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DESIGN OF A SLOTTED MICROSTRIP ANTENNA FOR S-BAND APPLICATIONS

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Abstract

In this paper, a new design of a slotted microstrip antenna with bandwidth characteristics is proposed. The antenna consists of a slotted rectangular patch. The ground plane is further improved to enhance the bandwidth of slotted microstrip antenna. The ground plane is partially present just below the feed line. By cutting a triangular slot on the patch improves the surface current density over the patch. With this design, the return loss response is found to be below -10dB with the frequency range of 2.5 GHz to 3.8 GHz. The designed antenna radiates electromagnetic waves uniformly in all directions over the frequency band. As this antenna operating from 2.5 GHz to 3.8GHz, it is a suitable candidate for S-band application.

Keywords- Bandwidth; Ground plane; electromagnetic waves; Slotted rectangular patch

Introduction

In today's world antenna plays a major role in wireless communication, due to its vast use in devices like- mobile phones, GPS systems, mp3 players etc. The antenna is a device i.e. used for efficient transmission and reception of electromagnetic waves. Depending upon the use, the antenna can operate in different frequency bands. In this paper, a triangular slotted microstrip antenna is designed with improved bandwidth in S-band i.e. ranging from 2GHz to 4.5 GHz. S-band is also called as radar frequency band and is mainly used where clarity and quick response is very much essential like in satellite communication, vehicular and mobile communication.

Among the different types of antenna present nowadays, a lot of research is going on microstrip antenna because of its advantages like- low cost, lightweight, compatibility for an embedded antenna in handheld wireless devices [1-3] and high performance. The main problem in this antenna is narrow bandwidth. The bandwidth of an antenna is inversely related to patch area; hence by loading different slots the area can be minimized as a result, bandwidth can be improved [4-7]. The objective of this paper is to improve the bandwidth of microstrip antenna by modifying the ground plane and introducing a triangular slot in the patch.

Antenna Design and Specification

The basic steps for the development of antenna are given below. The thickness of dielectric material, width and length of the patch, extension length of radiating patch is first calculated before designing the antenna using the following mathematical expressions.

Thickness of the dielectric medium is given as:

$$h \leq 0.3 \times \frac{c}{2 \times \pi \times f_r} \times \sqrt{\varepsilon_r}$$

Width of the radiating patch is as follows:

$$w = \left(\frac{c}{2 \times f_r}\right)\left(\sqrt{\frac{\varepsilon_r + 1}{2}}\right)$$

Length of metallic patch is calculated as:

$$L = \frac{c}{2 \times f_r \times \varepsilon_{reff}} - 2\Delta l$$

Where

c : Velocity of light $= 3 * 10^8$ m/s

ε_r : Dielectric constant of the substrate

f_r : Resonant frequency of antenna

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

Extension length of the radiating patch is as:

$$\Delta l = 0.412 \times h \times \left[\left(\frac{\varepsilon_{reff} + 0.03}{\varepsilon_{reff} - 0.258}\right) \times \left(\frac{w + 0.264h}{w + 0.8h}\right)\right]$$

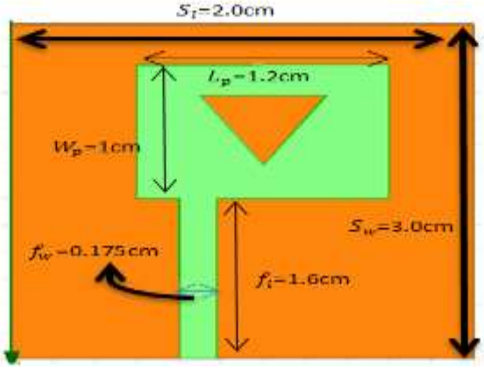

Figure 1.a. Geometry of proposed antenna (top view)

