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Design and Simulation of Dual Band Rectangular Patch Antenna for Bluetooth & Wimax Applications

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ABSTRACT
This paper presents a dual band rectangular patch antenna. Here Neltec NX 9240 epoxy[6] substrate material with dielectric constant 2.4 and tangent loss 0.0016 is used. The two bands produced are used for Bluetooth (2.4GHz-2.484GHz) and WiMax (3.2GHz-3.8GHz)[3] applications. The frequency used to set design parameters is 2.43 GHz, so our main focus is on the first Bluetooth band. The feeding technique used for feeding the antenna is coaxial probe feeding technique. When patch is slotted from the middle then its various parameters are being reached to the excellence. The antenna will be fruitful for Bluetooth and middle band WiMax applications. All the simulations are carried out on the IE3D Zeland software.
Keywords*-Rectangular Patch Antenna, Bluetooth and WiMax applications*

I. INTRODUCTION

Microstrip patch antenna consists of radiating patch component, dielectric substrate and ground [1]. It is a low profile antenna. It has many advantages like comfortability, light weight, small dimension, low cost.

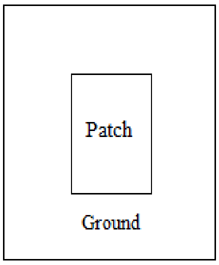

Figure1: Microstrip rectangular patch antenna

In the figure1 there are two rectangles, the lower rectangle is the ground plane which has the area L_g x W_g. Whereas the upper rectangle is the patch which has the area L x W. The substrate is at height h from the ground.

II. ANTENNA PARAMETERS

(a) Gain

The gain of an antenna is defined as the ratio of the intensity ,in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.Formula for gain is $G=4\pi.U(\theta,\phi)/P_{in}$, where, $U(\theta,\phi)$ is a intensity in a given direction, P_{in} is input power.

(b) Radiation pattern

The radiation pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates.

(c) Antenna efficiency

It is a ratio of total power radiated by an antenna to the input power of an antenna.

(d) Return loss

Return loss is the reflection of signal power from the insertion of a device in a transmission line.

(e) VSWR

Voltage standing wave ratio is defined as $VSWR=V_{max}/V_{min}$.It should lie between 1 and 2.

III. DESIGN MODEL

The design parameters are calculated by the following steps

Step1: Calculation of patch width is a first step. The following formula is used to calculate patch width w

$$w = \frac{c}{2f_o\sqrt{(\frac{\varepsilon_r+1}{2})}} \quad \textbf{(1)}$$

Where f_0 is resonant frequency, o_r is substrate dielectric constant and c is velocity of light. Here basic parameters f_0 & ε_r used for calculations are 2.43 GHz and 2.4 respectively

Step2: In second step the ε_{reff} is calculated. To calculate effective dielectric constant ε_{reff} , the formula is

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

Where ε_r is substrate dielectric constant, h is substrate height above ground and w is the width of patch. Design parameter h used here is 1.41 mm.

Step3: In this step ΔL is calculated. Formula for Length extension ΔL is

$$\Delta L = \frac{0.412h(\varepsilon_{reff}+0.3)\left\{\left(\frac{w}{h}\right)+0.264\right\}}{(\varepsilon_{reff}-0.258)\left\{\left(\frac{w}{h}\right)+0.8\right\}} \quad \textbf{(3)}$$

Where ε_{reff} is effective dielectric constant, h is substrate height above ground and w is the width of the patch.

Step4: Next step is to calculate $L_{effective}$. Formula for $L_{effective}$ is

$$L_{effective} = \frac{c}{(2f_o\sqrt{\varepsilon_{reff}})} \quad \textbf{(4)}$$

It is calculated with the help of c, f_0 & ε_{reff}.

Step5: After step4, Patch length is calculated by the following formula

$$L = L_{effective} - 2\Delta L \quad \textbf{(5)}$$

Step6: In the next step the ground length is calculated with the help of following formula

$$L_g = 6h + L \quad \textbf{(6)}$$

Step7: Finally ground width is calculated by the following formula

$$W_g = 6h + W \quad \textbf{(7)}$$

Finally the various parameters taken for the design are as follows

S.No.	Parameter	Value
1	f_0	2.43 GHz
2	ε_r	2.4
3	W	47.34 mm
4	h	1.41 mm
5	L	38 mm
6	L_g	46.46 mm
7	W_g	55.8 mm

Table1 : Various design parameters

The designed antenna is shown in the figure given below.

