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Gain Enhancement of Micro strip Patch Antenna with Slotting Technique

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Abstract: This present paper investigates how the defects of different shapes and sizes in the Slots (A, C, E, L, U) of a Micro strip Patch Antenna & improves its technical parameters like Gain, Return Loss, efficiency etc. This has been done by examining and experimenting by cutting different shapes of defects in the Slot of a Micro strip Patch Antenna. The performance and advantages of Micro strip antenna such as low cost, low profile, low weight made them perfect choice for communication systems engineers.
Key Words: Micro Strip Patch Antenna (MPA), S-parameter, VSWR, Gain, Directivity, 3D polar using HFSS Software etc.

I. Introduction

Micro strip antenna is generally working in communication system, radar, imaging due to their attractive features, such as low profile, conformability, low cost and light weight. With the help of slots, the size of micro strip patch antenna has been reduced. This result has been done by shifting the path of the current. [1] Once the slots are cut on the patch the path of the current is changed. Current travels additional path as compare to the without slot of micro strip antenna. With this idea the size of the antenna is reduced i.e. small size antenna has been used at lower frequency [8]. The micro strip patch is generally square, rectangular, circular, triangular and elliptical or some other common shape. Micro strip patch antennas can be fed by two methods contacting and non-contacting. The four most popular feed techniques used are the micro strip line, coaxial probe (both contacting schemes) [2], aperture coupling and proximity coupling (both non-contacting
Schemes)[3]. In this proposed designed micro strip feed line technique is used. For micro strip path antenna three types of methods of analysis are transmission line model, cavity model, and full wave model. In this proposed design transmission line model is used [4].

II. MICROSTRIP PATCH ANTENNA DESIGN

Steps for Designing MPA:

Step 1: Find Width of Patch (W)

$$W = \frac{c}{2fr\sqrt{\frac{2}{\varepsilon r+1}}} \quad (1)$$

fr=9.39GHz, W=17mm
εr= Relative permittivity
Dielectric Constant =1.2 for rogers RT/duroid 5880(tm) material

Step 2: Find Effective Dielectric Constant (εreff)
Effective dielectric constant value is near to the dielectric constant value and it is a function of frequency.

$$\varepsilon reff = \left(\frac{\varepsilon r+1}{2}\right) + \left(\frac{\varepsilon r-1}{2}\right) * (1 + 12\frac{h}{w})^{-\frac{1}{2}}$$

h=Thickness of substrate=1. 6mm, (2)

Step 3: Find the Length of Patch (L)

Due to fringing effect the Micro strip antenna looks electrically larger than its actual physical dimension.

$$\text{Leffective} = \left(\frac{c}{2fr\sqrt{\varepsilon reff}}\right) \quad (3)$$

Step 4: Calculation of ground plane dimensions

$L_{g=}$ 6h+L

$L_{g=}$32mm (4)

$W_{g=}$ 6h+W

$W_{g=}$34mm

Step 5: Calculation of Feed Point

For matching impedance between generator impedance and input patch impedance it is need to obtain feed point Location. For this feed would be given by L/4 distance is 9mm.

III. Antenna Design

In this paper we design five different slots of antennas such as A slot, C slot, E slot, L slot & U slot shape antennas and it is compared without slot on the ground plane using HFSS13V.

3.1 Basic Rectangular Patch Antenna

The rectangular patch antenna is shown in figure 1. The length and width of the antenna is 17mm and 17mm respectively. The printed antenna is etched on ground substrate. A micro strip patch antenna is designed for the resonant frequency 9.39GHz. Simple rectangular patch antenna is fed by micro strip feed technique is shown in figure 1.