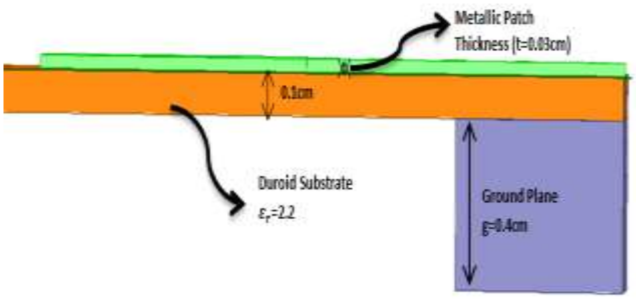

Figure 1.b. Geometry of proposed antenna (side view)

The structure of suggested microstrip antenna is shown in figure 1. The antenna consists of a radiating patch over the dielectric substrate and the ground plane is etched on the bottom side of the substrate. The designed antenna is excited by the help of microstrip feed line. The radiating patch is etched on the Duroid substrate and the dimension of the substrate is noted in table-1. At high frequency, the performance of the antenna can be improved by introducing slot on the radiating patch. In this design, a triangular slot is introduced on the radiating material to enhance the bandwidth of the proposed antenna. A 50ohm microstrip feed line of length1.6cm is connected to the edge of the metallic patch. The Duroid substrate is metalized on top and the bottom side and it has a low permittivity of 2.2, low loss and it enhances the performance of the antenna.

The designed antenna has a compact size of 3cm*2cm*0.1cm. The reflection loss shows the suggested microstrip patch antenna is able to achieve wide bandwidth varies from 2.5GHz to 3.8GHz.

Here the ground plane is modified to achieve a wide bandwidth and it is partially present just below the feed line. The radiating patch of dimensions 1cm*1.2cm*0.03cm is placed above the substrate. The performance of the antenna can be further improved by inserting a triangular shape slot on the patch.

Table 1. Design Parameters

Parameters	L_p	W_p	S_l	S_w	f_l	f_w	t	g
Unit(cm.)	1.2	1.0	2.0	3.0	1.6	0.175	0.03	0.4

Result and Discussion

The proposed triangular slotted microstrip antenna is simulated using HFSS software. The return loss of microstrip antenna without any slot is shown in fig 2 and the proposed antenna with triangular slot and modified ground is shown in fig.3. The return loss is below -20 dB which is much better than the unmodified antenna. As the return loss is very low, it shows proper impedance matching in between patch and feed. The bandwidth of the designed antenna is 1.3GHz ranging from 2.5-3.8GHz.

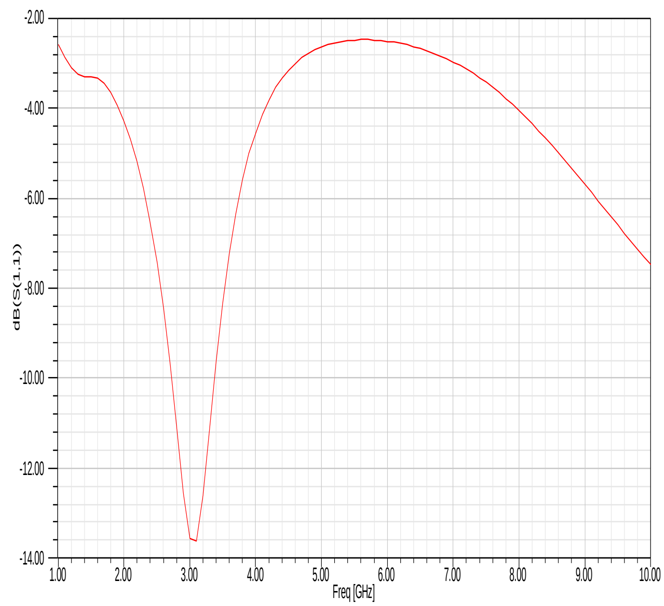

Figure 2. Return Loss vs. Frequency plot of un-slotted antenna

The 3D radiation pattern of the designed antenna is shown in fig 4 and it is observed that it radiates electromagnetic waves in all directions. Fig.5 depicts its 2D radiation pattern in H-plane.

The surface wave of the antenna is minimized by modifying the ground plan on the bottom side of the substrate. From fig.6 it is observed that the bandwidth is further improved by increasing height of the ground plane and an optimum result is found at a thickness of 0.4cm.

