Design of Rectangular Microstrip Antenna with Finite Ground Plane for WI-FI, WI-Max Applications

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Abstract— Microstrip antennas are suitable for mobile and satellite communication systems. This is particularly due to their main characteristics such as low volume and weight, as well as because they are easy to fabricate and to be installed on plane and curved surfaces. Nevertheless these antennas present some disadvantages like narrow bandwidth, low power operation, and radiation loss. There are some methods such as increasing the height of the substrate, which can be used to extend the efficiency and bandwidth. In this communication design and performance of a novel rectangular with finite ground is proposed to achieve wide band performance and circular polarization. "The proposed structure consists of a rectangular patch and the ground plan"

Keywords: Microstrip Antenna, Defected Ground Plan, WIMAX, WIFI

I. INTRODUCTION

Microstrip antennas are suitable for mobile and satellite communication systems. This is particularly due to their main characteristics such as low volume and weight, as well as because they are easy to fabricate and to be installed on plane and curved surfaces. Nevertheless these antennas present some disadvantages like narrow bandwidth, low power operation, and radiation loss. There are some methods such as increasing the height of the substrate, which can be used to extend the efficiency and bandwidth.

Microstrip patch antenna used to send onboard parameters of article to the ground while under operating conditions. The aim of the thesis is to design and fabricate rectangular Microstrip Patch Antenna with defected ground plan and study the effect of antenna dimensions Length (L), Width (W) and substrate parameters relative Dielectric constant (ε_r), substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width with and without defected ground plan. The application of this designed antenna is in wide band communication.

II. MICROSTRIP PATCH ANTENNA

Microstrip antennas are attractive due to their light weight, conformability and low cost.

In its most fundamental form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 2.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda_o < L < 0.5\ \lambda_o$, where λ_o is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda_o \le h \le 0.05\ \lambda_o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \le \varepsilon_r \le 12$.

A. Computing the effective patch length

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad 2.1$$

B. Computing the ε_{reff}

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}} \qquad 2.2$$

L L

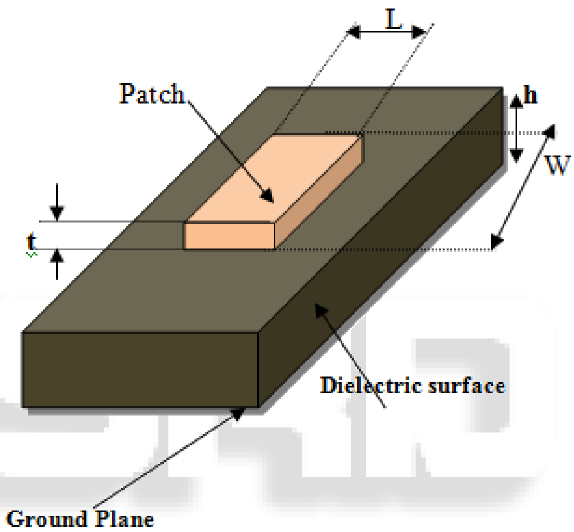


Fig. 2.1: Structure of Microstrip Antenna

C. The effective Length

$$L_{eff} = L + 2\Delta L \qquad 2.3$$

D. The Patch width

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad 2.4$$

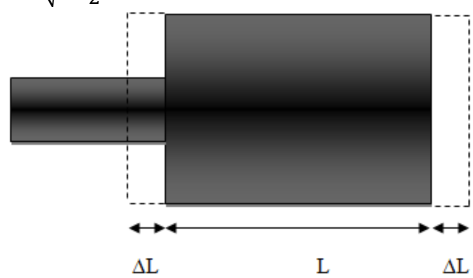


Fig. 2.10: Effective Length

By the above equation we can design rectangular patch shown in Simulation Result.

III. DEFECTED GROUND PLAN

High performance, compact size and low cost often meets the stringent requirements of modern microwave communication systems. There have been some new technologies such as

Low-temperature co-fire ceramic technology (LTCC), Low-temperature co-fire ferrite (LTCF) and some new structures such as Photonic band gap (PBG), DGS, Substrate integrates wave-guide (SIW) and so on to enhance the whole quality of system.

DGS is an etched periodic or non-periodic cascaded configuration defect in ground of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar wave guide) which disturbs the shield current distribution in the ground plane cause of the defect in the ground. This disturbance will change characteristics of a transmission line such as line capacitance and inductance. In a word, any defect etched in the ground plane of the microstrip can give rise to increasing effective capacitance and inductance.

