International Journal of Engineering & Technology, 7 (3) (2018) 1005-1007

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i3.12646
Research paper

Design of rectangular patched microstrip antenna at 2300 MHz

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Abstract

This research paper explains the design of rectangular shaped patch microstrip antenna power fed with coaxial probe feed, which is working around 2300 MHz 4G LTE band of frequency. It is designed by using the FR4 substrate. It applies to the devices which work around this frequency. Theoretical calculations are made and simulation results are performed using Zeland IE3D Software. Their simulation of antenna results exhibits the gain of 1.5 dB, return loss of -14 dB, VSWR of 1.5 and bandwidth of 80 MHz.

Keywords:*Antenna Design; GSM; LTE Band; Microstrip Antenna; Rectangular Patch.*

1. Introduction

With the new technologies, Patch antennas have been attracted more in antenna research. It can be used like in Wireless Fidelity (Wifi), Worldwide Interoperability for Microwave Access (Wimax), Global System for mobile communication (GSM) technologies.
The microstrip patch consists of pattern on upper side of the dielectric substrate and ground plane on the bottom side of it. The microstrip patch antenna has patch on upper side for radiation and ground on the other. The advantages of microstrip antennas are weightless, supports multi polarization, many frequency bands, less fabrication cost. [1-4].
This paper presents antenna design in microstrip Patches width rectangular shape, coaxial probe fed. This antenna is useful in 4G LTE band (2300 MHz) range of frequencies [5]. The antenna geometry designed here serves as the basis for the theoretical studies, which were carried out using a method of moments simulation package Integral Equation of Three Dimensional (IE3D).

2. Antenna design

2.1. Calculation of parameter

Before designing of antenna, we have to calculate the length and breadth of rectangular microstrip antenna [9] theoretically at 2300 MHz frequency.

$$\lambda_0 = \frac{C}{f} = \frac{3X10^8}{2300X10^6} = 0.13 \text{ m} = 130 \text{ mm} \quad (1)$$

C is the velocity of light in free space, f is the frequency of the antenna.
After calculating free space wavelength, we have to calculate resonant wavelength of microstrip transmission by using the substrate material dielectric constant. Here it is taken FR4 material as substrate.

$$\lambda = \frac{\lambda 0}{\sqrt{\varepsilon r}} = \frac{0.13}{\sqrt{4.4}} = 1.57 \text{ m} = 157 \text{ mm} \quad (2)$$

Dimensions of rectangular microstrip antenna are width and length is calculated by the following expressions.

$$\text{Width} = \text{width} = \frac{c}{2f0\sqrt{\frac{\varepsilon r+1}{2}}} \quad (3)$$

$$= \frac{3\times10^8}{2\times2300\times10^6} \times \sqrt{\frac{5.5}{2}}^{\frac{-1}{2}} = 30.73\text{mm}$$

$$\text{eff} = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{w}\right)}}\right] = 4.03\text{mm}$$

Where eff is effective epsilon, it is relative permittivity.

$$\text{Length} = \frac{c}{2f0\sqrt{\text{eff}}} - 0.824h\left(\frac{(\text{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\text{eff}-0.25)\left(\frac{w+0.8h}{h}\right)}\right) \quad (4)$$

$$= \frac{3\times10^8}{2\times2300\times10^6\times\sqrt{4.03}} - 0.824(1.80)$$

$$= 39.66 \text{ mm}$$

Thus λ_0=130 mm, width=30.73 mm rounded to 31 mm, length=39.66 mm rounded to 40 mm. The antenna is theoretically calculated for dimensions. Now it should be simulated in elctromagnetic (EM) software with the above calculations [6-7].

2.2. Antenna geometry

This section presents the antenna geometry. This geometry is rectangular patch designed for having length 40 mm width 31 mm.

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The substrate dielectric constant is 4.4 and height of the substrate is 1.6 mm.

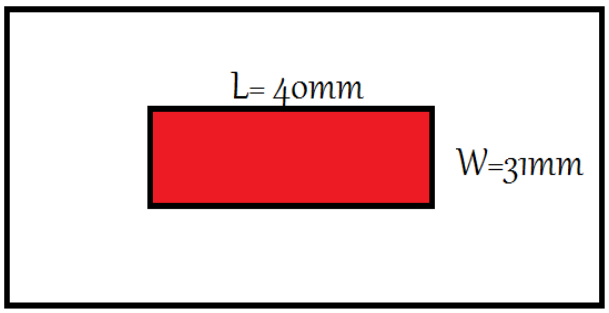


Fig. 1: Rectangular Microstrip Antenna Geometry Top View. L=Length of the Patch Antenna, W= Width of the Patch Antenna. The red in colour indicates the Patch and the White Space Indicates the Dielectric Substrate.

