Defected Ground Based Design of Multi Slotted Rectangular Microstrip Patch Antenna for S – Band Applications

Karmjeet Kaur, Jagtar Singh Sivia

***Abstract*— In this paper a multislotted Rectangular Microstrip patch antenna (MRPA) is introduced. The modified antenna consists of multislotted rectangular patch with defected ground, an air filled substrate whose dielectric constant ε_r is 1.0006 and feed of co-axial probe. With multislotted patch the various performance parameters of conventional antenna such as gain, return losses and size are improved. At resonant frequency of 2.1 GHz proposed antenna achieved a gain of 7.02 dB, whereas at frequency of 3.8 GHz gain of conventional antenna is 4.30 dB. With defected ground plane proposed design has achieved the gain up to 8.45 dB at the frequency of 2.1 GHz. Size of proposed antenna is reduced by 75 % than the conventional antenna. Also resonant frequency of proposed antenna is shifted to lower side. Analysis of proposed and conventional antennas is done by using HFSS (High Frequency Structural Simulator) software.**

Index terms—rectangular microstrip patch antenna, high frequency structural simulator, gain, VSWR

I. INTRODUCTION

In present days researchers are growing interest in this fractal antenna geometry due to various advantages such as lower manufacturing costs, small size and low profile [1, 2]. A microstrip patch antenna consists of a thin patch placed above the substrate material, a lower ground plane and a feed [3]. Generally copper material is used to design the patch which can have various shapes like square, rectangular, circular, elliptical and triangular. The most commonly used configurations are square, rectangular, dipole and circular because they have features like attractive radiation, simpler fabrication and ease of analysis [4, 5]. As per developments increasing in various Wireless Local Area Network (WLAN) protocols the requirements for antennas working on frequency 2-4 GHz in S band is also increasing. Now days the broadest spread protocols of WLAN IEEE 802.11n, also utilize the ISM, band (2.1–2.5 GHz) [6]. Various methods can be used to increase the performance characteristics and bandwidth of patch antenna, such as by using thick substrate, low dielectric and by using various feeding techniques [7].

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In this paper a new multislotted rectangular microstrip patch antenna is proposed by cutting four rectangular slots on rectangular patch for better return losses, bandwidth and gain improvement. The proposed antenna has a gain of 7.02 dB and return-loss of-20.21dB at 2.1GHz frequency whereas conventional rectangular microstrip patch antenna has gain of 4.30 dB and return loss of -15.88 dB at frequency of 3.8 GHz. Further by introducing defective design concept gain has been improved by 8.45 dB and return losses by -20.11 dB at the frequency of 2.1 GHz.

II. DESIGN OF ANTENNA/ANTENNA GEOMETRY

For the designing of micro strip antenna there is requirement of resonant frequency „f_r", height of substrate „h" and material of substrate. The designed antenna resonate at frequency „f_r" 2.1 GHz, air with dielectric constant (ε_r) =1.0006 is used as substrate material and patch placed 12.5 mm above from ground plane i.e. height of substrate „h" is 12.5 mm. Steps for the designing of proposed antenna are mentioned below.

Step1: A rectangular patch whose dimensions are calculated using equations 1-4 as given in [9-11]. The length and width of patch is 79 x 53mm respectively.

Practical width of radiating patch which leads to good radiation efficiencies given by

$$W = \frac{1}{2 f_r \sqrt{\quad}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{v_0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

Where v_0 is the free-space velocity of light.

The effective dielectric constant of micro-strip patch antenna as in [11] is given by

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

The expression for extension of length [9-11] is given by

$$\Delta L = h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{3}$$

Then actual length of patch as in [9-11] is given by

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \quad (4)$$

The dimensions of ground plane are calculated by using formula

$$L\ (\text{ground}) = 6h + L$$

$$W\ (\text{ground}) = 6h + W$$

Step 2: Four rectangular slots are cut from the rectangular patch to improve the gain and return-loss of the antenna. The layout design of conventional and proposed antenna is shown in figure 1(a) and figure 1(b) respectively. Co-axial feed of radius 1.2 mm of outer cylinder and 0.5 mm radius of inner cylinder of material „pec" is used to feed the antenna. These rectangular slots are also subtracted from the ground to design proposed antenna with defective ground. Various performance parameters of proposed antenna and conventional antenna are shown in Table 1.

Step 3: To improve the performance of proposed antenna in terms of improving the bandwidth and reducing the size of antenna ground plane of proposed antenna is made defective as shown in figure 1(c).

