

Microstrip Antenna Design by Entrenching the Ground Plane Around the Patch

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Abstract—A new approach to enhance the Front-To-Back Ratio (FTBR) of an inset fed microstrip patch antenna by entrenching the ground plane encircling the patch is described in this paper. By entrenching the ground plane around the patch, backlobe of the antenna gets suppressed. The FTBR has been improved to a value of 48.25 dBi, which is very much higher compared to the FTBR of reference microstrip antenna 13.29 dBi.

Index terms—Microstrip Antenna, Backlobe Suppression, Front-To-Back Ratio.

I. INTRODUCTION

The rectangular microstrip antennas is probably the most popular microstrip antenna design implemented by the designers[1]. The main advantages of the microstrip antennas are low cost fabrication, can be made on the surface of the product, low thickness, low profile, light weight, supports multiband operation[1-2]. However, it has the drawbacks of narrow bandwidth, low gain, poor cross polarization and undesirable backlobes.

The back lobe radiation is undesirable because a portion of energy is transmitted in an undesired direction. This energy transmitted in undesired direction may lead to interference with other wireless systems if the frequency is reused[3].

FTBR is a vital factor to be observed when the transmitted signal is not intended on the backside of the antenna. Back lobe can be suppressed by sacrificing some level of the gain in the forward direction [4].

Surface waves mainly contribute to the formation of back lobe. The ground plane guides the excited surface waves towards the edge of antenna. When the surface waves reach the edge of the ground plane they get diffracted [7],[9]. Surface waves have a zero cut off frequency and hence they are always excited [7]. Our interest is to design a microstrip patch antenna with reduced back radiation by suppressing the propagation of surface waves.

In [3], a slot antenna was designed with parasitic patches on the opposite side and also along the slot axis to reduce back lobe. In [5] a comb shaped choke has been used to effectively suppress the diffraction of surface wave and therefore to reduce the back lobe. In another paper[6], ground plane edges were shaped to achieve an increased Front-to-back ratio in a microstrip patch antenna.

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II. ANTENNA DESIGN

The structure of the proposed inset-fed microstrip antenna is shown in Fig.1. The dimensions of the antenna (width x length) are 56.8 mm x 47.4 mm (2692.32 mm²). The microstrip patch antenna designed for 2.45 GHz antenna is inset fed which is fed by a 50 Ω transmission line. The width of transmission line is 3.0 mm with a feed line gap of 2.59 mm on either side of the microstrip feed line. An FR-4 substrate with a relative permittivity of 4.3 and a thickness of 1.6 mm is used.

A trench is made on the ground plane encircling the patch except a strip of conductor unetched with a width of 0.5 along the mid of E-plane (shown as S_g) as in Fig.2. The effect of trench in the ground plane beneath the patch was investigated. The back lobe gets reduced considerably. Analysis was carried out by using CST Microwave Studio 2016. The location and width of the trench was optimized for maximum cancellation of back lobe.

TABLE I.

Antenna Dimensions

Microstrip antenna dimensions	
Parameters	Size(mm)
Length of patch(L)	28.20
Width of patch(W)	37.60
Length of ground plane(L _g)	47.40
Width of ground plane(W _g)	56.80
Inset depth(y ₀)	4.60
Inset feed width(w _f)	3.00
Inset feed to width gap(g)	2.59
Patch edge to trench gap(s _{wg})	0.50
Strip width which bifurcates the trench (S _g)	0.50

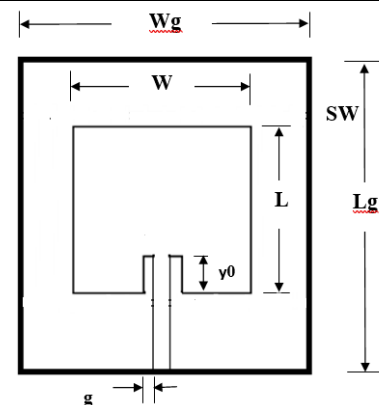


Fig.1 Geometry of the reference Microstrip patch antenna

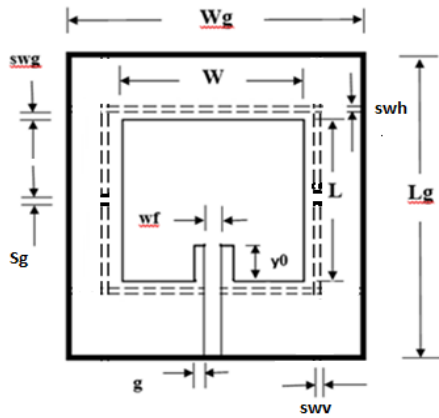


Fig.2. Geometry of Microstrip patch antenna by entrenching the ground plane around the patch (Top view)

III. ANALYSIS, RESULTS AND DISCUSSION

The presence of ground plane trench around the patch suppresses the surface wave propagation thereby reduces the formation of back lobe.