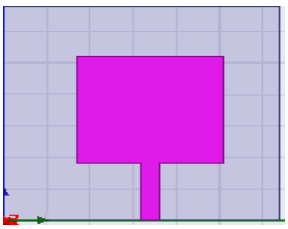

Fig 1: without slot Shape antenna

3.2 A shape Antenna Design

The Physical parameters of A Shape Antenna are designed. The antenna is designed using rogers RT/duroid 5880(tm) substrate having dielectric constant of 1.2

Length of ground plane $L_{g=}$32 mm

Width of ground plane $W_{g=}$34 mm

Length of Antenna L= 17 mm

Width of Antenna W= 17 mm

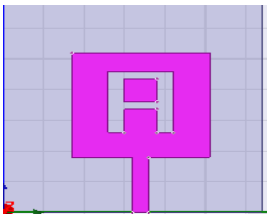

Fig 2: A Shape antenna

3.3 C Shape Antenna Design

The Physical parameters of C Shape Antenna are designed. The antenna is designed using rogers RT/duroid 5880(tm) substrate having dielectric constant of 1.2

Length of ground plane $L_{g=}$32 mm

Width of ground plane $W_{g=}$34 mm

Length of Antenna L= 17 mm

Width of Antenna W= 17 mm

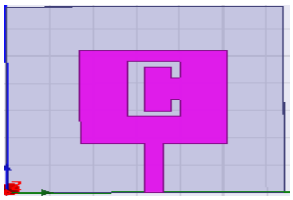

Fig 3: C Shape Antenna

3.4 E Shape Antenna Design

The Physical parameters of A Shape Antenna are designed. The antenna is designed using rogers RT/duroid 5880(tm) substrate having dielectric constant of 1.2

Length of ground plane $L_{g=}$32 mm

Width of ground plane $W_{g=}$34 mm

Length of Antenna L= 17 mm

Width of Antenna W= 17 mm

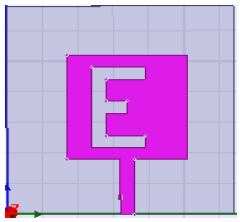

Fig 4: E Shape Antenna

3.5 L Shape Antenna Design

The Physical parameters of A Shape Antenna are designed. The antenna is designed using rogers RT/duroid 5880(tm) substrate having dielectric constant of 1.2

Length of ground plane $L_{g=}$32 mm

Width of ground plane $W_{g=}$34 mm

Length of Antenna L= 17 mm

Width of Antenna W= 17 mm

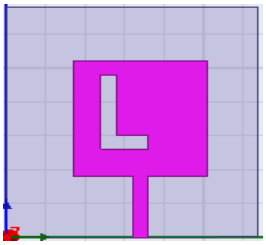

Fig 5: L Shape Antenna

3.6 U Shape Antenna Design

The Physical parameters of A Shape Antenna are designed. The antenna is designed using rogers RT/duroid 5880(tm) substrate having dielectric constant of 1.2

Length of ground plane $L_{g=}$32 mm

Width of ground plane $W_{g=}$34 mm

Length of Antenna L= 17 mm

Width of Antenna W= 17 mm

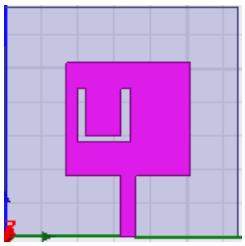

Fig 6: U Shape Antenna

IV. SIMULATION RESULTS

4.1 Return loss

Comparison of various parameters for without slot and slotted A, C, E, L & U- Micro strip Patch Antennas is given.

