International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 05 | May-2016 www.irjet.net p-ISSN: 2395-0072

An Efficient Patch Antenna in Rectangular Shape by using Defective Ground Structure

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Abstract - *The aim of this work is to design efficient and compact antenna. The design of rectangular microstrip patch antenna is done in this work operates at frequency of 1.716 GHz. The Patch antenna is low profile and easy to fabricate but it does not show high characteristic properties like bandwidth, gain, directivity, efficiency etc. By the use of defected ground structure, it is possible to design efficient patch antenna .With the help of defected structure, the proposed antenna has return loss -33dB, 10 dB bandwidth 109.4 MHz, gain and directivity are 4.432 and 4.842 respectively. This antenna shows huge efficiency that is 90.95%. This antenna is cheap, small in size, easy to fabricate and compact. Designing and simulation are performed in CST-MWS simulator tool.*

Key Words: Rectangular Microstrip Patch Antenna (RMPA), Return loss (RL), Defective Ground Structure, Bandwidth, Efficiency

1. INTRODUCTION

Microstrip patch antenna consist of a metallic patch on a dielectric layer which is supported by ground plane. The metallic patch can take many different configurations. The rectangular patch is the most popular because of the ease of analysis and fabrication[1]. Therefore, the work on rectangular microstrip patch antenna. Antenna cotains inductive and capacitve elements, but at resonant frequency it appears purely resistive circuit, this resistance consist loss resistance and radiation resistance. Discontinuities at truncated edge of microstrip transmission line are generated radiation mechanism. Due to radiation at the edges, antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used. A patch antenna is usually constructed on a dielectric substrate[1,2].

All simulation and designing are executed in Computer Simulation Technology – Microwave Studio (CST-MWS) Software tool.

2. FORMULAE

Parameters of rectangular microstrip patch antenna can be calculated with the help of given formulas as below given [3][4]. The width and the length of patch which is mounted over dielectric substrate can be calculated by using these formulae.

Width (W):

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Effective dielectric constant**:**

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

The actual length of the Patch (L):

$$L = L_{eff} - 2\Delta L$$

Where,

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$

Calculation of Length Extension:

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

Where,

c = free space velocity of light,

ε_r = Dielectric constant of substrate,

f_r = Resonating frequency,

ε_{reff} = Effective dielectric constant,

h = Height of dielectric substrate,

W = Width of patch,

L = Length of patch

and ΔL = Effective Length

3. SIMULATION OF PATCH ANTENNA

CST-MWS is used for simulation of patch antenna. The patch antenna etched on FR-4 lossy substrate which has dielectric constant ε_r = 4.3 and height from ground h = 1.6 mm. Area of ground is 100 X 90 mm^2. Area of substrate is also 100 X 90 mm^2. All parameters of RMPA are shown in fig. 1. All parameters are in millimeter (mm).

