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Design Of C-Shape Slot Microstrip Patch Antenna With Line Feed For WLAN Technology

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Abstract: *Microstrip patch antenna becomes very popular day-by-day because of its ease of analysis and fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. To overcome the drawbacks of patch antenna, various feeding techniques have proposed. We propose a new simple design based on line feed technique and the dielectric constant used is Teflon. In this paper we are inserting a C-Shape and H-Shape slot on rectangular patch to compare the impedance bandwidth and gain. After simulation, the obtained results for C-Shape slot on rectangular patch have impedance bandwidth 4% and gain as 4.8 db at 4.5GHz. The proposed antenna is suitable for WLAN technology.*
Keywords: *Microstrip; Bandwidth; Dielectric constant; Line feeding; Return Loss*

I. Introduction

Wireless communications have progressed very rapidly in recent years, and many mobile units are becoming smaller and smaller. It started with hand gestures, then sounds produced by vocal chords and gradually me moved to wired communication and now wireless communication. In wireless communication we mainly exploit the Electromagnetic Spectrum. To meet the miniaturization requirement, the antennas employed in mobile terminals must have their dimensions reduced accordingly. Planar antennas, such as micro strip and printed antennas have the attractive features of low profile, small size, and conformability to mounting hosts. For this reason, compact, broadband and wideband design technique for planar antennas have been attracted much attention from antenna researchers.[8] Very recently, especially after the year 2000, many novel planar antenna designs to satisfy specific bandwidth specifications of present day mobile cellular communication systems have been developed. Planar antennas are also very attractive for applications in communication devices for wireless local area network (WLAN) systems in the 2.4 GHz (2400 – 2484 MHz) and 5.2 GHz (5150 – 5350 MHz) bands.[11]

The major need for today's communication devices is to operate at broader band such as to support high speed internet, multimedia communication and similarly many more broadband services, this is achieved by using microstrip patch antennas, but inherently microstrip antennas are narrow band antennas so, various techniques are used to enhance the bandwidth of microstrip antenna[2]. The excitation of microstrip antenna can have many configurations like microstrip line, coaxial, aperture coupling and proximity coupling. Out of these microstrip line and the coaxial feeds are easy to fabricate. By using coaxial probe feed technique produces low spurious radiation but narrow bandwidth [3]. To increase the speed of access and number of users with less crosstalk and interference data rates and bandwidth have to be increased for a particular operating frequency. By using different feeding techniques available and by inserting different slots on patch improves return loss, gain and radiation pattern [1] [4]. So in this paper we are using H-Shape and C-Shape slot on fractal patch on the Ground plane is used to reduce the size of antenna [7]. Return loss is a measure of how well devices or lines are matched. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. Return loss is related to both standing wave ratio (SWR) and reflection coefficient (Γ). Increasing return loss corresponds to lower SWR. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss [5][6].

II. Design Specifications

Based on the simplified formulation that has been described, a design procedure is outlined which leads to practical designs of rectangular micro strip antennas. The procedure assumes that the specified information includes the dielectric constant of the substrate (ε_r), the resonant frequency (f_r), and the height of the substrate h.[10]

- Dielectric constant (ε_r)

i.e., $2.2 \leq \varepsilon_r \leq 12$ [2]

- Operating frequency (f_0) =1.85 to 5 GHZ
- Height (h)

i.e., $0.003\lambda_0 \leq h \leq 0.05\,\lambda_0$

Where λ_0=free space wavelength

- Width of the microstrip patch antenna,

$$w = \frac{1}{(2 * \mathrm{fr}\sqrt{\mu_\circ \varepsilon_\circ})} \sqrt{(\frac{2}{\varepsilon r + 1})}$$

Where, c = velocity of light

f_r = operating frequency

εr = substrate dielectric constant

Generally practical width, w< λ_0

- Effective dielectric constant

$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} * \frac{1}{\sqrt{(1+12h/w)}}$

- Length of the patch,

L= L_{eff} -2ΔL

Where

$L_{eff} = \frac{C}{2fo\sqrt{\epsilon r}}$ and

$\Delta L = 0.412h \frac{(\epsilon eff+0.300)(\frac{w}{h}+0.264)}{(\epsilon eff-0.258)(\frac{w}{h}+0.800)}$

For practical length , 0.3333 λ_0<L<0.5 λ_0[1]

III. Calculation of Parameters

In this session we consider three frequencies and calculations are done.