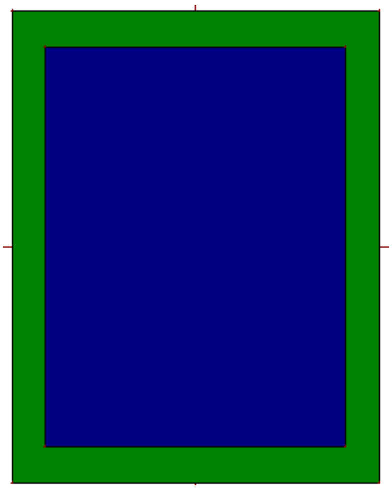

Figure2: Microstrip rectangular patch antenna

Now to improve the antenna performance a slot is made at a middle in the designed antenna as shown in the figure 3.

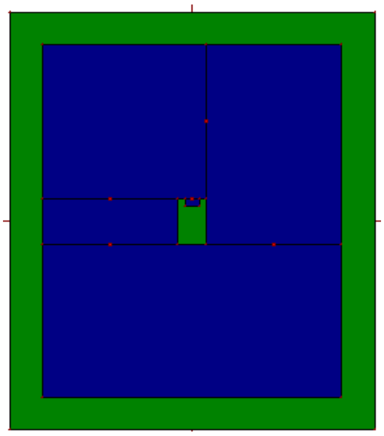

Figure3: Slotted microstrip rectangular patch antenna

IV. RESULTS AND DISCUSSION

The simulations are carried out on IE3D software. On feed point (-6.7,-14) two bands are obtained. The following diagram shows the best feeding point (-6.7,-14), which was chosen after carrying out many simulations.

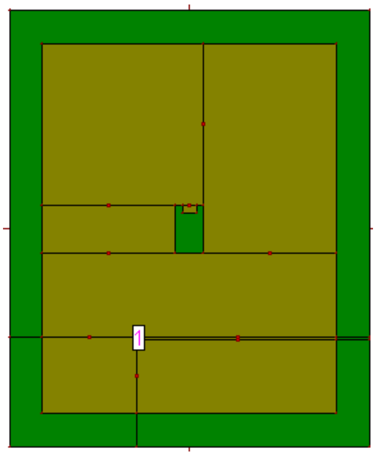

Figure4: Slotted microstrip rectangular patch antenna showing (-6.7,-14) feed point

The two resonant frequencies are 2.410 GHz and 3.232 GHz. The two bands make this antenna useful for two different applications. The first application is Bluetooth (2.4GHz-2.484GHz) and second application is WiMax (3.2GHz-3.8GHz range) application. The excellent results have been obtained especially for the first Bluetooth band; the following table signifies the results

S.No.	Parameter	Results
1	Return loss	-33.57dB
2	VSWR	1.05
3	Antenna efficiency	80.71%
4	Radiation efficiency	81.49%
5	Bandwidth	4.25%
6	Field gain	6.07583 dBi

Table2: Various results for the first Bluetooth band

Also the return loss of second band is -11.6005dB at 3.232 GHz frequency.

Given below are the figures for various results obtained after simulation

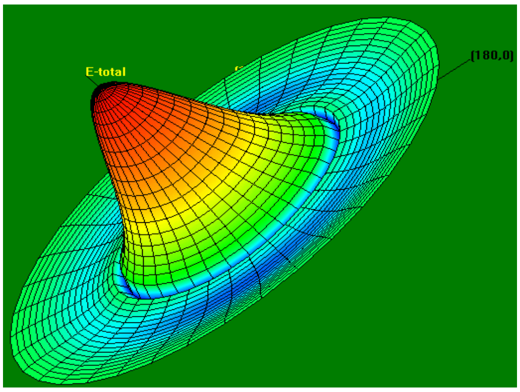

Figure5: Radiation pattern of slotted microstrip rectangular patch antenna at 2.410GHz

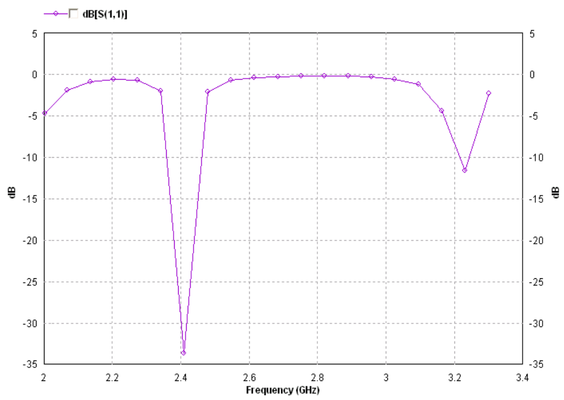

Figure6: Return losses (-33.57dB & -11.60dB at 2.410GHz & 3.232GHz respectively) of slotted microstrip rectangular patch antenna.