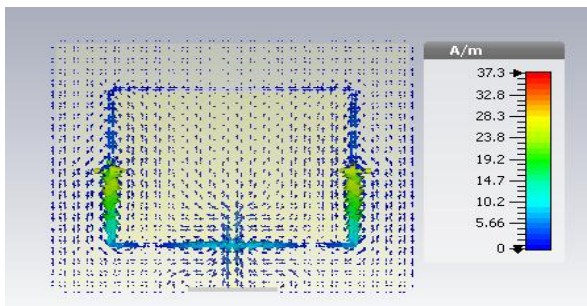


Fig.3 Surface current in the groundplane of proposed microstrip antenna

From Table 2, it is observed that the peak Front-to-Back ratio has improved from 13.29 dBi to 48.25 dBi (Fig.7). The broadside lobe gain has reduced from 3.04 dBi to 2.05 dBi.

Won-Gyu Lim in [10] has described that high impedance at the microstrip ground plane edge reduces the formation of back lobe. From Fig.3 & 4 it can be observed that stronger surface currents are concentrated at the centre of the trenches in E-plane. It is found that high impedance is observed at the trenches in horizontal plane. It can also be inferred from Fig. 4 that the surface current on the either side of the trenches of ground plane are oppositely directed leading to transmission line mode. In this mode the E and H fields in the direction normal to the ground plane gets cancelled out due to the current with equal amplitude flowing in the opposite direction.

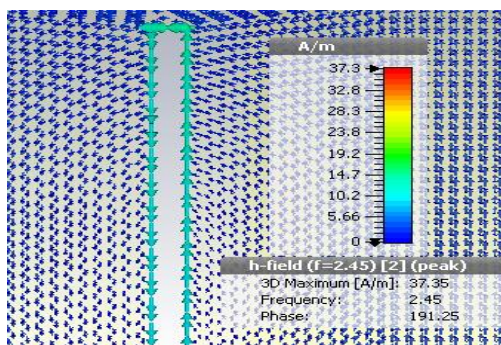


Fig.4 Surface current flow in the groundplane trench

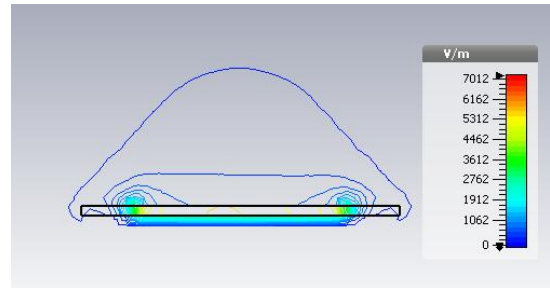


Fig.5 Electric field edge diffraction in the H-plane of reference antenna (Side view)

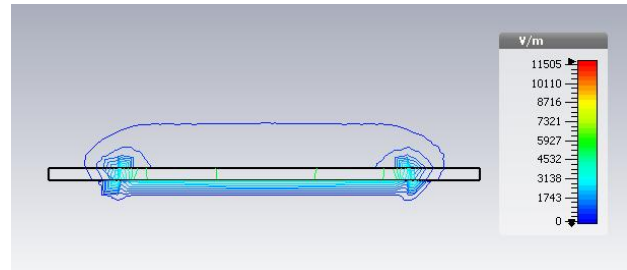


Fig.6 Electric field edge diffraction in the H-plane of the Patch antenna with trench in the ground plane (Side view)

From Fig 6, it can be inferred that high impedance formed at the edges of ground plane due to entrenching of ground plane has led to high attenuation of surface waves and therefore less edge diffraction and back lobe, whereas the edge diffraction in the reference antenna is more as shown in Fig 5. Reduction of the gain in the broadside direction indicates that the surface waves have also reduced the forward by increasing the radiating angle.

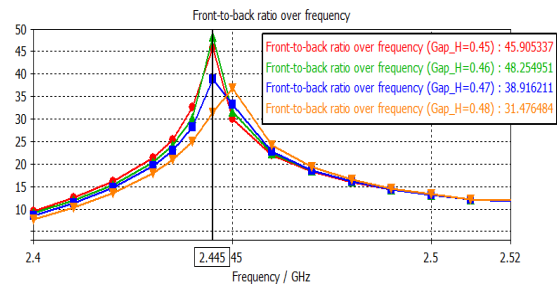


Fig.7. FTBR of proposed Antenna Design

TABLE II.

FTBR analysis of microstrip antenna by changing the H-Plane trench width

Antenna	Width of trench in H-Plane (mm)	Width of trench in E-Plane (mm)	Width of the unetched strip (sg) (mm)	Resonant Frequency (GHz)	Reflection coefficient	Forward Gain (dBi)	Peak FTBR (dBi)
Reference	-	-	-	2.42	-25.02	3.04	13.54
Design 1	0.45	0.41	0.5	2.47	-21.18	2.07	45.90
Design 2	0.46	0.41	0.5	2.47	-21.12	2.05	48.25
Design 3	0.47	0.41	0.5	2.47	-20.87	2.04	38.91
Design 4	0.48	0.41	0.5	2.47	-20.78	1.99	36.80

IV. CONCLUSION

In this paper a new configuration by entrenching the ground plane around the patch is proposed to suppress the radiation on the backside of inset fed microstrip antenna. It is shown that backlobe level of the microstrip antenna can be reduced by 34.71 dBi by sacrificing a gain of 1 dBi in the broadside direction. The proposed microstrip antenna is unidirectional and can be fabricated with ease. By this approach back lobe of microstrip antenna can be reduced without increasing the ground plane dimension and without adding reflectors. This technique can also be used for increasing isolation between closely-spaced MIMO antennas.

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