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Design Of Wideband U Slot Microstrip Antenna

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ABSTRACT— The objective of the work is to design a wideband Rectangular Micro strip Antenna for covering wireless Mobile Applications. The proposed antenna geometry describes a coaxial fed rectangular patch printed over a FR4 substrate of thickness 1.6mm and permittivity ε_r=4.4.The design parameters for the antenna are length and width of the patch and slot. Broadening the antenna bandwidth is achieved by U-slot technique. The antenna analysis is carried out with full wave simulation Ansoft HFSS by using the parameters Return loss (dB), Bandwidth, VSWR, Radiation Pattern and gain. The antenna operating frequency range is 1.85GHz - 2.49GHz with VSWR less than 2. It exhibits wideband which corresponds to the gain of 5.48dB. It has wireless applications which require more bandwidth such as for covering all wireless applications of WiMAX, WiFi, WCDMA 3G, and some 4G LTE etc. The simulation results are compared for the performance of antenna.

KEYWORDS— Wideband, u slot, rectangular microstrip antenna

I. INTRODUCTION

In high performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, performance, ease of installation and aerodynamic profile are constrains, low profile antennas may be required. As U slot microstrip antenna operating at a higher order TM_{02} mode it is considered as the desirable candidate for stationary terminals of various indoor wireless communication networks [1].This antenna is best for its wideband characteristics. It is designed to perform other functions which include dual and triple band operations with small and wide frequency ratios as well as circular polarization and also this antenna is simple in structure but versatile in applications [2]. The primary advantage of this approach is the case of fabrication as the design does not require alignment between multiple layers of dielectric and metals. Two U slots are included to provide the operating frequency bands [3]. Dual frequency microstrip antenna for small frequency ratio applications are presented with double u slot etched on the radiating element. The antenna has enough freedom to control the dual design frequencies. It covers the applications such as WCDMA 3G and 4G LTE [4]. A dual frequency resonance antenna is achieved by introducing U shaped slot in semicircular disk. It is analyzed by using circuit theory concept. It is found that the resonant frequency depends inversely on the slot length and feed point while it increases with increasing the slot width and coaxial probe feed radius [5]. In recent years, some papers were reported for dual/triple band operation by using single/double U slot in the microstrip antenna. It is seen that the applications which require dual frequency operation with small frequency ratio were designed by using the U slot in a wideband microstrip antenna [6].The consequences of designing indoor wireless systems with directional antennas at one or both ends of line of sight links are studied [6]. A few designs by using U slot in getting the dual frequency and circular polarization were widely discussed [7].A miniaturized u slot patch antenna with enhanced bandwidth is discussed [8].Several designs for small size wide bandwidth microstrip antenna and designs are based on wideband patch antenna is discussed [9]. Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages with feed [10-12]. The paper is organized as follows: Section 2 explains the antenna operating principle, Section 3 describes about the design specifications, Section 4 details about the parametric study, Section 5 describes about the simulation results and Section 6 concludes the paper.

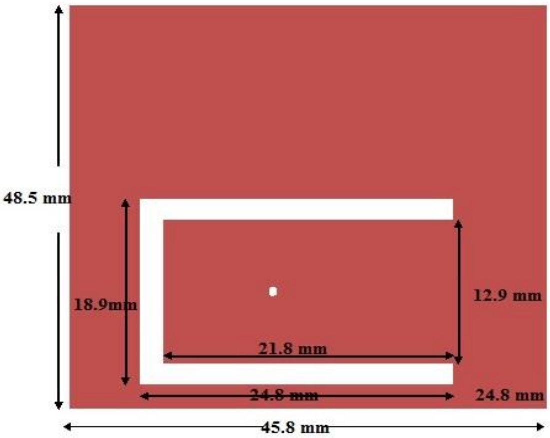


Fig.1.Top view of proposed U slot Microstrip antenna
L=48.5mm, W=45.8mm

II. ANTENNA OPERATION PRINCIPLE AND DESIGN

A .Operation Principle

To design a rectangular patch microstrip antenna operating at wideband the patch length L and width W should be selected correctly .Therefore in order to work on wideband and for the challenge to overcome the narrow bandwidth the u slot inclusion on the patch surface is introduced. It has the advantage of radiating in wideband with better efficiency.

