**THE MICROSTRIP ANTENNA WITH IMPEDANCE MATCHING PART**

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## 1. RECTANGULAR MICROSTRIP ANTENNA

The rectangular patch antenna shown in Fig. 1., is the most commonly used microstrip antenna. The rectangular patch antenna is fed from a microstrip transmission line.

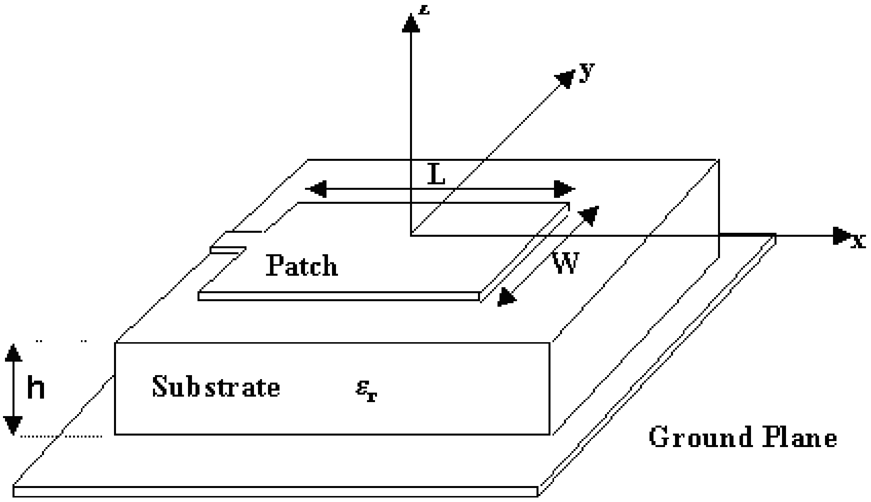


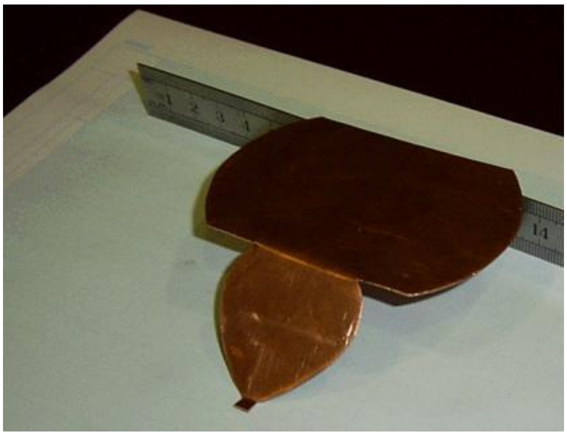

**Fig. 1. Rectangular Microstrip Patch Antenna**

The substrate thickness h is much less than the wavelength. The rectangular patch antenna is usually operated near resonance in order to obtain a real-valued input impedance. Models are available for determining the resonant frequency, with the cavity model usually yielding accurate results. The fringing fields act to extend the effective length of the patch. Thus, the length of a half-wave patch is slightly less than a half wavelength in the dielectric substrate material. This is similar to foreshortening a half-wave dipole to achieve resonance. The amount of length reduction depends on $\varepsilon_r$, h, and W. Formulas are available to estimate the resonant length, but empirical adjustments are often necessary in practice.

The microstrip patch antenna printed on a dielectric substrate is a narrow band element. That is mainly due to the limitations imposed by the dielectric substrate. Because of efficiency and cost considerations, the substrate cannot be too thick. In order to increase the microstrip element bandwidth, additional resonators (slots and parasitic elements) can be used. In this project a new impedance matching technique (patch element) will be designed. Patch antenna uses aperture coupling and air. This results in a higher bandwidth and a better efficiency. Feeding part of patch antenna increases the bandwidth of a microstrip patch antenna radiator.

## 2. THE MICROSTRIP ANTENNA WITH IMPEDANCE MATCHING PART

The newly developed Radiated part is comprised of two elements; the microstrip patch element (main radiated part) and the impedance matching element. The addition of the circular parts in the flanks of the main radiated element results in broad band radiation.