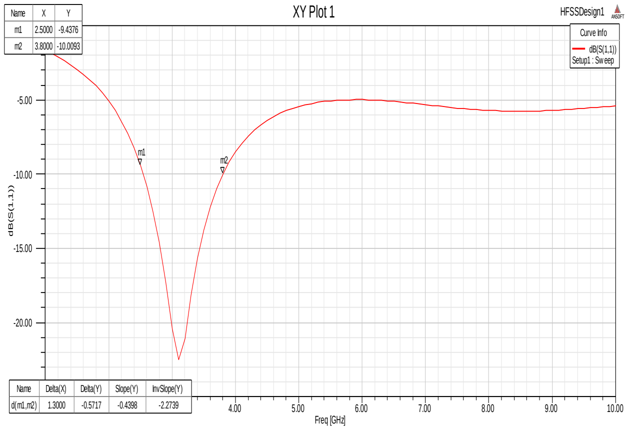

Figure 3. Return loss vs. Frequency plot of modified antenna

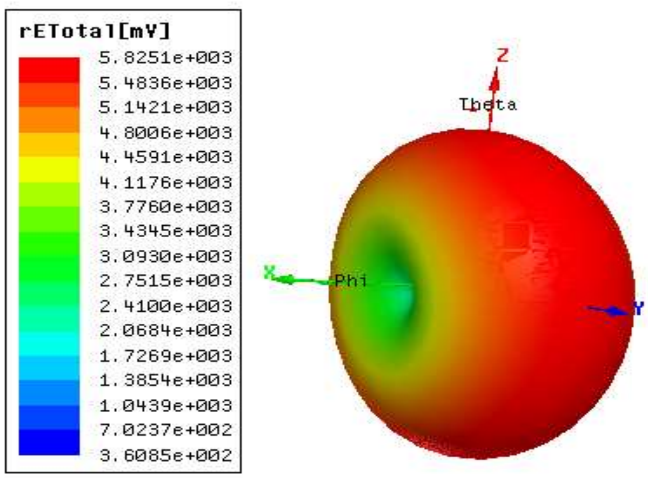

Figure 4. 3D Radiation Pattern of Designed antenna

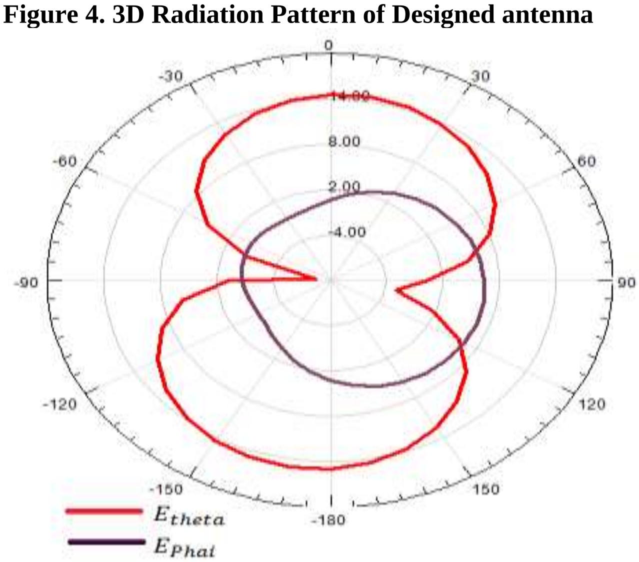

Figure 5. 2D Radiation Pattern of designed antenna in H-plane ($\varnothing = 0^{\circ}$)

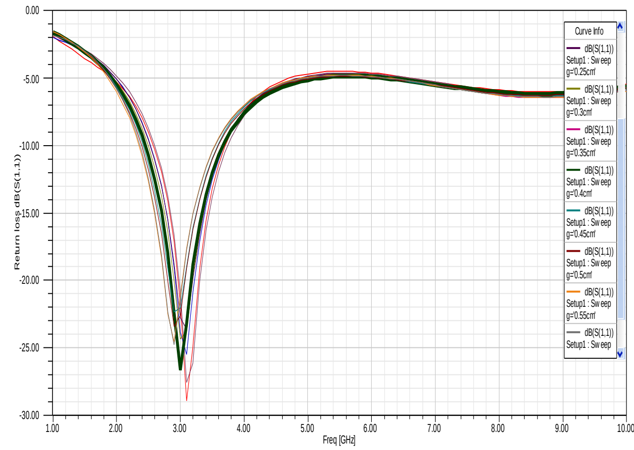

Figure 6. Return loss Vs. Frequency Plot for different values of g(ground thickness)