Assuming Operating frequency , (f_0) = 4.5 GHz

Dielectric constant as TEFLON

For Teflon dielectric constant(ε_r)=2.2

Calculation of width:

$$w = \frac{1}{(2 * \mathrm{fr}\sqrt{\mu_\circ \varepsilon_\circ})} \sqrt{(\frac{2}{\varepsilon r + 1})}$$

W= 26.3 mm

Practical width , w< λ_0

i.e., 0.0263mm < 0.066mm

Calculation of height:

Height (h) = $0.003\lambda_0 \leq h \leq 0.05\ \lambda_0$

$\lambda_0 = c / f_0$

$\lambda_0 = \frac{3*10^8}{4.5G}$ = 0.066 mm

0.198 mm ≤ h ≤ 3.3 mm

Assuming height = 0.8 mm which is in between 0.198 and 3.3 mm

Calculating Effective Dielectric Constant:

$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} * \frac{1}{\sqrt{(1+12h/w)}}$

ε_{eff} = 2.11

Calculating length:

We know that , L_{eff} = L+2ΔL

➔ L= L_{eff} -2ΔL

$L_{eff} = \frac{c}{2f0\sqrt{\varepsilon eff}}$

L_{eff} = 22.9 mm

$\Delta L = 0.412h \frac{(\epsilon eff+0.300)(\frac{w}{h}+0.264)}{(\epsilon eff-0.258)(\frac{w}{h}+0.800)}$

ΔL = 0.422 mm

L= L_{eff} -2ΔL = 22.4 mm

For practical length

0.3333 λ_0<L<0.5 λ_0

0.3333(0.066)<L<0.5(0.066)

21.9 mm < L < 33 mm

Ground Plane Dimensions:

Length of the ground plane (L_g) = 2L = 44.94 mm

Width of the ground plane (W_g) = 2W= 52.6 mm

Assuming Operating frequency (f_0) = 2.6GHZ,

Dielectric constant as TEFLON

For Teflon dielectric constant(ε_r)=2.2

Calculation of width:

$$w = \frac{1}{(2 * fr\sqrt{\mu_\circ \varepsilon_\circ})}\sqrt{(\frac{2}{\varepsilon r + 1})}$$

W = 0.046m

W = 46mm

Practical width w < λ_0

0.046 < 0.115

Calculation of height:

Height (h) = 0.003 $\lambda_0 \leq h \leq 0.05\ \lambda_0$

λ_0 = **c** / f_0

λ_0 = 0.115

0.115 ≤ h ≤ 5.7mm

Assuiming height = 1.5mm which is in between 0.115and 5.7mm

Calculating Effective Dielectric Constant:

$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} * \frac{1}{\sqrt{(1+12h/w)}}$

ε_{eff} = 1.7803

calculating length:

we know that , L_{eff} = L+2ΔL

➔ L = L_{eff} -2ΔL

$L_{eff} = \frac{c}{2f0\sqrt{\varepsilon eff}}$

L_{eff} = 43mm

$\Delta L = 0.412h\,\frac{(\epsilon eff+0.300)(\frac{w}{h}+0.264)}{(\epsilon eff-0.258)(\frac{w}{h}+0.800)}$

ΔL = 0.83014267mm

L = L_{eff} -2ΔL

L = 41.33mm

For practical length

0.3333 λ_0<**L**<0.5 λ_0

38.3<L<57.5

Assuming Operating frequency (f_0) = 2.1GHZ

Dielectric constant as TEFLON

For Teflon dielectric constant(ε_r) = 2.2

Calculation of width:

$$w = \frac{1}{(2 * fr\sqrt{\mu_\circ \varepsilon_\circ})}\sqrt{(\frac{2}{\varepsilon r + 1})}$$

W = 0.0564m

W = 56.4mm

Practical width w < λ_0

0.0564 < 0.115

Calculation of height:

Height (h) = 0.003 $\lambda_0 \leq h \leq 0.05\ \lambda_0$

λ_0 = **c** / f_0

λ_0 = 0.142

0.4 ≤ h ≤ 7.1mm

Assuiming height = 2.8mm which is in between 0.4 and 7.1mm

Calculating Effective Dielectric Constant:

$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} + \frac{1}{\sqrt{(1+12h/w)}}$

ε_{eff} = 2.07

Calculating length:

we know that , L_{eff} = L+2ΔL

➔ L = L_{eff} -2ΔL

$L_{eff} = \frac{c}{2f0\sqrt{\varepsilon eff}}$

$L_{eff} = 49.6mm$

$\Delta L = 0.412h \frac{(\epsilon eff+0.300)(\frac{W}{h}+0.264)}{(\epsilon eff-0.258)(\frac{W}{h}+0.800)}$

