Design & Analysis of C shape Microstrip Antenna

[1]Vishal Upmanu, [2] Dr.D.B.Ojha, [3] Ajay kumar Yadav,

Mewar University, Chittorgarh(Raj.)

ABSTRACT

The design and analysis of c shaped micro strip patch antenna is presented. A computer simulation using the IE3D software was performed and the s parameters of the antenna were measured. By using only single patch a high impedance bandwidth is achieved .In this thesis MATLAB program for the design and analysis of all the parameters and for different patches have made. These results obtained through MATLAB program yields results compatible with the theoretical analysis of MSA.

1. INTRODUCTION

Deschamps first proposed the concept of the microstrip antenna in 1953. However, practical antennas were developed by Munson and in the 1970's. The numerous advantages of microstrip antenna, such as its low weight, small volume, and ease of fabrication using printed-circuit technology, led to the design of several configurations for various applications. With increasing requirements for personal and mobile communications, the demand for smaller and low profile antennas has brought the microstrip antenna to the forefront.

A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The top and side views of a rectangular microstrip antenna are shown in Figure. However other shapes such as the square, circular, triangular, semicircular, sectoral, and annular ring shapes shown in Figure are also used. Radiation from the microstrip antenna can occur from the fringing fields between the periphery of the patch and ground plane. The length L of the rectangular patch for the fundamental TM01 mode excitation is slightly smaller than λ/2, where λ is the wavelength in the dielectric medium, which in terms of free space wavelength λ0 is given as λ0/√εe, where εe is the effective dielectric constant of a microstrip line of width W. The value of εe is slightly less than the dielectric constant εr of the substrate because the fringing fields from the patch to the ground plane are not confined in the dielectric only, but are also spread in the air.

To enhance the fringing fields from the patch, which account for the radiation, the width W of the patch is increased. The fringing fields are also enhanced by decreasing the εr or by increasing the substrate thickness h. Therefore, unlike the microwave integrated circuit applications, microstrip antenna uses microstrip patches with larger width and subtrates with lower εr and thickness h. For microstrip antenna applications in the microwave frequency band, generally h is taken greater than or equal to 1/16th of an inch. There are many configurations that can be used to feed antennas. The four most popular configurations are .

1 Microstrip line

The microstrip line is also a conduction strip usually much smaller width compared to the patch. The microstrip line is easy to fabricate, simple to match by controlling position and rather simple to model. However as the substrate thickness increased surface waves and spurious feed radiation increases. Which for practical designs limit the bandwidth (typically 2-5%)

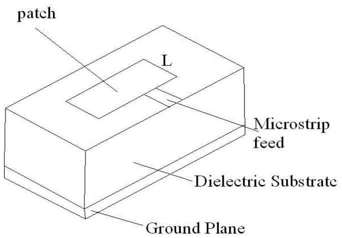


Figure:Line

feed achieve different benefits. The most important is higher network capacity, i.e. the ability to serve more user per base station, thus increasing revenues of network operators, and giving customers less probability of blocked or dropped calls. Also, the transmission quality can be improved by increasing desired signal power and reducing interference.

2 Coaxial probe

The coaxial or probe feed arrangement is shown in Figure. The center conductor of the coaxial connector is soldered to the patch. The main advantage of this feed is that it can be placed at any desire location inside the patch to match with its input impedance. The disadvantages are that the whole has to be drilled in the substrate and that the connector protrudes outside the bottom ground plane, so that it is not completely planar. Also, this feeding arrangement makes the configuration asymmetrical

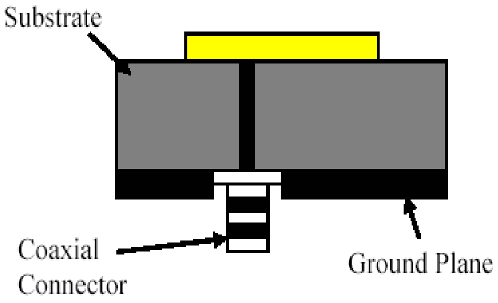


Figure: coaxial feed

3 Aperture coupling

This is most difficult to fabricate and it also has narrow bandwidth. However it is somewhat easier to model and has moderate spurious radiation. Another method for indirectly exciting a patch employs aperture coupling. In the aperture coupled microstrip antennas patch through an electrically small aperture or slot cut in the ground plane, as shown in Figure. The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of configuration. The shape, size and location of the aperture decide the amount of coupling from the feedline to the patch. The slot aperture can be either resonant or nonresonant.