Defected Ground Structure is the one of the methods to use for this purpose. In this method the size of the antenna is reduced. DGS is realized by introducing a shape defected on a ground plane thus will disturb the shielded current distribution depending on the shape and dimension of the defect .The disturbance at the shielded current distribution will influence the input impedance and the current flow of the antenna. It can also control the excitation and electromagnetic waves propagating through the substrate layer. DGS is any defect etched in the ground plane of the microstrip can give rise to increasing the effective capacitance and inductance. DGS have the characteristics of stop band slow wave effect and high impedance.

DGS are basically used in microstrip antenna design for different applications such as antenna size reduction, cross polarization reduction, mutual coupling reduction in antenna arrays, harmonic suppression etc. DGS is widely used in microwave devices to make the system compact and effective

IV. SIMULATION RESULTS

A. Reference Antenna

Following results shown for the Antenna1 (i.e. Microstrip antenna without defected ground plan) :

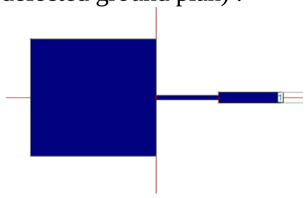


Fig. 4.1: Microstrip Patch Antenna Designed Using IE3D

1) S-Parameter Plot

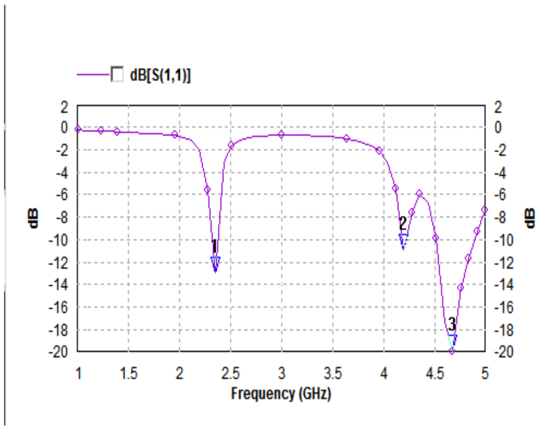


Fig. 4.2: S-parameter Plot for Reflection Coefficient v/s Frequency

2) VSWR Plot

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible.

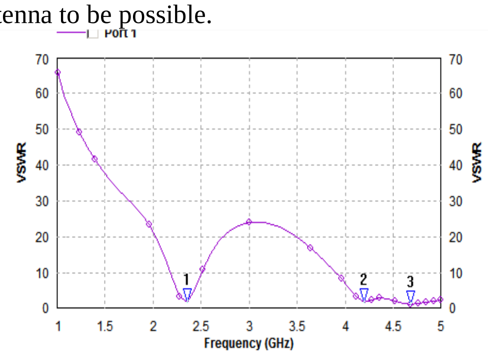


Fig. 4.4: VSWR v/s Frequency Plot

3) Smith Chart

The Smith Chart is plotted on the complex reflection coefficient plane in two dimensions and is scaled in normalized impedance (the most common), normalized admittance or both, using different colors to distinguish between them. These are often known as the Z, Y and YZ Smith Charts respectively. Normalized scaling allows the Smith Chart to be used for problems involving any characteristic impedance or system impedance, although by far the most commonly used is 50 ohms.

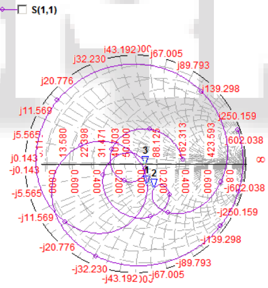
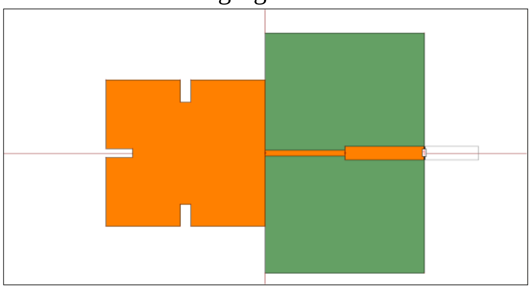


Fig. 4.5: Smith Chart Display

B. Defected Ground Structured microstrip Antenna

Antenna2 structure has been designed by taking finite ground plane and defecting it. All other parameters of Antenna2 structure are same as Antenna1. Length of defected ground plane is 30 mm and width of defected ground plane is 60 mm. Length of Slot is 5 mm and width of slot is 3 mm. Designed antenna shown in following figure 5.2.