*B.*Antenna Geometry

The proposed antenna geometry consist of coaxial fed rectangular microstrip patch which is printed over a FR4 substrate which is having the thickness of 1.6mm and permittivity ε_r=4.4. A U slot is cut on the patch surface which is mounted over the substrate of size 65*65mm. The other side of the substrate is coated with metal ,which describes the ground plane of the antenna. Hence the dimensions of the antenna are shown in table 1.

III.DESIGN SPECIFICATION

The essential parameters for the design of rectangular microstrip patch antenna: The formulas for calculating the length, width and value of air gap are taken from [9]

Frequency of Operation (f_0): The resonant frequency of the antenna must be selected appropriately. For a wireless application ranges from 1.8GHz to 2.4GHz.The center frequency covering this band is ,

$$f_o=1.5\text{GHz}$$

Dielectric Constant of the substrate (ε_r): The dielectric material selected for our design is FR4 epoxy which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimension of the antenna.

Height of the dielectric substrate (h): For the microstrip patch antenna to be used in wideband applications, it is essential that the antenna is not bulky. Hence the height of the dielectric substrate is selected as 1.6mm.

Hence the essential parameters for the design are

f_r=1.5GHz
ε_r=4.4
h=1.6mm

Step 1: Calculating the width of the microstrip patch:

The width of the microstrip patch antenna is given as:

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

Step 2: Calculating the length of the microstrip patch:

The length of the microstrip patch antenna is given as:

$$\Delta L=(0.412*h)\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.813\right)} \qquad (2)$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff}=L+2\Delta L \qquad (3)$$

For the given resonance frequency f_0, the effective length given by,

$$L_{eff}=\frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \qquad (4)$$

For a rectangular Microstrip patch antenna, the resonant frequency for any mode is given by James and Hall as:

$$f_0=\frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{l}\right)^2+\left(\frac{n}{m}\right)^2\right]^{1/2} \qquad (5)$$

Where m and n are modes along L and W respectively. Using the above formulae, the dimensions of Rectangular microstrip antenna are calculated as L=48.5mm and W=45.8mm

Step 3: Optimum value of air gap height:

The optimum air gap height is,

$$\Delta=0.14\lambda_0-h\sqrt{\varepsilon_r} \qquad (6)$$

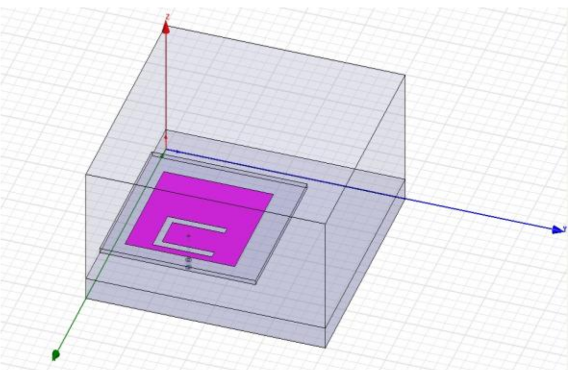
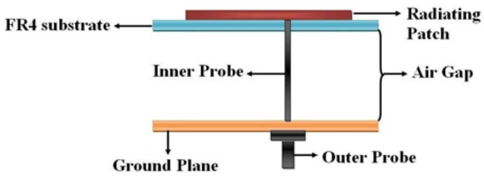


Fig.2. Geometry of proposed U slot microstrip antenna: (a)Top view of proposed antenna



(b) Side view of Proposed Antenna

TABLE 1

DIMENSIONS OF PROPOSED U SLOT MICROSTRIP ANTENNA

PARAMETERS	VALUE
Length of the patch	48.5mm
Width of the patch	45.8mm
Dielectric constant(FR4)	4.4
Height of the substrate	1.6mm
Air gap	8mm

IV .PARAMETRIC STUDY

The parameters that have critical influence on the antenna performance are chosen for parametric study.The parameters are length and width of the slot and patch. The dimensions of antenna are arrived by conducting the parametric study using ANSOFT HFSS software. The slot width and air gap between the ground plane and substrate the key design parameters. The following shows the graphical representation of variation of the design parameters. Figure 5 shows the variation of patch length and figure 6 shows the variation of patch width. Figure 7 gives the variation of slot width. Also Figure 8 gives the simulated radiation pattern and Figure 9 gives the simulated radiation efficiency. It is found that by varying the patch length, patch width, slot length and slot width the wider bandwidth is achieved. Also it is found that by placing air gap between the ground plane and the substrate the gain, Return loss and efficiency is increased resulting in wider bandwidth [Table II].