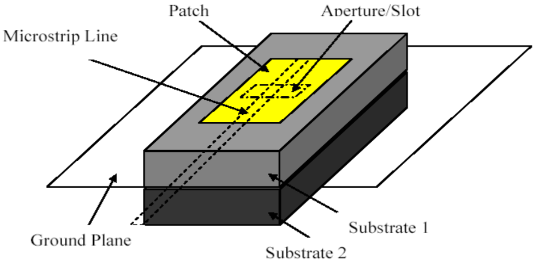


Figure: Aperture coupling

4 Proximity coupling

The electromagnetic coupling is also known as proximity coupling. The feed line is placed between the patch an ground plane, which is separated by two dielectric media, one for patch and other for feed line to optimize the individual performances, and an increase in the BW due to overall substrate thickness of microstrip antennas. The disadvantages are that the two layers need to be aligned properly and that the overall thickness of the antennas increases.

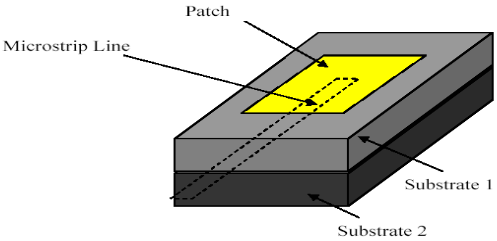


Figure: Proximity coupling

ANALYSIS AND DESIGN

Design parameter for rectangular patch:

The three essential parameters for the design of a rectangular microstrip patch antenna are:

Frequency of operation (fo) :

The resonant frequency of the antenna must be selected appropriately .The resonant frequency selected for my design is 900 MHz

Dielectric constant of the substrate(er):

The dielectric material selected for my design is quartz which has a dielectric constant of 4.2. a substrate with high dielectric constant has been selected since it reduces the dimensions of the antenna .

Height of the dielectric substrate (h):

For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna should not be bulky .Hence the height of the dielectric substrate is selected as 0.8mm.

Hence the essential parameters for the design are:

fo= 1.5GHz

er= 4.2

h=2 mm

Designed parameters for C shaped patch:

$$C_1 = \frac{\varepsilon_e \varepsilon_0 LW}{2h} \cos^{-2}\left(\frac{\pi y_0}{L}\right)$$

Where

L= length of the patch

W= width of the patch

h= thickness of the substance

ε_e = effective dielectric constant

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}}$$

ε_r= relative dielectric constant of the substance

y_0=feed point location along the y-axis i.e., alog the lrngth of the patch

Also

$$L_1 = \frac{1}{C_{1.}\omega_r^{2}}$$

and

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-1/2}$$

$$R_1 = \frac{Q_r}{\omega_r C_1}$$

Where

Q_r =quality factor of the patch

ω_r =resonance frequency of the patch

$$Q_r = \frac{c\sqrt{\varepsilon_e}}{4 f_r h}$$

Where

c=velocity of light in free space

The input impedance of the resonant circuit

$$Z_{patch} = \frac{1}{\left(\frac{1}{R_1} + j\omega c_1 + \frac{1}{j\omega L_1}\right)}$$

$$\Delta L = \frac{h\mu_0\pi}{8}(l/L)^2$$

Where $\mu_0 = 4\pi 10^{-7}$ and l = equivalent length of the notch

$$\Delta C = \left(\frac{l}{L}\right)\cdot C_s$$

C_s =gap capacitance

$$Z_{patch} = \frac{1}{\left(\frac{1}{R_1} + j\omega C_2 + \frac{1}{j\omega L_2}\right)}$$

where $C_2 = \dfrac{C_1 \cdot \Delta C}{C_1 + \Delta C}$

$$L_2 = L_1 + \Delta L$$

The coupling coefficient between these two resonators

$$C_p = \frac{1}{\sqrt{Q_1 \cdot Q_2}}$$

where Q_1 = quality factor of the resonant circuit due to normal current $= \dfrac{\omega L_1}{R_1}$

and Q_2 = quality factor of the resonant circuit due to notch effect $= \dfrac{\omega L_2}{R_1}$