The top view of the rectangular microstrip antenna with ground outer length equal to 80 mm, ground outer width equal to 60 mm, inner length equal to 40 mm, inner width equal to 31mm.

3. Findings and outcomes

The antenna design is done on Electromagnetic (EM) software and it is simulated. The following results were presented.

i) Radiation pattern.
ii) Impedance.
iii) S-parameters.
iv) VSWR.
v) Total Field Gain

Radiation pattern:
The far field three dimensional radiation patterns at 2300 MHz is presented in figure 2.
Impedance:
It is shown by the smith chart characteristics in Figure 3.
S-Parameters:
This graph shows the S-Parameter display at around 2300 MHz frequency for less than -10dB in figure 4.
VSWR:
The voltage standing wave ratio (VSWR) graph is presented. It gives the curve resonating at 2300 MHz less than 2 in figure 5.
Total Field Gain:
The graph shows the gain around 1.5 dB for the resonating frequency 2300 MHz.

3.1. Radiation pattern measurement

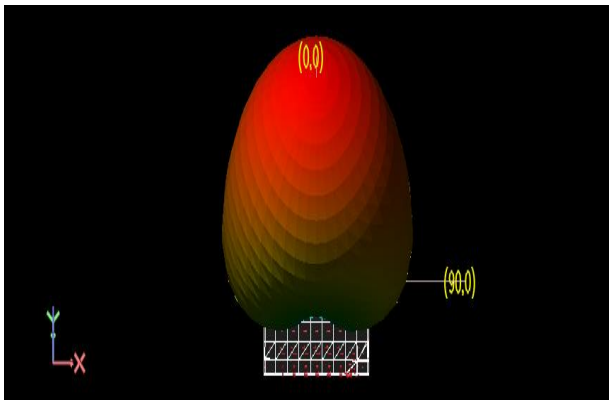


Fig. 2: Three Dimensional Radiation Pattern Display of Rectangular Microstrip Antenna. The red Colour Indicates the Maximum Radiation of Power.

The figure 2 gives the information about the 3Dimensional pattern of Rectangular Microstrip Antenna [8-12]. From the radiation pattern diagram major lobe in the z direction, patch in x and y direction.

3.2. Impedance measurement

Smith chart is a graphical way of representation of real part and imaginary part of the impedance of an antenna.

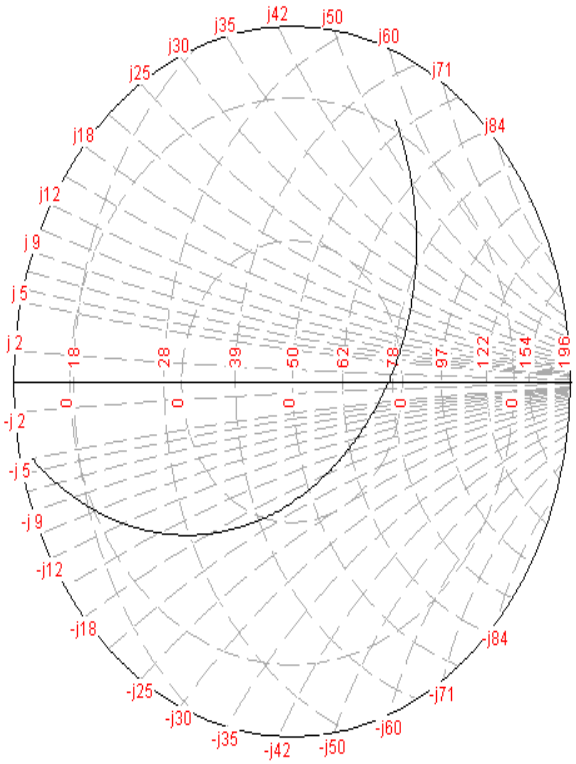


Fig. 3: Impedance Characteristics Display of Rectangular Microstrip Antenna. The Point at Which the Curve and Horizontal Line meets is the Impedance for the Resonant Frequency.

The figure 3 gives the smith chart display of the feed impedance and antenna impedance match. This information is about the matched impedance of the antenna, which is nearly equal to 50 ohms.

