International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5S3, July 2019

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 aninset fed microstrip patch antennabyentrenching the ground plane encircling the patch is described in this paper.By entrenching the groundplane around patch,backlobe of the antenna getssuppressed.The FTBRhas been improvedto 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 arelow 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 thedrawbacks 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 energytransmitted in undesired direction may lead to interference with other wireless systems if the frequency is reused[3].

FTBR is avitalfactorto be observed when the transmitted signal is not intended on the backside of the antenna.Back lobe canbe suppressed by sacrificing some level of the gain in the forwarddirection [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 frequencyand hence they are always excited [7].Our interest isto 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 shapedchoke has been used to effectively suppress the diffraction of surface wave and therefore to reduce the back lobe. Inanother paper[6],ground plane edges were shapedto achieve an increased Front-to-back ratio in a microstrip patch antenna.

Manuscript published on 30 July 2019.
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II. ANTENNA DESIGN

The structure of the proposed inset-fed microstrip antenna is shownin Fig.1.The dimensions of the antenna (width x length) are 56.8 mm x 47.4 mm (2692.32 mm^2).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 is3.0 mm with a feed line gap of2.59 mm on either side of the microstrip feed line. An FR-4 substrate with a relative permittivity of 4.3and a thickness of 1.6 mm is used.

A trench is madeon 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 Sg) asin Fig.2.The effect of trench in the ground plane beneath the patch was investigated. The back lobe gets reduced considerably. Analysis was carried outby 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(Lg)	47.40
Width of ground plane(Wg)	56.80
Inset depth(y0)	4.60
Inset feed width(wf)	3.00
Inset feed to width gap(g)	2.59
Patch edge to trench gap(swg)	0.50
Stripwidth which bifurcates the trench (Sg)	0.50

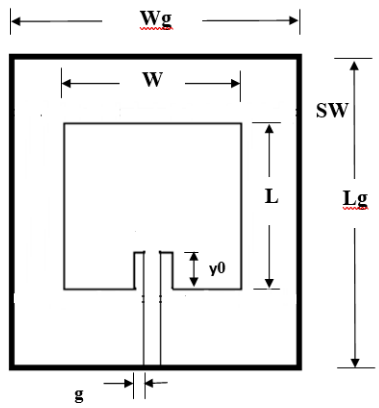

Fig.1 Geometry of the reference Microstrip patch antenna

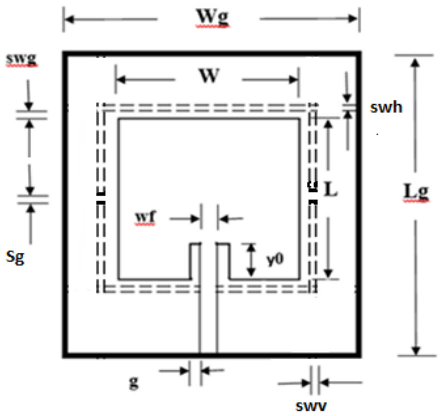

Fig.2. Geometry of Microstrip patch antenna by entrenching the ground planearound the patch (Top view)

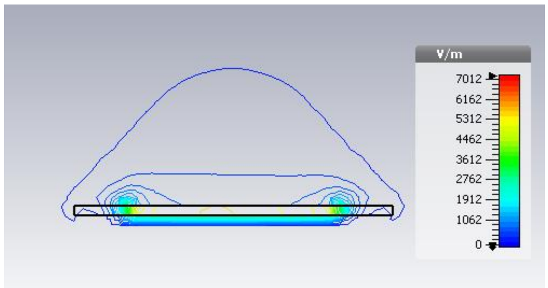

Fig.5 Electric field edge diffraction in the H-plane of thereference antenna (Side view)

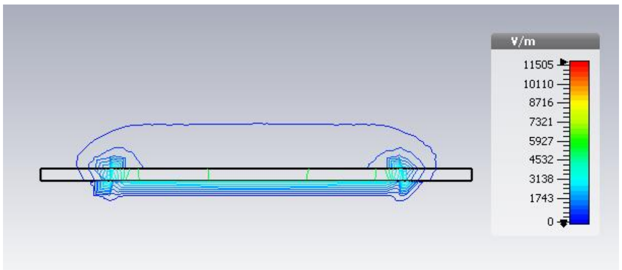

Fig.6 Electric field edge diffraction in theH-plane of the Patch antenna with trench in the ground plane (Side view)

III. ANALYSIS,RESULTS AND DISCUSSION

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

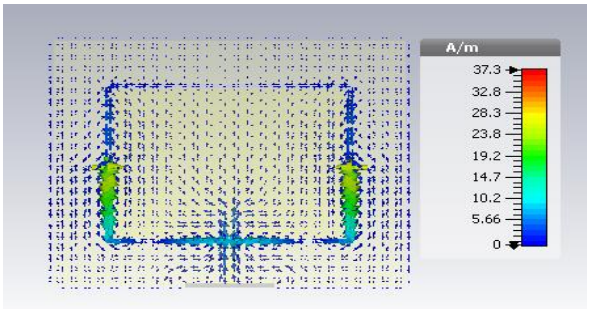

Fig.3 Surface current in the groundplane of proposed microstrip antenna

From Table 2, itis observed that the peak Front-to-Back ratio hasimproved 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 theformation 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 thecurrent with equal amplitude flowing in the opposite direction.

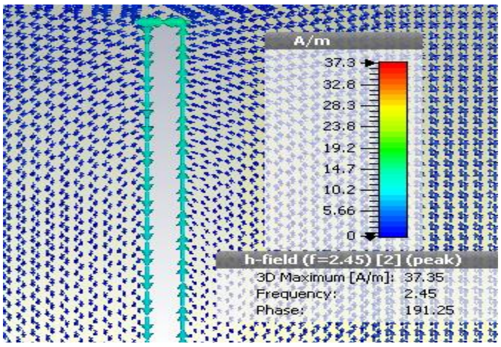

Fig.4 Surface current flow in the groundplane trench

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 thatthe surface waves have also reducedthe forward by increasing the radiating angle.

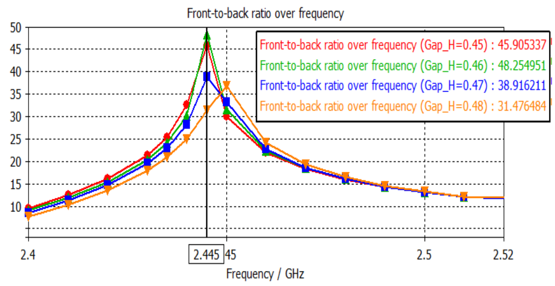

Fig.7. FTBR of proposed Antenna Design

Retrieval Number: E10590785S319/2019©BEIESP
DOI:10.35940/ijeat.E1059.0785S319
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

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

Antenna	Width of trench inH-Plane (mm)	Width of trench inE-Plane (mm)	Width of the unetched strip(sg) (mm)	Resonant Frequency (GHz)	Reflection co-efficient	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 isproposed to suppress the radiation on the backside of inset fed microstrip antenna.It is shown that backlobe level of the microstripantenna can be reduced by34.71 dBi by sacrificing a gain of 1 dBi in the broadsidedirection. The proposed microstrip antenna is unidirectional and can be fabricated with ease.By thisapproach back lobe of microstrip antenna can bereducedwithout increasing the ground planedimension and without adding reflectors.This technique can also be used for increasing isolationbetween closely-spaced MIMO antennas.

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