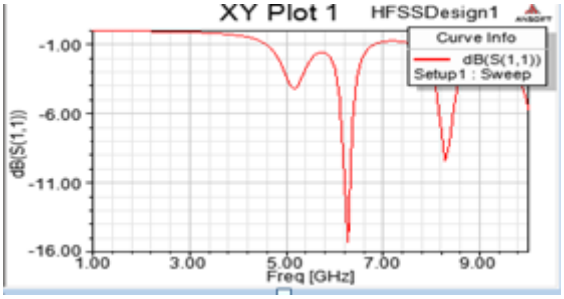

Fig7: Return loss versus frequency plot without slot

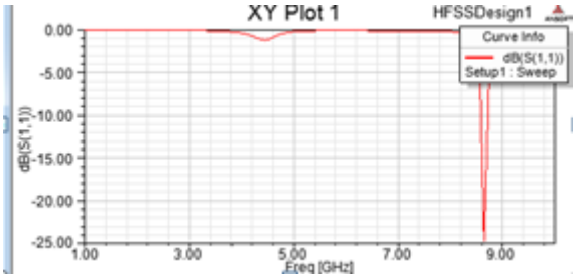

Fig 8: Return loss versus frequency plot with A-slot

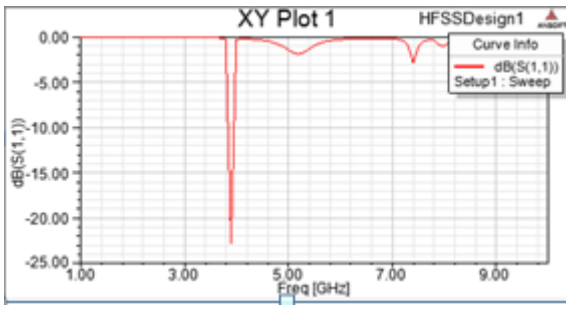

Fig 9: Return loss versus frequency plot with C-slot

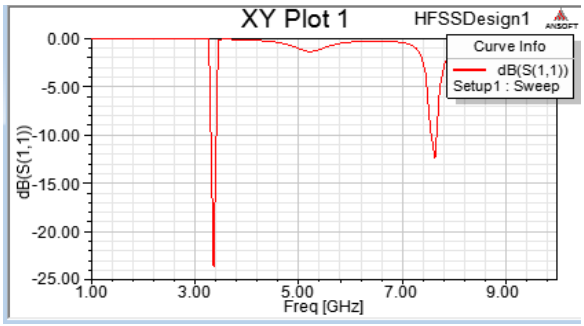

Fig 10: Return loss versus f requency plot with E-slot

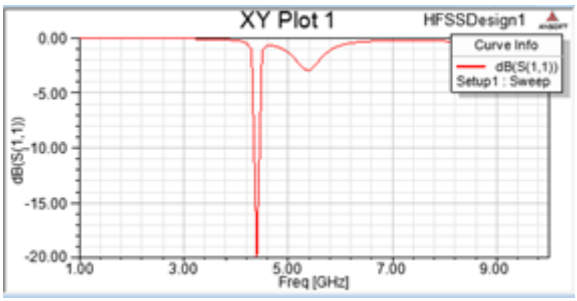

Fig 11: Return loss versus frequency plot with L-slot

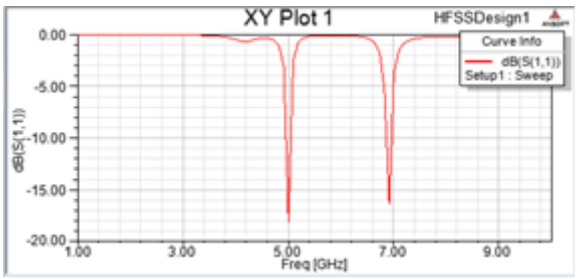

Fig 12: Return loss versus frequency plot with U-slot

4.2 Gain

Three dimension radiation pattern of A, C, E, L & U slotted Rectangular Micro strip Patch Antennas at 9.39GHz and without slot rectangular patch antenna are shown in figure respectively.