V. SIMULATION RESULTS

From the above results it is clear that broadening of antenna bandwidth is achieved by using U slot technique. According to the simulated results the U slot technique increases the impedance bandwidth .If lower dielectric constant substrate are used the height of substrate and patch size increases thereby bandwidth is increased. The simulation results for the parameters such as return loss, VSWR, gain, axial ratio and radiation efficiency as a function of frequency are discussed. Hence it is shown that the antenna is resonating at the frequencies of 1.85GHz to 2.49GHz.It has the Return Loss (dB) of 1.85 at -10.43 and 2.49 at -10.42 which has the center frequency at 1.5GHz. In the desired operating frequencies, the VSWR is less than two. Hence, the impedance matching is good between the both frequency range of 1.85 GHZ and 2.49 GHZ. The VSWR in both the frequency range is less than 2. (VSWR < 2) and it has the gain value of about 5.48 dB. The radiation efficiency is obtained as 0.83 or 83 %. Also, the air between the substrate and ground plane influences the radiation pattern. The variation of airgap on the performance of antenna is shown in table II.

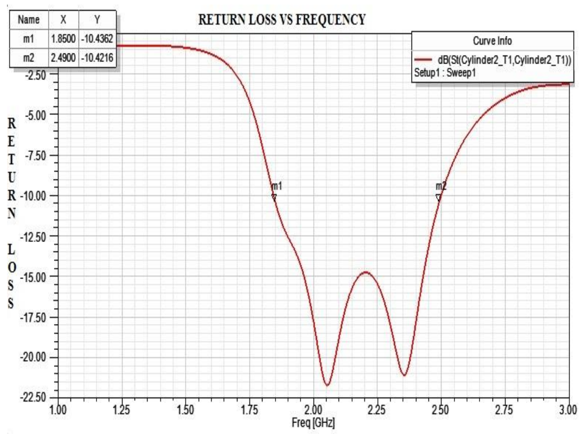


Fig.3 Simulated Return Loss Vs Frequency

This above result shows the Simulated Return loss vs Frequency. It is inferred from the return loss graph that the antenna exhibits return loss value -10.43 dB at 1.85 GHz and
-10.42 at 2.49GHz.

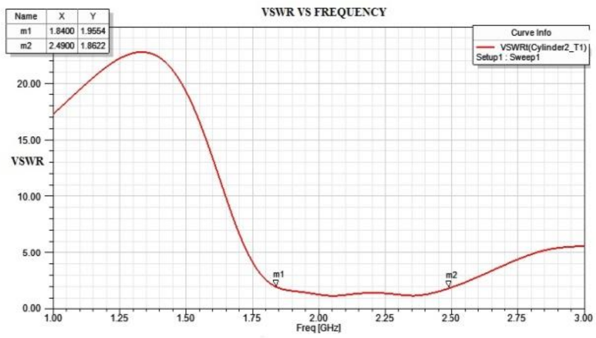


Fig.4.Simulated VSWR vs Frequency

This above result shows the simulated VSWR vs Frequency .It is inferred from the graph that VSWR is less than 2.Hence the antenna is resonating at 1.85 to 2.49GHz.