The mutual inductance $= L_m$

The mutual capacitance $= C_m$

$$L_m = \frac{C_p^2(L_1 + L_2) + \sqrt{C_p^2(L_1 + L_2)^2 + 4C_p^2(1 - C_p^2)}L_1 L_2}{2(1 - C_p^2)}$$

$$C_m = \frac{-(C_1 + C_2) + \sqrt{(C_1 + C_2)^2 - 4C_1C_2}(1 - C_p^{-2})}{2}$$

The input impedance of the notched rectangular microstrip patch antenna

$$Z_{in} = Z_{notch} + \left(\frac{Z_{patch} Z_{in}}{Z_{patch} + Z_{in}}\right)$$

Where

$$Z_{in} = j\omega L_m + \frac{1}{j\omega C_m}$$

Reflection coefficient $= \Gamma = \dfrac{Z_0 - Z_{in}}{Z_0 + Z_{in}}$

Where Z_0 = characteristic impedance of the co-axial feed (50Ω)

$$\text{VSWR} = S = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$$\text{Bandwidth} = \frac{S-1}{Q\sqrt{S}}$$

And Return loss = $20\log|\Gamma|$

Designed parameters

For designing the notched rectangular microstrip patch antenna, following parameters were used

Design frequency = 1.5GHz

Free space wavelength = 100mm

Dilectric constant (R-T duriod) =4.2

Loss tangent (tanδ) =0.2

The thickness of the substrate (h) =.02λ

Length of the patch (L) =0.5 λ

Width of the patch (W) =0.4 λ

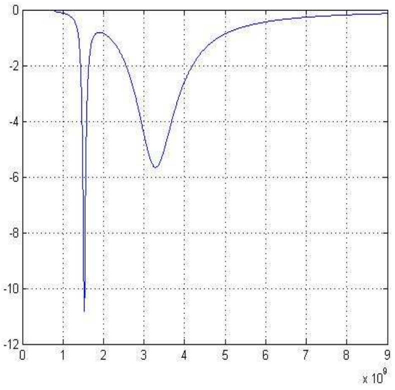
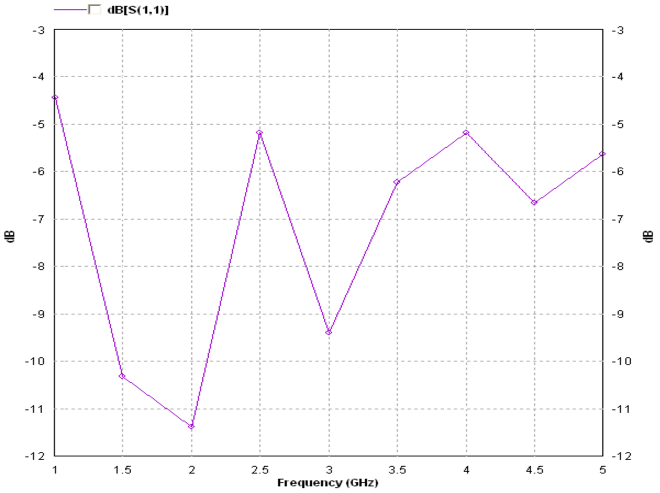
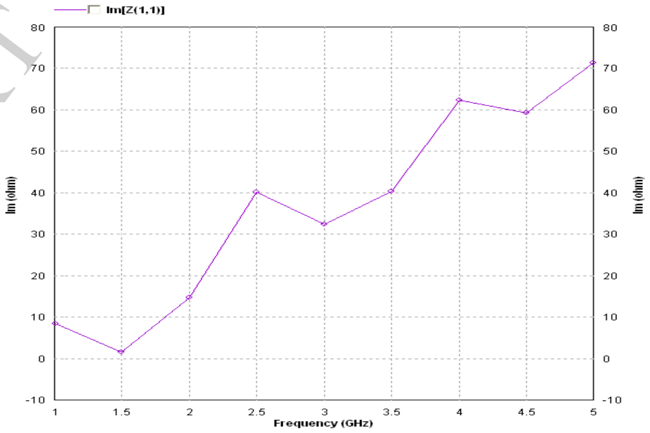