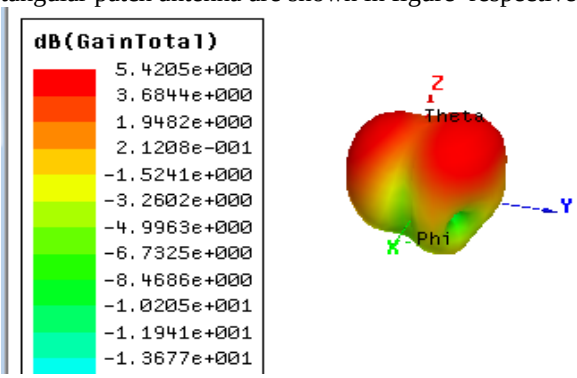

Fig 13: Three dimension radiation pattern of without slot

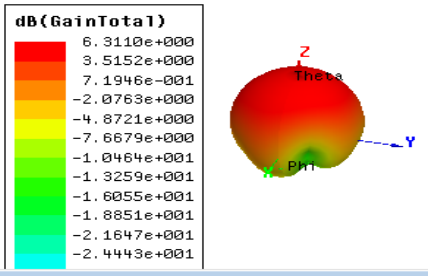

Fig14: Three dimension radiation pattern of A-slot

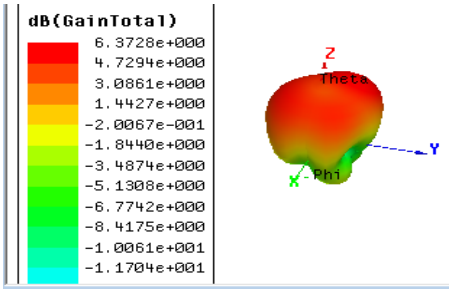

Fig 15: Three dimension radiation pattern of C-slot

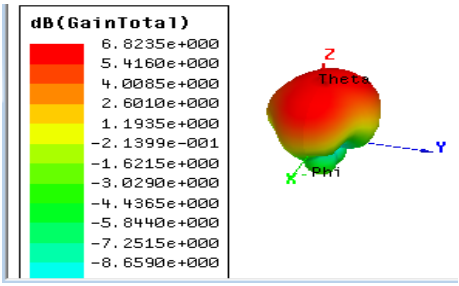

Fig 16: Three dimension radiation pattern of E-slot

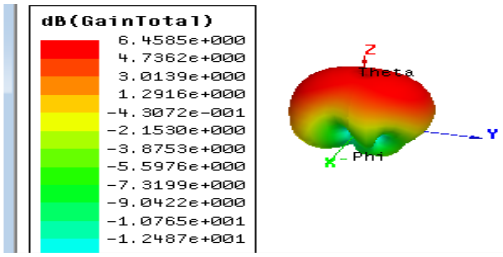

Fig 17: Three dimension radiation pattern of L-slot

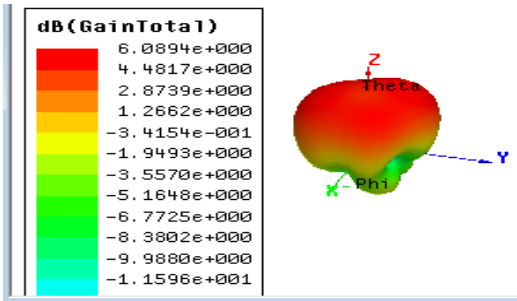

Fig 18: Three dimension radiation pattern of U-slot

4.3 Performance parameters of without and with slotted A, C, E, L & U Micro strip Patch Antennas at 9.39 GHz

This comparable table shows the effects of slots on the performance of micro strip antenna. When the slots are cut on the patch resonant frequency is decreases, return loss increases.

With and Without slot antenna	Return loss	Gain	BW
Without Slot	-16dB	5.4dB	0.1
A Slot	-23dB	6.2dB	0.11
C Slot	-23dB	6.3dB	0.10
E Slot	-24dB	6.8dB	0.10
L Slot	-20dB	6.4dB	0.10
U Slot	-20dB	6.08	0.09

Table1: Comparison of various performances of without slot & different slots of micro strip patch antenna.

V. CONCLUSION

A theoretical review on micro strip patch antenna is presented in this paper. Some effect of disadvantages can be minimized. Increasing gain ,bandwidth and lowering VSWR for making patch antenna for application specific is achieved by introducing slots in the geometries of patch antenna. As compared to conventional micro-strip antenna gain is improved, VSWR is reduced so thereby overall efficiency of the antenna increases. Different slots shaped are compared with without slot and it is found that bandwidth of conventional rectangular micro strip antenna can be enhanced respectively using A, C, E, L, and U-patch over the substrate. The E-shaped patch antenna has the highest Gain followed by A, C, L-shaped patch antenna and U-shaped patch antenna.

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