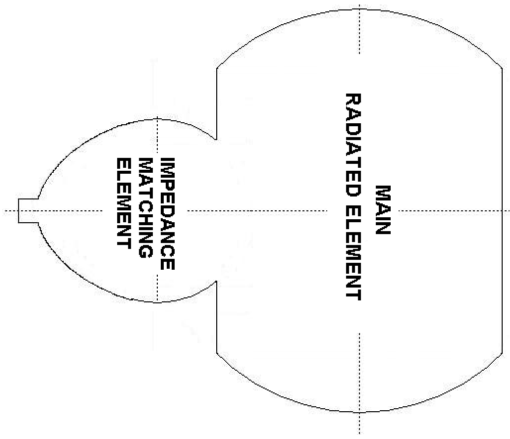



**Fig. 2. Newly developed radiated part**

The impedance matching element, transforms the 50 ohm feeding impedance to main radiated element impedance. This transformation enables broadband radiation as well as improving the antenna gain by a minimum of 3 dB, in relation to the normal patch antenna gain. It is easy to manufacture this antenna, which is economical and it can be further developed in 1.5 gigahertz to 5 gigahertz or even higher frequency ranges, by using mathematical formulas. The data gathered in the experiments that were carried out, are for 2.4 gigahertz ISM band.

## 3. MATHEMATICAL FORMULAS

The relationship of bandwidth to wavelength ($\lambda$), height of the dielectric (h), and dielectric constant ($\varepsilon_r$). $\varepsilon_r$ is the dielectric constant of the substrate. Since the substrate is air, $\varepsilon_r = 1$, $\lambda_0 = \frac{c}{f}$ Where $\lambda$ is the free-space wavelength, $c$ is the velocity of light, $f$ is the antenna operating frequency.

Radiated element width W, $W = \frac{\lambda_0}{2}$

The length L of a resonant half-wavelength patch is $L = \frac{\lambda_0}{2} - 2\Delta\ell$

The effective dielectric constant $\varepsilon_e = 1$ **,** Since the substrate is air, $\varepsilon_r = 1$

The normalized line extension $\frac{\Delta\ell}{h}$,

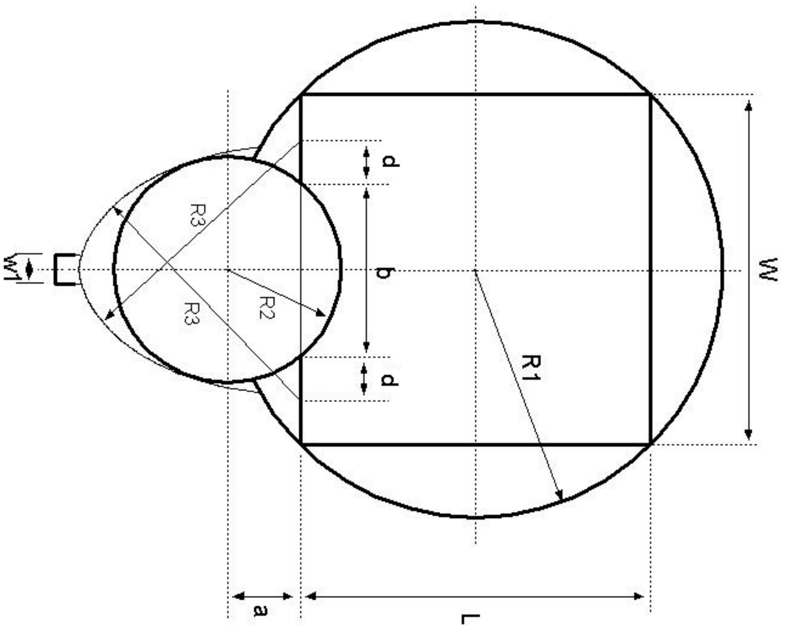



**Fig 3. Design Details of the Newly Developed Antenna**

Upon determining the W and L sides of the antenna we proceed to draw a circle whose center is the center of the rectangular main radiated element and its radius is $R_1$,

$$R_1 = \sqrt{(\frac{W}{2})^2 + (\frac{L}{2})^2}$$

The top and bottom arcs of the circle are not utilized and only the flanks are kept (fig 2.). Impedance matching element is comprised of one full circle with radius $R_2$ and two partial circles with radii $R_3$. The center of the full circle is at a distance of 'a' from the rectangle, the center of the partial circles are on the bottom edge of the rectangle as shown in fig 3.

