ADVANCE TECHNIC OF RECTANGULAR MICROSTRIP PATCH ANTENNA WITH EBGS

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Abstract. Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, Visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource.

Keywords: LAN, IE3D, EBGS, MICs, VSWR, PSO, photolithographic.

1.INTRODUCTION

An antenna changes radio signals in the air into electricity, or vice versa. Antennas send signals, receive signals, or both. All NETGEAR wireless devices have an antenna, either a visible pole on the outside, or inside.The distance that an antenna sends (transmits) depends on the type, and the amount of power running through it.

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970[R.Garg,2000]. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on micro strip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice.

Mictrostrip Antennas are among the most widely used types of Antennas in the microwave frequency range[K.F.Lee.1997], and they are often used in the millimeter-wave frequency range as well [D.M.Pozar,D.H.Schaubert,1995]. (Below approximately 1 GHz, the size of a Mictrostrip Antenna is usually too large to be practical, and other types of Antennas such as wire Antennas dominate). Also called Patch Antennas, Mictrostrip Patch Antennas consist of a metallic Patch of metal that is on top of a grounded dielectric substrate of thickness *h*, with relative permittivity and permeability εr and μr as shown in Figure 1.(usually μr=1). The metallic Patch may be of various shapes, with rectangular and circular being the most common, as shown in Figure 1.

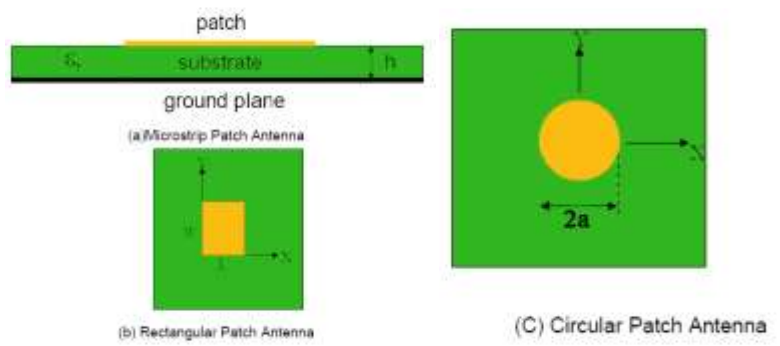


Figure 1. Rectangular & Circular Patch Antennas

Advantage of the Mictrostrip Antenna is that it is usually low profile, in the sense that the substrate is fairly thin[F.E.Gardiol]. If the substrate is thin enough, the Antenna actually becomes "conformal," meaning that the substrate can be bent to conform to a curved surface (e.g., a cylindrical structure). A typical Substrate thickness is about 0.02 λ0[S K Behera]. The metallic Patch is usually fabricated by a photolithographic etching process or a mechanical milling process, making the construction relatively easy and inexpensive (the cost is mainly that of the substrate material). Other advantages include the fact that the Mictrostrip Antenna is usually lightweight (for thin substrates) and durable[D. R. Jackson and J. T. Williams,1991].

Disadvantages of the Mictrostrip Antenna include the fact that it is usually narrowband, with bandwidths of a few percent being typical. Some methods for enhancing bandwidth are discussed later, however. Also, the radiation efficiency of the Patch Antenna tends to be lower than some other types of Antennas, with efficiencies between 70% and 90% being typical[D. R. Jackson,1997].

2.BASIC PRINCIPLES OF OPERATION

The metallic Patch essentially creates a resonant cavity, where the Patch is the top of the cavity, the ground plane is the bottom of the cavity, and the edges of the Patch form the sides of the cavity[D. M. Pozar,1986]. The edges of the Patch act approximately as an open-circuit boundary condition. Hence, the Patch acts approximately as a cavity with perfect electric conductor on the top and bottom surfaces, and a perfect "magnetic conductor" on the sides[C. A. Balanis,1997]. This point of view is very useful in analyzing the Patch Antenna, as well as in understanding its behavior. Inside the Patch cavity the electric field is essentially *z* directed and independent of the z coordinate. Hence, the Patch cavity modes are described by a double index (*m*, *n*). For the (*m*, *n*) cavity mode of the rectangular Patch the electric field has the form

$$E_z(x,y) = A_{mn}\cos\left(\frac{m\pi x}{L}\right)\cos\left(\frac{n\pi y}{W}\right) \tag{1}$$