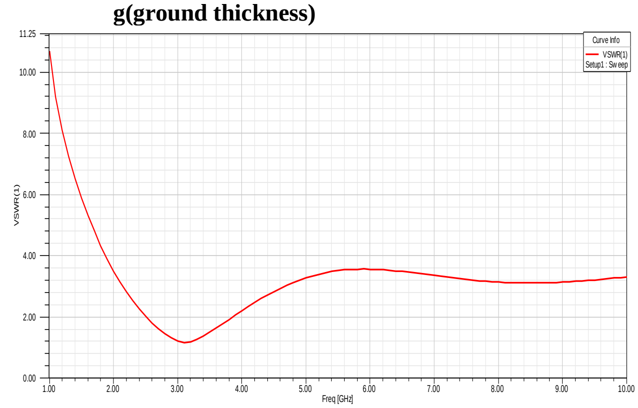

Figure 7. VSWR plot for the Designed antenna

The voltage standing wave ratio of the proposed antenna is depicted by fig.7.The VSWR is found to be less than 2.15 in the frequency range 1.3 GHz which is within the acceptable limit. The designed antenna shows a flat gain variation over the frequency range 2.5GHz – 3.8GHz as shown in fig.8.

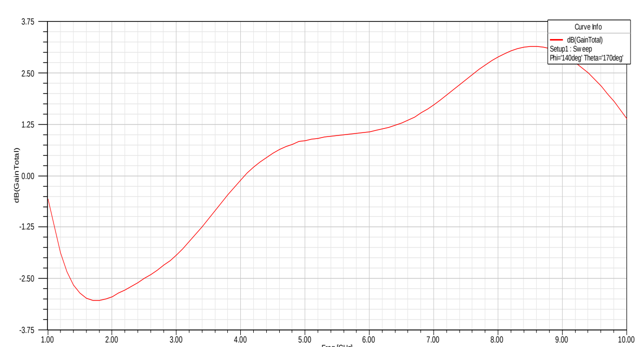

Figure 8. Gain vs. Frequency plot of designed antenna

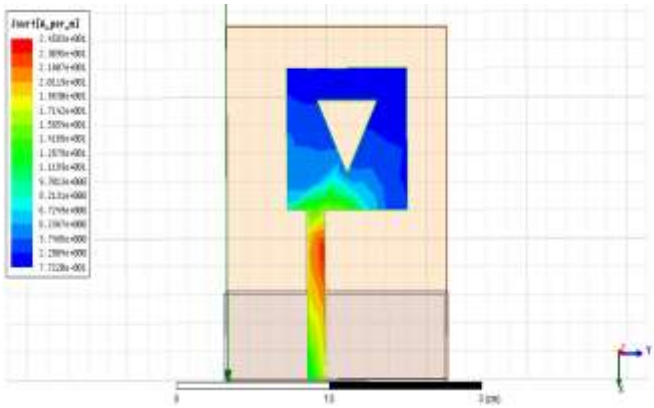

Figure 9. Surface current distribution on the radiating patch

The surface current distribution over the radiating patch is shown in fig.9.The current density of the patch is increased by inserting a triangular slot at the middle of the patch.

Conclusion

The slotted microstrip antenna is simulated successfully using HFSS software and the parameters of the antenna have been examined for an ideal design. The overall dimension of the antenna is 3cm*2cm*0.1cm. Moreover, by adding the triangular slot on the patch improves the frequency bandwidth. After simulation, it is observed that the slotted patch antenna has omnidirectional radiation pattern and smooth gain variation over the frequency range. As the antenna is operating from 2.5GHz to 3.8 GHz, the slotted microstrip antenna is preferred for S-Band applications.

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Biographies

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