

DESIGN OF MICRO STRIP ANTENNA AND STUDY OF PARAMETES BY VARYING THE FREQUENCY

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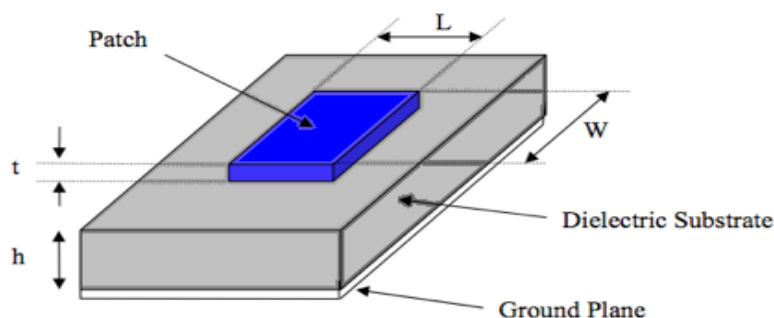
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Abstract: Today the micro strip antennas are mostly used in wireless communication due to its advantages such as small size, low cost, light weight etc. But there are some drawbacks with these antennas like low gain, narrow bandwidth, and low efficiency. In this paper we increase the bandwidth by varying the frequency. The rectangular micro strip antenna is operated at frequency (1.5, 4.5 and 9.5 GHz) and dielectric substrate(2.2) for the height 0.05cm . We calculate the width, length, VSWR and bandwidth when antenna is fed by a transmission line of 50 ohm. Input impedance is calculated by error and trial method.

Keywords: Micro strip antenna, bandwidth improvement, dielectric substrate.

INTRODUCTION

Now days the demand of microstrip antenna is very large in the applications of wireless communication due to their smaller size, lesser weight and low cost. The manufacturing and fabrication of such antennas are very easy and simple. The use of microstrip antenna is limited because of its drawbacks such as narrow bandwidth, less gain and low efficiency. Bandwidth increases as the thickness of substrate is increased and dielectric substrate is decreased. We can use the transmission line model for calculation of parameters of rectangular microstrip antenna.



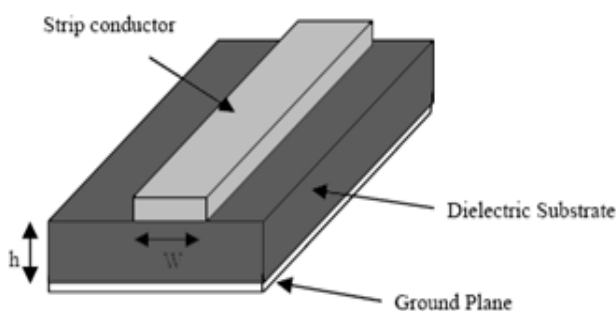
Structure of rectangular microstrip antenna

It is a very thin of thickness h ($h \ll \lambda_0$), λ_0 is the wavelength in free space.

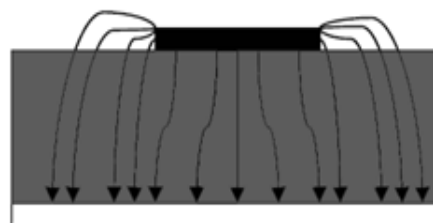
II. TRANSMISSION LINE MODEL ANALYSIS:

A rectangular microstrip patch antenna can be represented as an array of two radiating narrow aperture /slots, each of width W and height h separated by a distance L .

This is a non-homogeneous lines of two dielectrics, the substrate and air.