Where L is the Patch length and W is the Patch width. The Patch is usually operated in the (1, 0) mode, so that L is the resonant dimension and the field is essentially constant in the y direction. The surface current on the bottom of the metal Patch is then x directed, and is given by

$$E_z(x,y) = A_{mn}\cos\left(\frac{m\pi x}{L}\right)\cos\left(\frac{n\pi y}{W}\right) \tag{2}$$

For this mode the Patch may be regarded as a wide Mictrostrip line of width W, having a resonant length L that is approximately one-half wavelength in the dielectric[H. Pues and A Van de Capelle,1984]. The current is maximum at the centre of the Patch, $x = L/2$, while the electric field is maximum at the two "radiating" edges, $x = 0$ and $x = L$. The width *W* is usually chosen to be larger than the length (*W* =1.5 *L* is typical) to maximize the bandwidth, since the bandwidth is proportional to the width. (The width should be kept less than twice the length, however, to avoid excitation of the (0, 2) mode.)

At first glance, it might appear that the Mictrostrip Antenna will not be an effective radiator when the substrate is electrically thin, since the Patch current in (2) will be effectively shorted by the close proximity to the ground plane. If the modal amplitude *A*10 were constant, the strength of the radiated field would in fact be proportional to *h*. However, the Q of the cavity increases as *h* decreases (the radiation Q is inversely proportional to *h*). Hence, the amplitude *A*10 of the modal field at resonance is inversely proportional to *h*. Hence, the strength of the radiated field from a resonant Patch is essentially independent of *h*, if losses are ignored. The resonant input resistance will likewise be nearly independent of *h*. This explains why a Patch Antenna can be an effective radiator even for very thin substrates, although the bandwidth will be small[W. F. Richards, Y. T. Lo, and D. D. Harrison,1981].

3. DESIGN SPECIFICATIONS

The three essential parameters for the design of a rectangular Mictrostrip Patch Antenna:

•Frequency of operation (*fo*): The resonant frequency of the Antenna must be selected appropriately. The Mobile Communication Systems uses the frequency range from 2100-5600 MHz. Hence the Antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 2.4 GHz.

•Dielectric constant of the substrate (ε*r*): The dielectric material selected for our design is RT Duroid which has a dielectric constant of 2.45. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the Antenna.

•Height of dielectric substrate (*h*): For the Mictrostrip Patch Antenna to be used in cellular phones, it is essential that the Antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.58 mm.

Hence, the essential parameters for the design are:

- *fo* = 2.4 GHz
- ε*r* = 2.45
- *h* = 1.58 mm

Step 1: Calculation of the Width (*W*):
The width of the Mictrostrip Patch Antenna is given as:

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \tag{3}$$

Substituting *c* = 3.00e+008 m/s, ε*r* = 2.45 and *fo* = 2.4 GHz, we get:
W = 0.0475 m = 47.5 mm

Step 2: Calculation of Effective dielectric constant (ε*reff*):
The effective dielectric constant is:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{4}$$

Substituting εr = 2.45, W = 47.5 mm and h = 1.58 mm we get:
$\varepsilon reff$ = 2.3368

Step 3: Calculation of the Effective length ($Leff$**):**
The effective length is:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \tag{5}$$

Substituting $\varepsilon reff$ = 2.3368, c = 3.00e+008 m/s and fo = 2.4 GHz we get:
$Leff$ = 0.0406 m = 40.625 mm

Step 4: Calculation of the length extension (ΔL**):**
The length extension is:

$$\Delta L = 0.412h\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{6}$$

Substituting $\varepsilon reff$ = 2.3668, W = 47.5 mm and h = 1.58 mm we get:
ΔL = 0.81 mm

Step 5: Calculation of actual length of Patch (L**):**
The actual length is obtained by:

$$L = L_{eff} - 2\Delta L \tag{7}$$

Substituting $Leff$ = 40.625 mm and ΔL = 0.81 mm we get:
L = 39 m = 39 mm

Step 6: Calculation of the ground plane dimensions (Lg **and** Wg**):**

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by [9] that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the Patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$Lg = 6h + L = 6(1.5) + 39 = 48$ mm
$Wg = 6h + W = 6(1.5) + 47.5 = 56.5$ mm