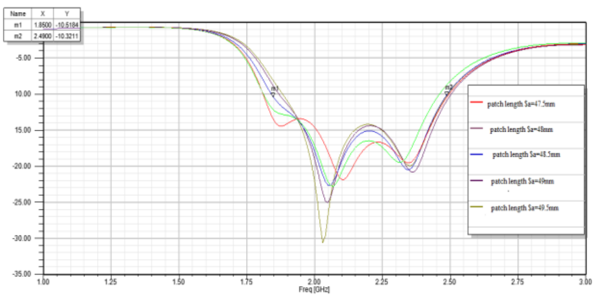


Fig 5.Parametric analysis.(a)variation of patch length

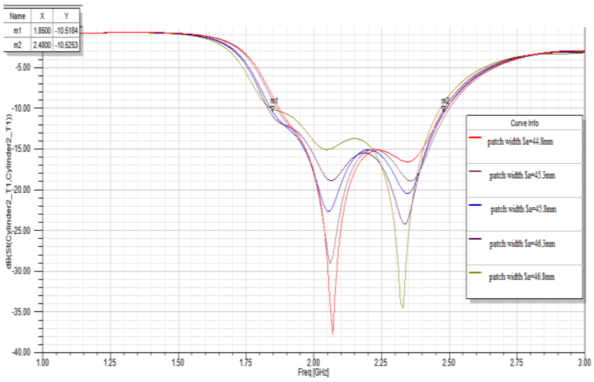


Fig 6. Parametric analysis.(b)variation of patch width.

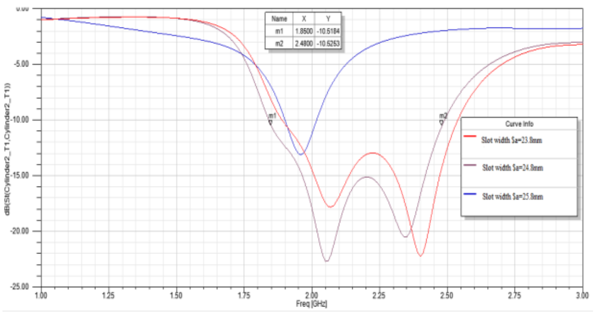


Fig 7.Parametric analysis. Variation of slot width

Hence the above results shows the variation of patch width and variation of slot width.It clearly shows that the antenna is working under the specifications and resonates from 1.85 GHz to 2.49GHz which has many wireless applications.

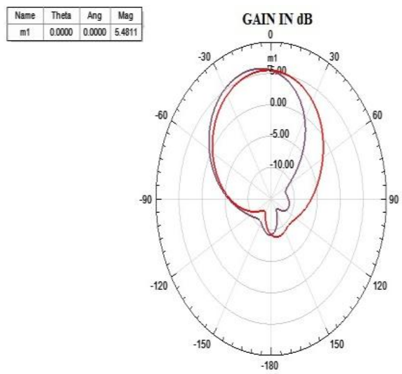


Fig.8. Simulated Radiation Pattern

It is inferred from the above simulated radiation pattern graph that the antenna is clearly having the gain of about 5.48dB at 1.5GHz.

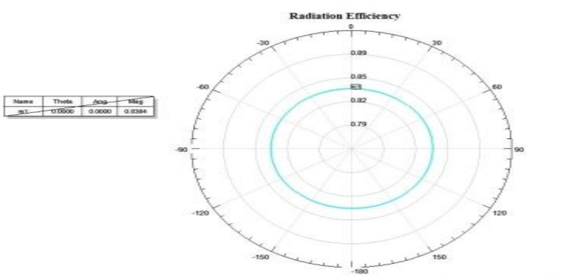


Fig.9.Simulated Radiation Efficiency

It is inferred from the above graph that the antenna is having the radiation efficiency of about 0.83 or 83%.

TABLE II
SIMULATED OUTPUT COMPARISON

Parameters	Impedance BW	Gain (dB) at 2GHz	Resonant frequency	Efficiency
Without Air Gap	1.85GHz-2.49GHz	5.48	1.78 at -21.013 and 2.34 at -18.40	83%
Air Gap	[illegible]		[illegible]	22.34%

VI.CONCLUSION

Thus the above result shows that the antenna resonates from 1.85GHz to 2.49GHz .Thus a simple, low cost wideband micro strip patch antenna for wireless applications is designed, and simulated. It has wireless applications of WiMAX which operates at 2.3GHz, WiFi which works at 2.4 to 2.5GHz, WCDMA 3G which works at the frequency range of 1.92 to 1.98GHz and 2.11 to 2.17GHz and some of the 4G LTE bands and also it works for many wireless terminals.

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