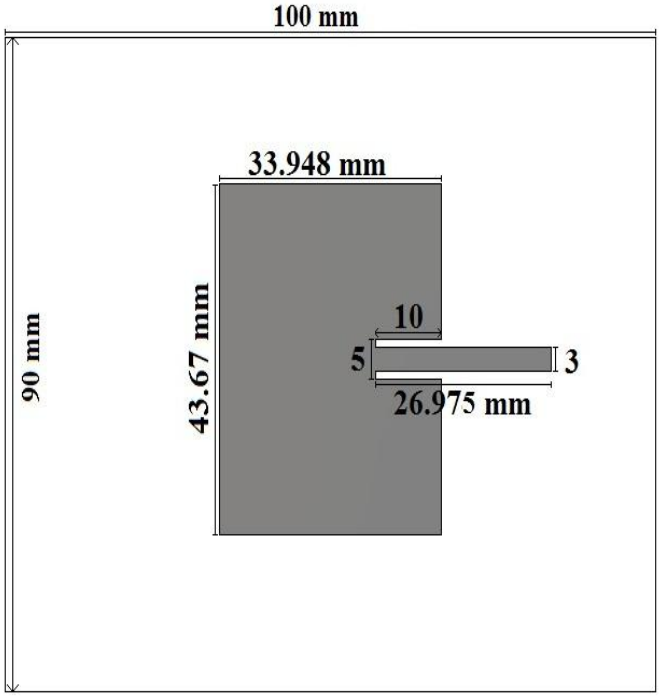

Fig. 1: Microstrip Rectangular patch antenna at 1.716 GHz (all dimensions are in millimeter)

To enhance the operation of various passive circuits, such as the reduced the size of amplifiers, the filter characteristics enhancement and applications to suppress harmonics in patch antennas, the use of discontinuities in ground planes is presently employed [5]. Multiple slots of discontinuities in ground plane enhanced the characteristics of rectangular microstrip patch antenna[6]. These discontinuities improved gain, directivity and bandwidth and reduced return loss and also reduce size of patch antenna. In this work, two rectangular, one circular and one 14 hands polygon shape discontinuities are introduced. The discontinuities at ground of rectangular microstrip patch antenna are shown in fig. 2. All parameters are in millimeter (mm).

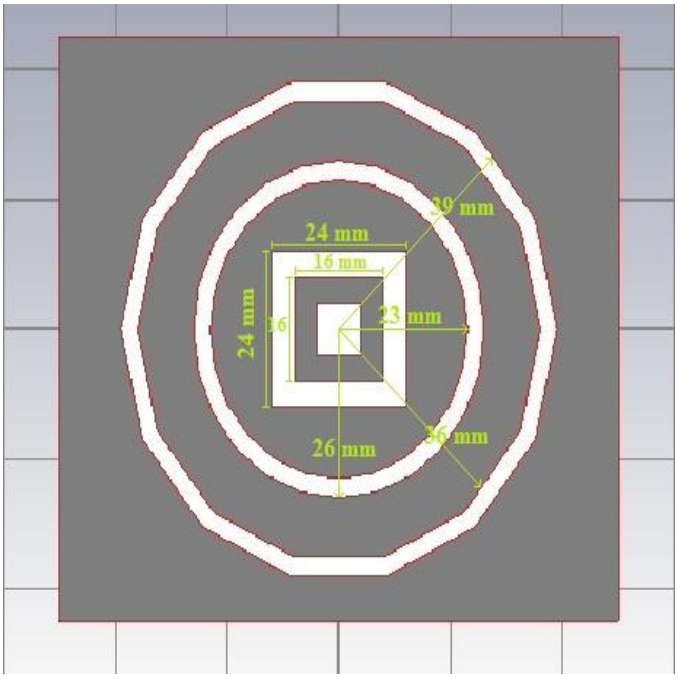

Fig. 2: Discontinuities at ground structure of rectangular patch antenna (all dimensions are in millimeter)

Designed antenna is simulated in CST tool at resonate frequency. After simulation, return loss and operating band of antenna is shown in fig. 3. Fig. 3 shows the RL of -33.24 dB and huge band of 109.4 MHz.

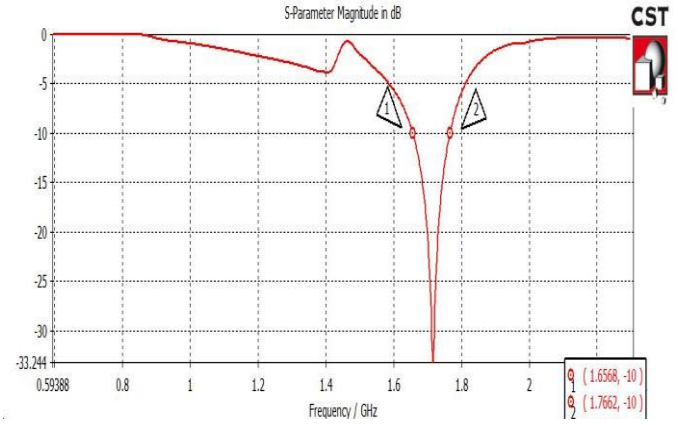

Fig. 3: Result of antenna show Return Loss of -33.24 dB and bandwidth of 109.4 MHz.