Step 7: Determination of Inset feed depth (y0):

An inset-fed type feed is to be used in this design. As shown in Figure 4.1, the feed depth is given by y0. The feed point must be located at that point on the Patch, where the input impedance is 50 ohms for the resonant frequency. Hence, a trial and error method is used to locate the feed point.
In this case we use PSO to obtain the optimum feed depth, where the return loss (R.L) is most negative (i.e. the least value). According to [5] there exists a point along the length of the Patch which gives the minimum return loss.

Rin (y = y0) = Rin (y = 0) cos4 (π*y0/L)
Where, Rin (y=0) = 0.5 * (G1 ± G12)

$$Z_c = \begin{cases} \dfrac{60}{\sqrt{\epsilon_{reff}}} \ln\left[\dfrac{8h}{W_0} + \dfrac{W_0}{4h}\right], & \dfrac{W_0}{h} \leq 1 \\ \dfrac{120\pi}{\sqrt{\epsilon_{reff}}\left[\dfrac{W_0}{h} + 1.393 + 0.667 \ln\left(\dfrac{W_0}{h} + 1.444\right)\right]}, & \dfrac{W_0}{h} > 1 \end{cases}$$

(8)

$$G_1 = \begin{cases} \dfrac{1}{90}\left(\dfrac{W}{\lambda_0}\right)^2 & W \ll \lambda_0 \\ \dfrac{1}{120}\left(\dfrac{W}{\lambda_0}\right) & W \gg \lambda_0 \end{cases} \qquad G_{12} = \frac{1}{120\pi^2}\int_0^{\pi}\left[\frac{\sin\left(\frac{k_0 W}{2}\cos\theta\right)}{\cos\theta}\right]^2 J_0(k_0 L \sin\theta)\sin^3\theta\, d\theta$$

(9)

Using the first equation (assuming that ZC in the second equation is 50 Ω) where Rin (y=y0) =50Ω
We get: y0 = 13 mm

4.FIGURES AND TABLES

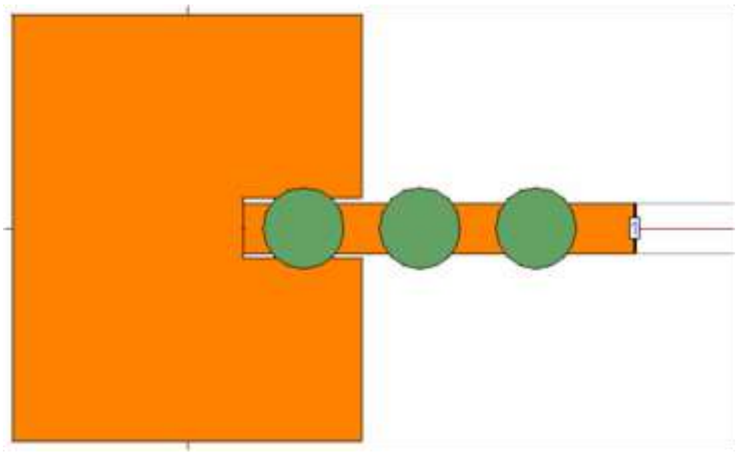


Figure 2. Mictrostrip Patch Antenna designed with EBGS using IE3D

4.1. Design Specification:

fo = 2.4 GHz
εr = 2.45
h = 1.58 mm
L = 39.4 mm
W = 46.9 mm

y0 = 13.2 mm

EBGS Radius = 4.5 mm

Distance between EBGSs = 10mm

4.2. Case I: Resonant frequency

We calculate the resonant frequency a Mictrostrip Antenna, using its parameters like width (W), length (L), permittivity of the substrate (εr) and height (h) of the substrate. We apply Particle Swarm Optimization technique for optimization of ΔL. The optimized ΔL is used for calculating the resonant frequency of rectangular Mictrostrip Patch Antenna.