$\Delta L = 1.4mm$

$L = L_{eff} - 2\Delta L$

$L = 46.8mm$

For practical length

$0.3333\ \square_0 < \mathbf{L} < 0.5\ \square_0$

$0.046 < L < 0.07$

Table 1: Comparison of Antenna Parameters for Different Frequencies

Frequency (f_0)	Teflon (ε_r)	Height of the Substrate (h)	Width of the Patch (W)	Length of the Patch (L)	Width of the Ground Plane (W_g)	Length of the Ground Plane (L_g)
4.5GHz	2.2	0.8mm	26.3mm	61mm	52.6mm	44.94mm
2.1GHZ	2.2	2.8mm	56.4mm	46.8mm	73.2mm	63.6mm
2.6GHZ	2.2	1.5mm	46mm	41.3mm	55mm	50.3mm

From table we consider 4.5GHz frequency.

IV. Outline of Patch Antenna At 4.5 Ghz

The outline of patch antenna at 4.5 GHz is shown in the fig.1.

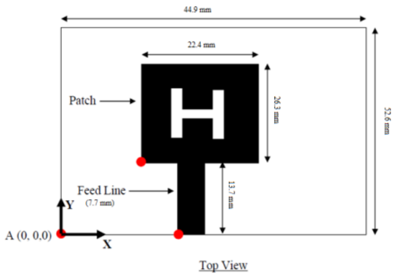

Figure 1: Patch antenna dimensions at 4.5 GHz

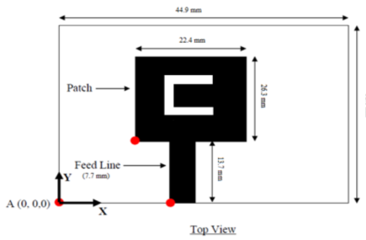

Figure 2: Patch antenna dimensions at 4.5 GHz

Results regarding the performance of patch antenna and comparison of parameters with C and H- Shape slots on patch designed at an operating frequency of 4.5 GHz

V. Results

The below outputs represents the plots of **C-shape** slot on patch antenna with line feed.

S-parameters (S11) Vs Frequency plot:

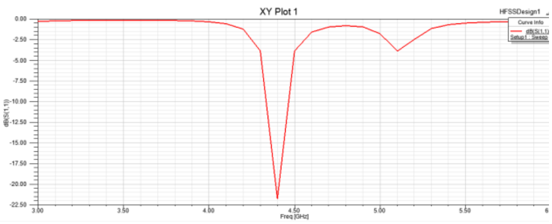

Figure 3 : S-parameters (S11) Vs Frequency plot

Here the Patch antenna is simulated at operating frequency of 4.5GHz. The S11 value at
-10db is return loss.

Return loss = -21.50

Impedance Bandwidth:

The difference between upper and lower-cut off frequencies at S11 value -10db from the above graph is taken as bandwidth.

Bandwidth(%) = (4.49 GHz – 4.31 GHz) / 4.5GHz

Impedance Bandwidth **= 4 %**

Directivity:

The directivity obtained for the designed micro strip line feed patch antenna is obtained as

D (θ, φ) = 5.2 db (as W< lambda)

The plot of directivity at different angles of θ is as follows.

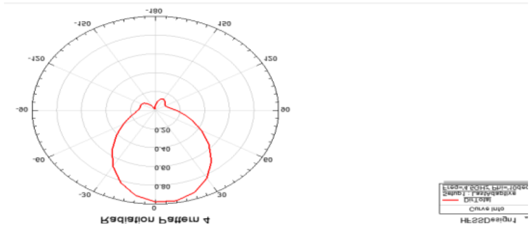

Figure 4 : Polar plot for directivity

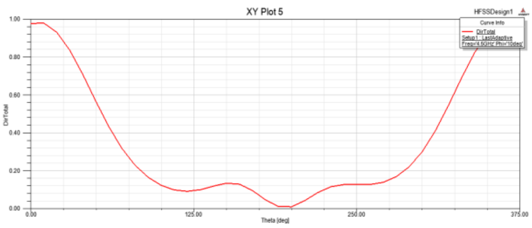

Figure 5 : Rectangular plot for directivity

Radiation Efficiency:

Radiation efficiency obtained for this design is 0.92465 .

Gain:

Antenna Gain in a particular direction is equal to the Directivity in that direction multiplied by the Antenna Efficiency.

G (θ, φ) = E*D (θ, φ)

G (□, □) = 4.8 db

The plot of gain at different angles of θ is as shown below.