After simulation, radiation pattern of designed antenna is shown in below fig. 4 which also shows gain of 4.432 and total efficiency of 90.95%.

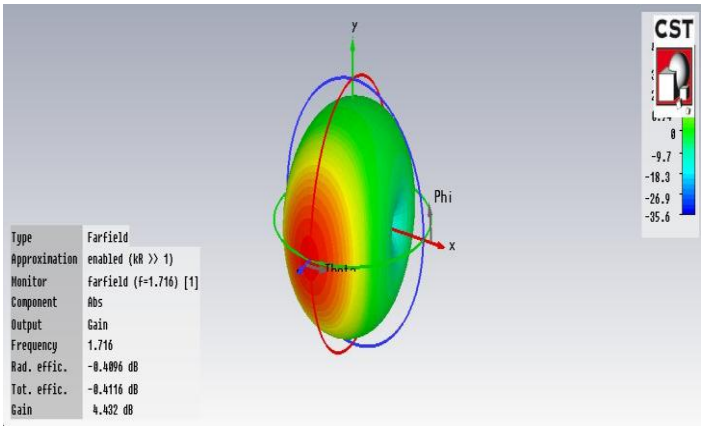

Fig. 4: Radiation pattern of microstrip antenna shows gain and total efficiency

After simulation, radiation pattern of supposed antenna is shown in below fig. 5 which shows directivity of 4.842 dBi.

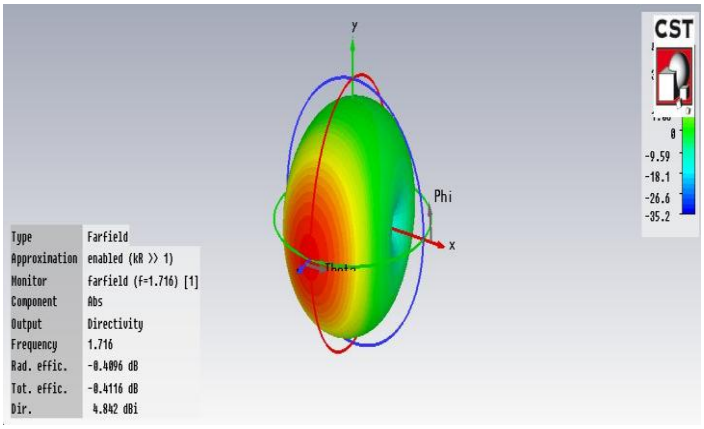

Fig. 5: Radiation pattern of RMPA shows directivity 4.842 dBi

The executed results of the antenna with defected or slotted ground structure are shown in figure 3, 4 and 5. On the basis of simulated result, it has been found that the characteristics of antenna can be increased by defected ground structure[7].

Fig. 3 shows RL and operating band of antenna with defected ground. This figure shows return loss -33.24 dB and a wide band of 109.4 MHz. Fig. 4 and fig. 5 show the radiation pattern of RMPA with defected ground structure. These figures show the gain of 4.432 dB, directivity of 4.842 dBi and massive efficiency of 90.95%. This design also show the size reduction, at this resonating frequency (1.716 GHz) required a comparatively big size patch antenna.

4. CONCLUSIONS

In the above work, the performance parameters of executed antenna with defected structure have been observed and found that performance of patch antenna with defective ground structure is improved. The purpose of this paper provides a reduced size microstrip patch antenna with huge efficiency and wide bandwidth. Finally gotten in result, a small size, less power consumed and less cost antenna at operating frequency 1.716 GHz.

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