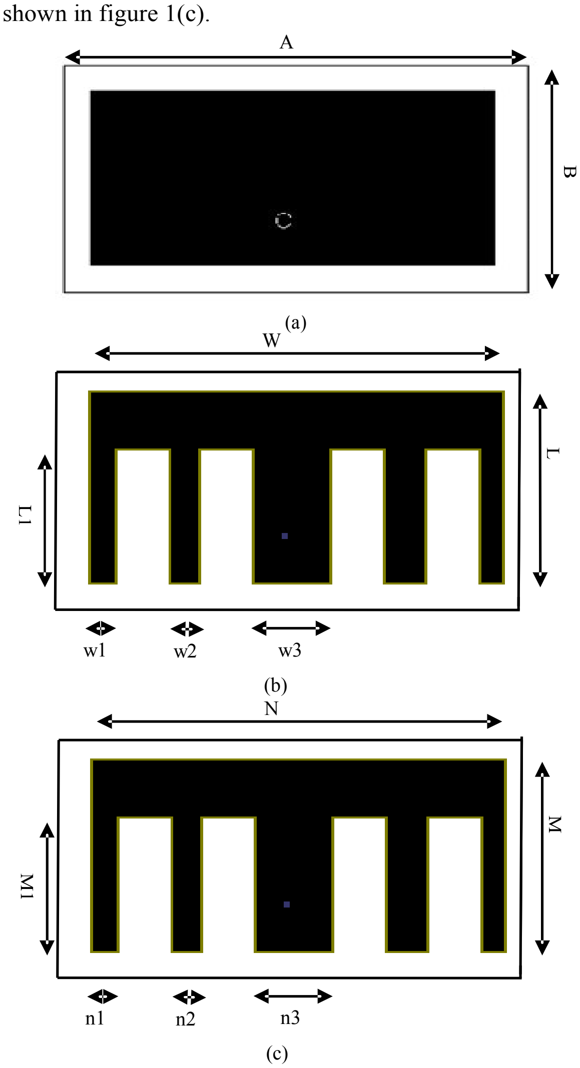


Fig.1. (a) Layout of Conventional antenna (b) Front view of Proposed antenna (c) Back view of Deflective ground plane

TABLE1 VARIOUS PARAMETERS OF ANTENNA

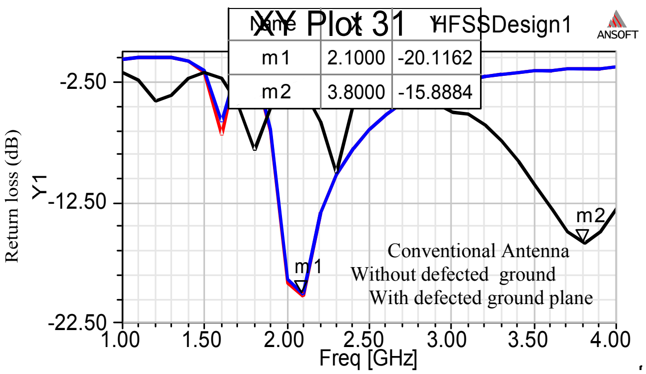
S No	*Parameters*	*Value*
1	Substrate material used	Air
2	Relative permittivity of the substrate	1.0006
3	Thickness of dielectric substrate (h)	12.5mm
4	Length of Substrate (A)	85mm
5	Breadth of Substrate (B)	63mm
6	Length of Patch (W)	79mm
7	Breadth of Patch (L)	53mm
8	Length of slots (L1)	35mm
9	Width of first slot (w1)	5mm
10	Width of second slot (w2)	75mm
11	Width of third slot (w3)	13mm
12	Length of Defected Ground (N)	85mm
13	Breadth of Defected Ground (M)	63mm
14	Length of slots (M1)	35mm
15	Width of first slot (n1)	5mm
16	Width of second slot (n2)	75mm
17	Width of third slot (n3)	13mm

III. SIMULATION RESULTS

Using software package HFSS various parameters like gain, return losses, radiation pattern and VSWR of conventional and proposed antenna are analyzed. At frequency of 3.8 GHz the conventional antenna has gain of 4. 30 dB and return losses of -15.88 dB whereas proposed multislotted rectangular microstrip patch antenna has return losses -20.21dB and gain 8.4 dB at 2.1 GHz . Further by introducing defective design concept gain has been improved by 8.45 dB and return losses -20.11 dB at the frequency of 2.1 GHz. Bandwidth up to MHz is analyzed by the proposed antenna.

A. Return losses

At resonant frequency of 3.8 GHz return loss of the conventional antenna is -15.88 dB whereas proposed antenna has return losses -20.21dB at 2.1 GHz. Further by introducing defective ground return losses are further improved to -20.11 dB at the same frequency. Comparison of Return losses v/s frequency plot simulation results for both the conventional as well as proposed antenna with and without deflecting ground plane is as shown in figure 2.