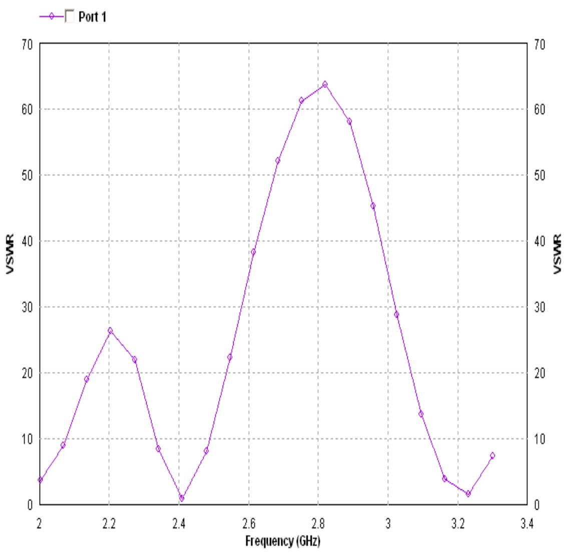

Figure7: VSWR (1.05 & 1.74 at 2.410GHz & 3.232GHz respectively) of slotted microstrip rectangular patch antenna

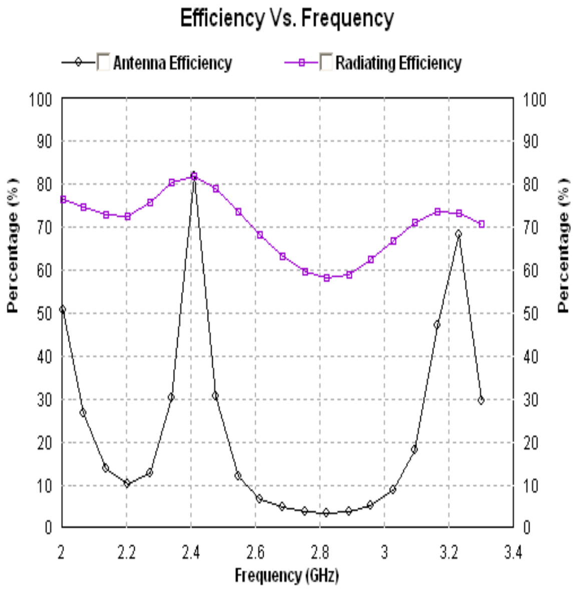

Figure8: Antenna and radiating efficiencies (antenna efficiency 80.71% & radiating efficiency 81.49% for the first band) of slotted microstip rectangular patch antenna

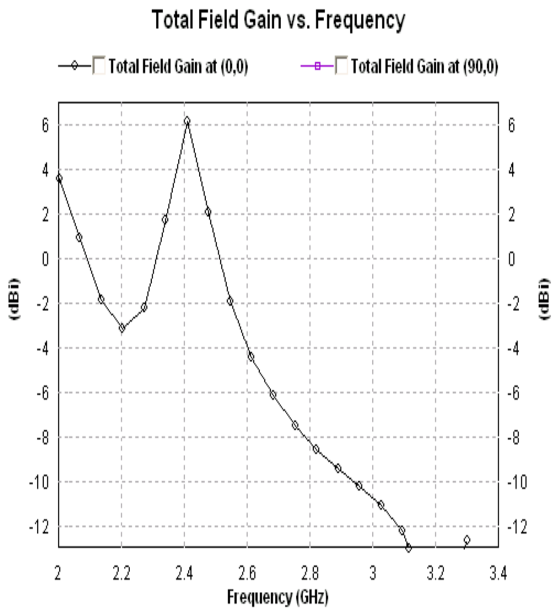

Figure9: Field gain (6.07583dBi for the first band) of slotted microstrip rectangular patch antenna.

V. CONCLUSION

The designed slotted microstrip patch antenna is a dual band antenna which can be used for Bluetooth (2.4GHz-2.484GHz) and WiMax (3.2GHz-3.8GHz) applications. At center frequency 2.410GHz a return loss of -33.57dB was excellent which proves that this antenna is very fruitful for Bluetooth applications. In addition a VSWR of 1.05 at 2.410 GHz is obtained. Also the second band of antenna has a return loss of -11.60dB at 3.232GHz.Secondary as the antenna is slotted down it becomes light in weight [4] which is a desirable application.

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