3.3. S-parameter measurement

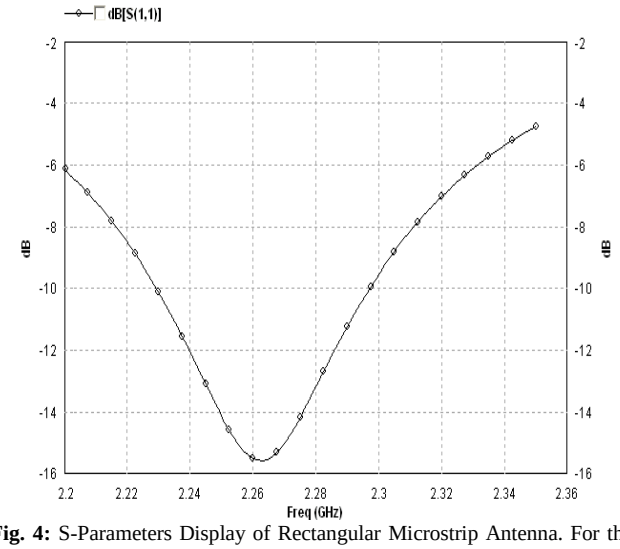


Fig. 4: S-Parameters Display of Rectangular Microstrip Antenna. For the Resonant Band, It Is Less Than -10 dB.

The above figure gives the information about S-Parameters of rectangular Microstrip antenna is resonated to 2260 MHz. The value below -10 dB is acceptable. Here the lower cutoff frequency is 2230 MHz and the upper cutoff frequency is 2310 MHz then the bandwidth is around 80 MHz.

3.4. VSWR measurement

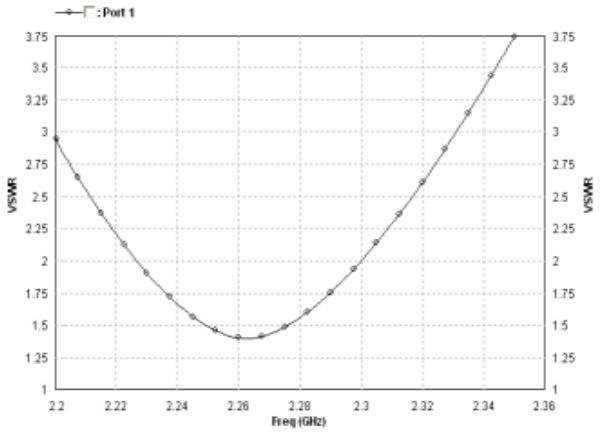


Fig. 5: VSWR Display of Rectangular Microstrip Antenna. For Resonant Bands, It Is Less Than 2.

The figure 5 gives the information about VSWR. Its value is < 2 at 2300 MHz and from this we can obtain reflection coefficient of microstrip antenna by using the formula like reflection coefficient, K= (S-1)/(S+1). Where 'S' denotes the VSWR.

3.5. Gain measurement

The power gain value of the antenna is got with the frequencies and displayed here.

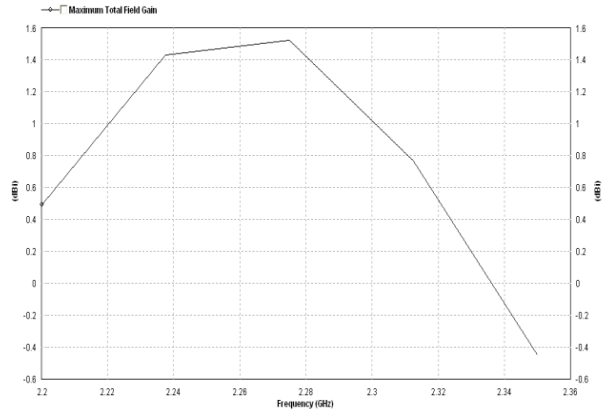


Fig. 6: Total Field Gain vs.Frequency. This Display Gives the Gain Value for the Total Electric Field.

The above figure gives the information about Gain vs. Frequency by simulation the value of gain is above 1 dB at 2300 MHz all the results were listed in Table-1.

Table 1: Results of Antenna

Parameters	Values
Frequency (MHz)	2300
Return loss (dB)	-14
Gain (dB)	1.5
Bandwidth (MHz)	80
VSWR	1.5

4. Conclusion

Coaxial probe fed Microstrip rectangular shape patch antenna is theoritically calculated, designed in simulation software and the results are simulated and analyzed. The resonance frequency obtained is 2300 MHz and it is achieved at VSWR value less than 2. The future work of this antenna is design of antenna in high frequency substrates with low dielectric constant. Also, the work can be improved to get high gain of the antenna. This antenna can be operated for 4G LTE bands in India and may be used for wireless communication, satellite communication, Radar applications.

Acknowledgement

Authors acknowledge the Management and Head of the ECE department, G. Pulla Reddy Engineering College (autonomous), Kurnool, Andhra Pradesh, India for motivating research in the Research lab centre related to antenna.

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