Micro Strip Lines



Electric Field Lines

The width of the rectangular patch can be calculated by following equation:

$$W = \frac{c}{2f_0\sqrt{\epsilon_r+1}} \quad (1)$$

The value of effective dielectric constant(ϵ_{reff}) is slightly smaller than dielectric constant(ϵ_r) due to the fringing field effect around the patch.

$$\epsilon_{\text{reff}} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} \left[\frac{1}{\sqrt{1+12\frac{h}{W}}} \right] \quad (2)$$

Where ϵ_{reff} = Effective dielectric constant

ϵ_r = Dielectric constant of substrate

H = Height of dielectric substrate

W = Width of the patch

When the dimension of the patch along its length have been extended on each end by a distance ΔL which is a function of the effective dielectric constant(ϵ_{reff}) and W/h ratio and approximate relation for the normalise extension of the length is given by:

$$\Delta L = 0.412h \left[\frac{(\epsilon_{\text{reff}}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{\text{reff}}-0.258)\left(\frac{W}{h}+0.8\right)} \right] \quad (3)$$

The effective length(L_{eff}) of the patch is given as:

$$L_{\text{eff}} = L + 2\Delta L \quad (4)$$

For a resonance frequency the effective length(L_{eff}) is given as:

$$L_{\text{eff}} = \frac{c}{2f_0\sqrt{\epsilon_{\text{reff}}}} \quad (5)$$

The actual length of microstrip patch can be calculated as:

$$L = \frac{1}{2f_0\sqrt{\epsilon_{\text{reff}}}} - 2\Delta L \quad (6)$$

For a rectangular microstrip antenna resonance frequency is given as:

$$f_r = \frac{c}{2L\sqrt{\epsilon_r}} \quad (7)$$

III. DESIGN PROCEDURE OF RECTANGULAR PATCH

Step 1: Selection of substrate

Dielectric constant of a substrate material plays an important role for overall performance of patch antenna. Almost all the properties of an antenna depend on the types of substrate used in designing.

Substrate selection of material depends on its loss tangent, temperature gradient and thickness. Ideally thick and low dielectric constant substrate having low insertion loss is preferred for broadband applications and higher frequency.

Step 2: Rectangular patch parameters

The increase in power radiation is because of larger width and it results decrease in resonance resistance, due to this the bandwidth and radiation efficiency is increased.

We can choose the patch width greater than patch length. It is recommended that $1 < W/L < 2$

In the case of rectangular patch antenna the bandwidth is given by:

$$BW = 3.77 \left(\frac{\epsilon_r - 1}{\epsilon_r^2} \right) \left(\frac{h}{\lambda} \right) \left(\frac{W}{L} \right) \quad (8)$$

Where VSWR is Voltage Standing Wave Ratio and is calculated by:

$$\frac{VSWR}{1-\Gamma} = 1+\Gamma \quad (9)$$

Here Γ is the reflection coefficient and is calculated from the input impedance of the path and characteristic impedance of the feed line.

$$\Gamma = \frac{Z_{\text{in}} - Z_0}{Z_{\text{in}} + Z_0} \quad (10)$$

Here Z_{in} = Input Impedance

And Z_0 = Characteristic Impedance

IV. DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA

The frequency is selected properly for the design of antenna. In this paper frequency is varied for the substrate material. The frequency is between 1 and 10 GHz.

The substrate material used for the design of antenna is FR4 material and the dielectric constant value is taken as 2.2 (i.e. $\epsilon_r = 2.2$).

The height taken for the substrate material is 0.05 cm (i.e. $h = 0.05$ cm).

The parameters used for the design of the antenna are: $F_0 = 1.5, 4.5, 9.5$ GHz, $\epsilon_r = 2.2$ (FR4 material), and $h = 0.05$ cm

For the design of antenna we use the transmission line model.

Calculation of the antenna parameters:

For same height and substrate value, the antenna parameters are:

Width(W):

The width is calculated by using equation(1): $\epsilon_r = 2.2$, $h = 0.05$ cm, $f_0 = 9.5$ GHz and the width (W) = 1.25 cm

Effective dielectric constant(ϵ_{reff}):

Equation(2) gives the value of effective dielectric constant (ϵ_{reff}): $\epsilon_r = 2.2$, $h = 0.05$ cm, $f_0 = 9.5$ GHz and effective dielectric constant(ϵ_{reff}) = 2.09

Extension in length(ΔL):

Equation (3) gives the value of extension in length: $\epsilon_r = 2.2$, $h = 0.05$ cm, $f_0 = 9.5$ GHz and extension in length(ΔL) = 0.026 cm

Effective length(L_{eff}):