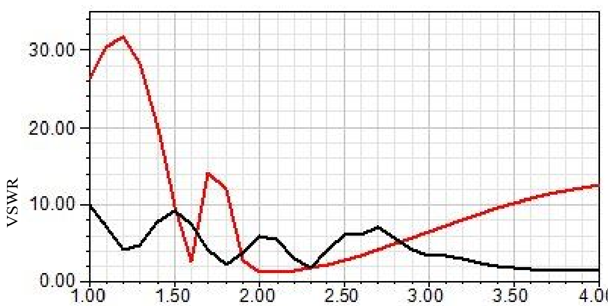


Frequency in GHz

Fig. 2. Plot of return loss v/s frequency of conventional and proposed antenna

B. VSWR

Antenna VSWR is the property of the antenna used to get impedance matching [8, 9]. VSWR of proposed antenna with defected ground, without defected ground whereas for that of conventional antenna is shown. Plot of VSWR v/s frequency for both the antenna is as shown in figure3.



Frequency in GHz

Fig.3. Plot of VSWR v/s frequency

C. Radiation Pattern

Two dimensional radiation pattern of conventional antenna in E and H plane at resonant frequency of 3.8 GHz is shown in figure 4. Similarly radiation pattern of proposed antenna at 2.1 GHz with full ground and defected ground are shown in figure5 and figure 6 respectively.

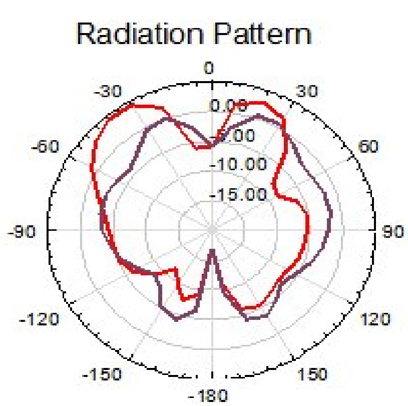


Fig. 4. Two dimensional radiation pattern of conventional antenna at 3.8 GHz

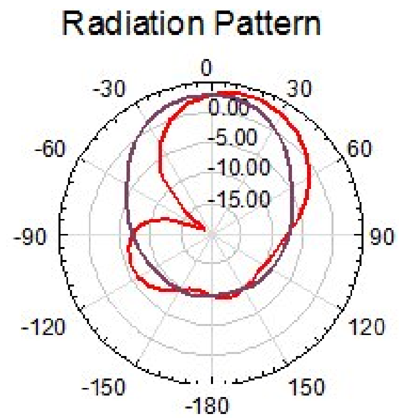


Fig. 5.Two dimensional radiation pattern of proposed antenna at 2.1 GHz

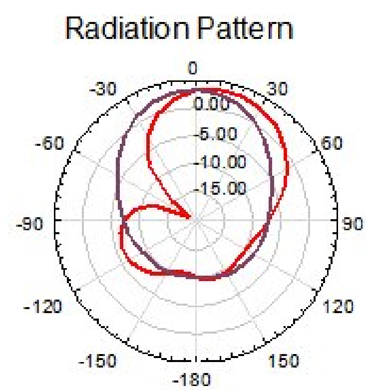


Fig. 6.Two dimensional radiation pattern of proposed antenna with defective ground at 2.1 GHz

Table 2 shows the comparative results of the conventional antenna, Proposed Antenna with and without defective ground plane.

Table (2) Simulation Results

Case	Resonant frequency (GHz)	Return loss(dB)	Gain (dB)
Conventional antenna	3.5	-10.91	2.37
	3.8	-15.88	4.30
	4	-12.87	5.25
Proposed antenna without defected ground	1.93	-10.03	7.53
	3.4	-20.21	7.02
	7.3	-10.71	6.40
Proposed antenna with defected ground	1.94	-10.30	9.28
	2.1	-20.11	8.45
	2.3	-10.52	7.65

IV. CONCLUSION

A multislotted S-band with defected ground plane rectangular microstrip patch antenna with co-axial feed has been introduced in this paper. Size of proposed antenna has been reduced by 75 % from the conventional antenna by introducing rectangular multi slots. After calculation of results at resonant frequency of 3.8 GHz the conventional antenna has return losses of -15.88 dB and absolute gain of 4. 30 dB whereas proposed multislotted rectangular microstrip patch antenna has return losses -20.21dB and gain 7.02 dB at 2.1 GHz is obtained. Further by making ground plane defective designed antenna has improved gain 8.45 dB and return losses by -20.11 dB at the same frequency.

Therefore, the proposed antenna with defected ground plane shows improved results in terms of return loss, gain and radiation pattern. So from above results and parameters it is clear that proposed antenna has improved and better results than conventional antenna and also a frequency shift towards lower side which makes our antenna useful, efficient and meets the need of S band of ISM.

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[12] HFSS (High Frequency Structural Simulation Tool), Software Tool.

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