4.3. Case II: Feed point calculation

The input impedance of rectangular Mictrostrip Patch Antenna is a vital parameter in deciding the amount of input power delivered to the Antenna, thus, reducing the coupling effect of the RF signal to the nearly circuits. The calculation of an exact 50 ohms input impedance of a rectangular Mictrostrip Patch Antenna becomes extremely difficult when the Antenna size is drastically small. In this paper, an attempt has been made to exploit the capability of PSO technique to calculate the input impedance by searching the feed point position. The feed point is calculated by using below equation which is optimized by PSO technique to get accurate results.
$Rin\ (y = y\ 0) = Rin\ (y = 0)\cos 4\ (\pi * y0/L)$.

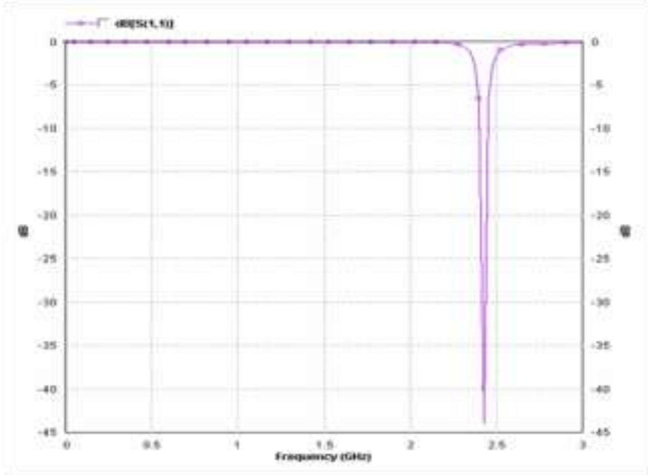
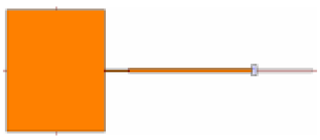
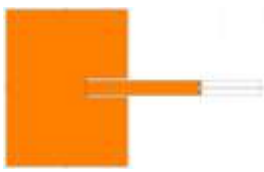
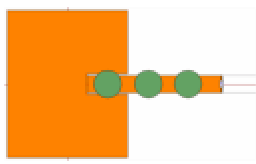
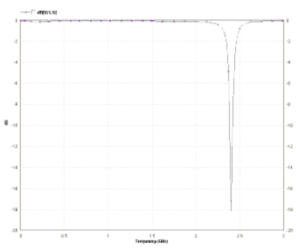
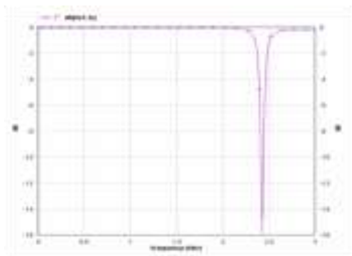
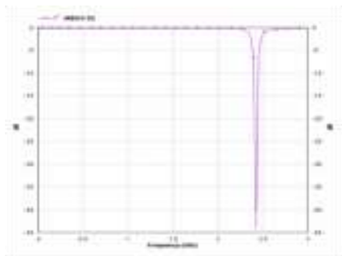


Figure 3. S-parameter plot for Return loss v/s frequency of (c) [Bandwidth: 0.04548GHz]

Serial	Design I	Design II	Design III
1			
2			
3	**Bandwidth** 0.02985 GHz	**Bandwidth** 0.02767GHz	**Bandwidth** 0.04548GHz

	Depth -18dB	**Depth** -16dB	**Depth** -44dB

Table 1. Comparison between three designs of Mictrostrip Patch Antenna

5. CONCLUSIONS

This paper we have designed three wideband microstrip patch antennas. The characteristics of proposed antennas have been investigated through different parametric studies using IE3D simulation software. The proposed antennas have achieved good impedence matching, stable radiation patterns, and high gain. The phi-shaped antenna can be used for Wireless LAN application in the frequency range 5.2 to 5.8 GHz. Also we have found that if we use EBGS on transmission line that we have shown in figure then we get the best output for this design and we proved that if we use EBGS then we will get an exclusive output of Antenna. By integrating or differentiating our model it can be used in industrial purposes. The output will serve better than ever before.

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