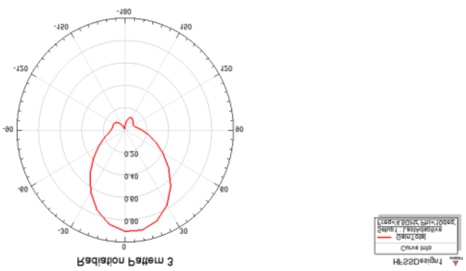

Figure 6 : Polar plot for gain

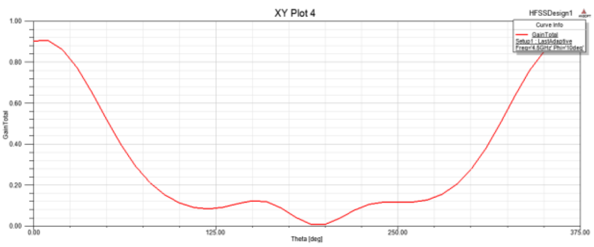

Figure 7: Rectangular plot for gain

VSWR Vs Frequency Plot:

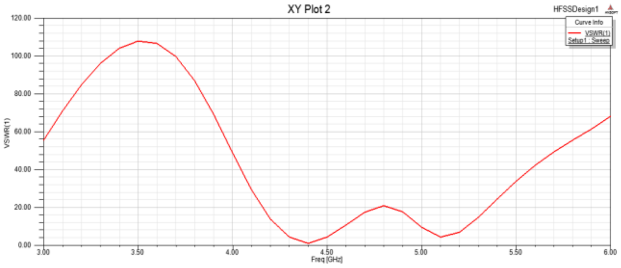

Figure 8: VSWR Vs Frequency Plot

VSWR obtained from the above graph is 1.

VSWR = 1

Radiation Pattern:

The 2-D far field pattern obtained for 4.5GHz is as shown below.

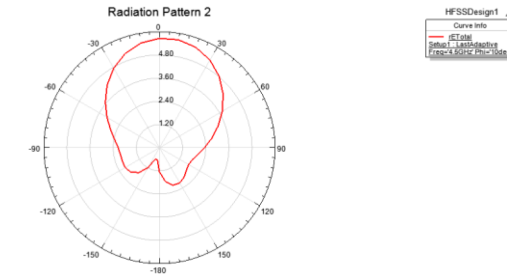

Figure 9: Polar plot for radiation pattern

3-D far field pattern is shown below.

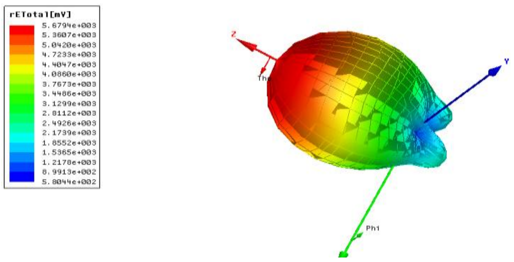

Figure 10: 3-D Radiation pattern

Table 2: Comparison of Output Parameters at Different Frequencies for H-slot

FREQUENY (GHz)	RETURN LOSS (db)	BANDWIDTH (MHz)	DIRECTIVITY (db)	GAIN (db)	VSWR
4.5	-22.7	70	5.2	4.7	1
2.6	-19	60	5.2	4.6	1
2.1	-18	50	5.2	4.7	0.8

The table 3 shows comparision of antenna output parameters at frequency 4.5 GHz with C-Shape and H-Shape slots on patch.

Table 3: Comparison of Output parameters at 4.5 GHz for C and H-shape slots

PARAMETER	C-Shape slot	H-Shape slot
Return loss (db)	-21.5	-22.7
Band width (%)	4.5	1.5
Gain (db)	4.8	4.7
Directivity (db)	5.2	5.2
VSWR	1	1

From the table 3 simulation results the patch designed with C-Shape slot produces more bandwidth and gain.

VI. Conclusion And Future Scope

Conclusion:

In this paper we designed patch antenna operating at 4.5 GHz and compared the results for C and H-Shape slots. We can say that there are many aspects that affect the performance of the antenna such as dimensions, selection of the substrate, feed technique and also the Operating frequency can take their position in effecting the performance. From the above table we conclude that the design with C-Shape slot provides more bandwidth and gain compared to H-Shape slot results.

Future Scope

It is very important to take the feed technique, the impedance and the substrate as main parameters into consideration. The proper position to terminate the Feed line also affects the performance of the antenna. In future other different type of feed techniques can be used to calculate the overall performance of the antenna without missing the optimized parameters in the action.

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