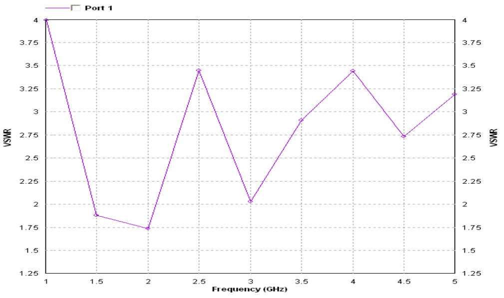
figure: frequency vs return loss for single notch

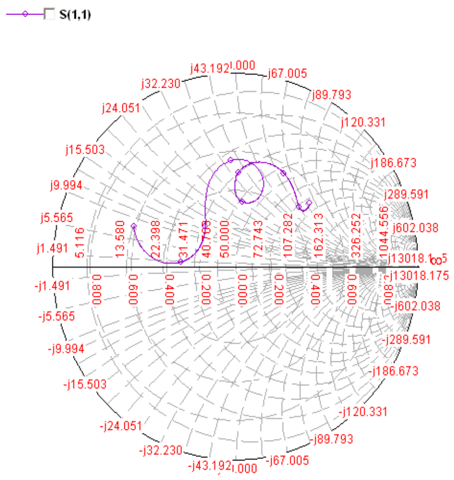
IE3D SIMULATION FOR C SHAPED MICROSTRIP PATCH

Various results taken by the IE3D for c shaped microstrip patch antenna are represented by the graphs given below

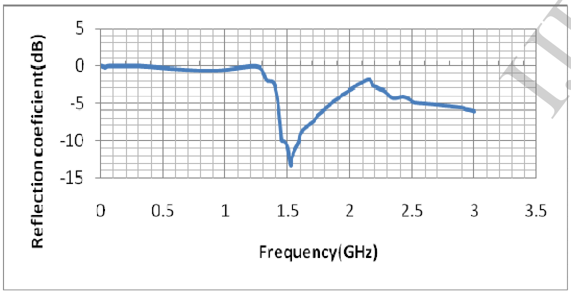








RESULT ANALYSIS



CONCLUSION

From the work conducted on the micro strip patch antenna ,it can be concluded that micro strip antennas are low profile ,simple and inexpensive to manufacture using modern printed circuit board technology ,mechanically robust when mounted on rigid surfaces .and when the particular patch shape and mode are selected they are very versatile in term of resonant frequency, polarization ,pattern and impedance. in addition by adding loads b/w the patch and the ground plane. such as pins. shorting posts and varactor diodes adaptive elements with variable resonant frequencies. impedance, polarization and pattern can be designed..in this project we have made a MATLAB program for the design and analysis of all the antenna parameters ,and various patch of different dimensions, the latter being dependent on the substrate permittivity and the resonant frequency as required by the user.All the polar plots and the graphs of variations in the results with respect to frequency have also been plotted in the report.

REFERENCES

[1] K. R. Carver and j. W. Mink, "*Microstrip antenna technology*", IEEE Trans . Antenna Propag. Vol. AP- 29,pp.1-24,1981.

[2] Ballanis C A, "*Antenna Theory and design New York*", 1980.

[3] Wong B F & Lo Y T, "*Microstrip antenna for dual frequency operations*", IEEE Trans. Antenna Propag.1984.

[4] Pandey V. K. & Vishvakarma B R, "*Theoretical analysis of linear array antenna of Stacked Patches, Indian J Radio & Space Physics*", 2005.