4.1 Microstrip Patch Antenna Designed using IE3D

1) S-Parameter Plot

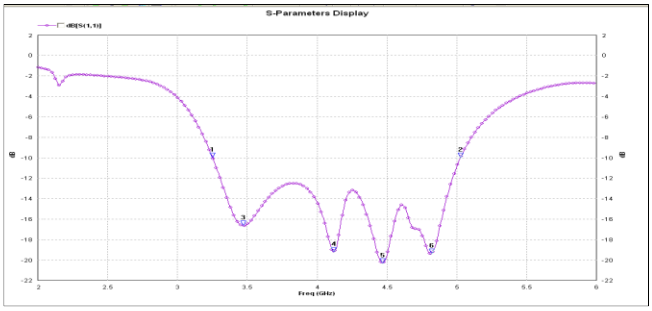


Fig. 5.2: S-parameter Plot for Reflection Coefficient v/s Frequency

2) VSWR Plot

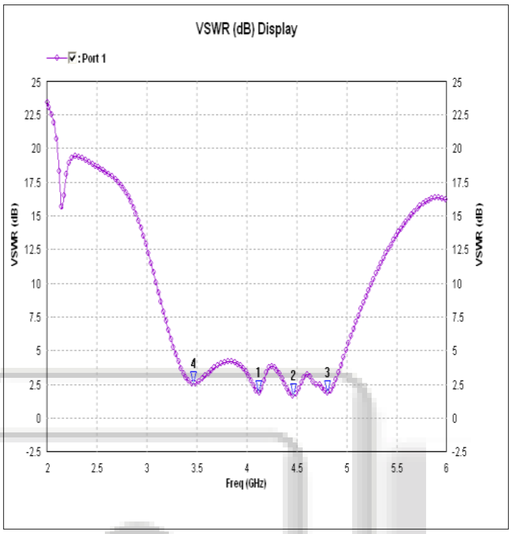


Fig. 5.4: VSWR v/s Frequency Plot

3) Smith Chart

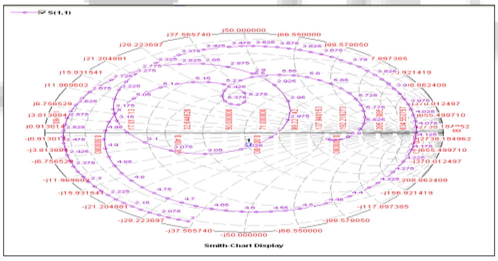


Fig. 5.6: Smith Chart Display

C. Total Field Gain of Defected Ground Plan Microstrip Antenna

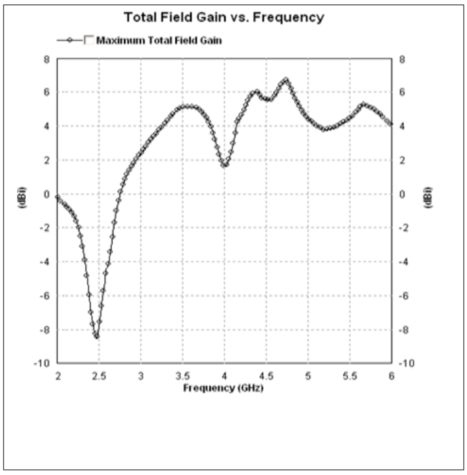


Fig. 5.8: Total Gain v/s Frequency

V. CONCLUSION

The optimization of the Microstrip Patch is partially realized which concludes that the gain of microstrip can increased in defected ground plan. Now it can cover the range from 3.2 GHz to 5 GHz applications

Following table shows the comparative study of the results:

S.No.	Antenna Parameter	Reference Patch Antenna	Defected Ground Patch Antenna
1	Resonant Frequency	2.3, 4.2 & 4.6 GHz	4.1, 4.4 & 4.8 GHz
2	Impedance	56, 61 & 69 Ω	51 Ω
3	VSWR	1	1.9
4	Bandwidth	2 - 3%	45.08 %
5	Gain	2 dBi	4 dBi

Table 6.1: Comparative study of the results of

By the above table it conclude that the bandwidth of rectangular patch antenna with defected ground is increases up to 45.08% where as the bandwidth of rectangular patch antenna with infinite ground plan has 2-3% of bandwidth. Also the gain of modified antenna has been increased up to 4 dBi. The modified antenna can use in wide band applications of wireless communication.

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