Equation(4) is used for effective length calculation: $\epsilon_r = 2.2$, $h = 0.05$ cm, $f_0 = 9.5$ GHz and effective length(L_{eff}) = 1.09 cm

Actual length of the antenna(L):

Equation (6) gives the value of actual length(L): $\epsilon_r = 2.2$, $h = 0.05$ cm, $f_0 = 9.5$ GHz and actual length(L) = 1.04 cm

V. RESULT

Effect of frequency on the antenna performance

Items	Dielectric Thickness(h cm)	Antenna specifications (cm)	F_0 (GHz)	BW	BW%
1.	0.05	W=7.905 cm $\epsilon_{\text{reff}} = 2.1784$ $\Delta L = 0.026$ cm L= 6.7 cm VSWR= 5.25	1.5	0.0027	0.27%
2.	0.05	W=2.63 cm $\epsilon_{\text{reff}} = 2.14$ $\Delta L = 0.027$ cm L= 2.2 cm VSWR=5.06	4.5	0.0083	0.83%
3.	0.05	W=1.25 cm $\epsilon_{\text{reff}} = 2.09$ $\Delta L = 0.026$ cm L= 1.04 cm VSWR=5.06	9.5	0.0178	1.78%

VI. CONCLUSION

This papers shows that the bandwidth increases with the increase of frequency. At low dielectric constant value and low substrate height we can improve the bandwidth of the patch antenna by increasing the value of frequency. We use dielectric constant value as 2.2 and thickness (h) is 0.05 cm but vary the frequency value. It is easy to improve the bandwidth by varying the frequency.

REFERENCES

- [1] A.K Bhattachar jee, S.R Bhadra, D.R. Pooddar and S.K. Chowdhury. 1989. Equivalence of impedance and radiation properties of square and circular microstrip patch antennas. IEE Proc. 136(Pt, H, 4): 338-342.
- [2] R. G. Voughan. 1988. Two-port higher mode circular microstrip ntennas. IEEE, Trans. Antennas Propagat. 36(3): 309-321.

- [3] T Huynh and K.F. Lee. 1995. Single layer single patch wideband microstrip patch antenna. Electronic letters. L (31): 1310-1311.
- [4] Constantine A. Balanis. 2005. ANTENNA THEORY ANALYSIS AND DESIGN. 3rd Edition. John Wiley and Sons.
- [5] V Zachou. 2004. Transmission line model Design Formula for Microstrip Antenna with Slots. IEEE.
- [6] V Zachou. 2004. Transmission line model Design LETTERS. 2nd August. 43(16).
- [7] Jani Ollikainen and Pertti Vainikainen. 1998. Radiation and Bandwidth Characteristics of Two Planar Multistrip Antennas for Mobile Communication Systems. IEEE Vehicular Technology Conference. Ottawa, Ontario, Canada. 2: 1186-1190.
- [8] Lorena I. Basilio. 2001. The Dependence of the Input Impedance on Feed Position of Probe and Microstrip Line-Fed patch Antennas. IEEE Transaction on Antennas and Propagation. 49(1).
- [9] J. R. James and P. S. Hall. 1989. Handbook of Microstrip Antennas. London, Peregrinus.
- [10] Ray K. P. 1999. Broadband, Dual Frequency and Compact Microstrip Antennas. Ph. D. Thesis. Indian Institute of Technology, Bombay, India.
- [11] K. Sharma and Lotfollah Shafai, "Performance of a Novel phi-Shape Microstrip Patch Antenna With Wide Bandwidth", *IEEE Trans. Antennas Propagat*, Vol 8,468-471 June 2009.
- [12] K. L. Wong and W. H. Hsu, "A broadband rectangular patch antenna with a pair of wideslits," *IEEE Trans. Antennas Propagat*. Vol 49, 1345-1347, Sept. 2001.
- [13] K. L. Wong and W. H. Hsu, "Broadband triangular microstrip antenna with U-shaped slot," *Electron. Lett.* 33, 2085-2087, Dec. 4, 1997.
- [14] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, "Microstrip Antenna Design Handbook," Artech House, 2000.
- [15] Kin-Lu Wong Compact and Broadband Microstrip Antennas- *Wiley Publications*.