In this paper, an inverted T-shaped stub and two E-shaped stubs are proposed at 4 band frequency for the application of WiMAX. It has simple planar structure of small dimension of $48 \times 17.5 mm^2$ with the proposed work of the antenna system is evaluated. The directivity and return loss are measured. Hardware can be tested using this data.The investigation has been limited mostly to theoretical study due to lack of distributive computing platform. Detailed experimental studies can be taken up at a later stage to find out a design procedure for various frequencies.

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