$$a = R_1 - \frac{L}{2}$$

$$b = \frac{\lambda_0}{4}$$

$$d = \frac{\lambda_0}{16}$$

$$R2 = \sqrt{(\frac{\lambda}{8})^2 + (R_1 - \frac{L}{2})^2}$$

$$R_3 = \frac{\lambda_0}{4} + \frac{\lambda_0}{8}$$

$$C + a = \sqrt{(R_3^2 - \left(\frac{b}{2} + d\right)^2)}$$

**4. EXPERIMENTS**

In order to determine the elevation h of the main radiated element from the ground plane the characteristic impedance of microstrip antenna is used. The h can be used to adjust the resonant frequency.

The effective dielectric constant $\varepsilon_e = 1$ **,** Since the substrate is air, $\varepsilon_r = 1$

$$Z_0 = \eta_0\{\frac{W'}{h} + 1.393 + 0.667\ell n(\frac{W'}{h} + 1.444)\}^{-1} \quad , \quad \frac{W'}{h} \geq 1 \qquad [1]$$

$$\frac{W'}{h} = \frac{W}{h} + \frac{1.25}{\pi}\frac{t}{h}\left(1 + \ell n\frac{2h}{t}\right) \qquad , \qquad \frac{W}{h} \geq 1/2\pi$$

$\eta_0 = 120\pi$ ohms

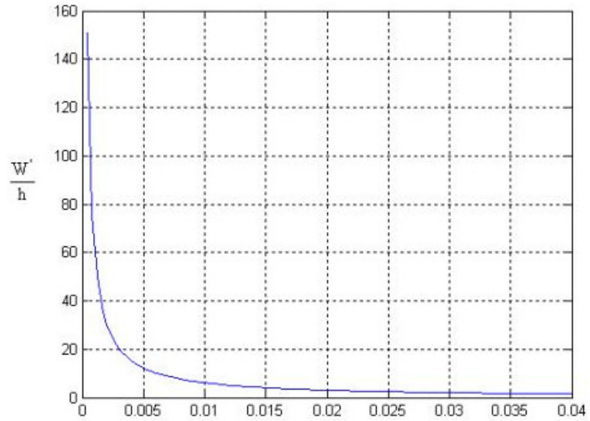



**Fig 4. Relationship of $\frac{W'}{h}$ with h.**

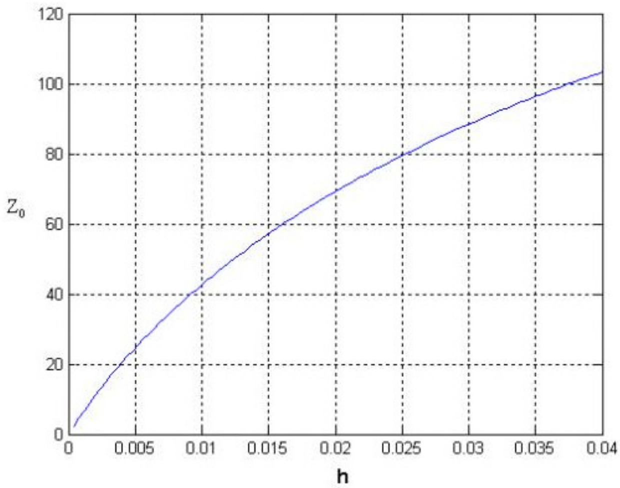



**Fig 5. Relationship of $Z_0$ with h.**

$0.015\,\text{m} \leq h \leq 0.035\,\text{m}$ , $50\,\text{ohms} \leq Z_0 \leq 100\,\text{ohms}$

as could be seen from the figures 6 and 7.

## 5. ANTENNA DESIGN FOR WIFI

$c = 3*10^{8}$ m/sec, $f = 2500$ Mhz

$\varepsilon_r = 1$ , $\lambda_0 = \dfrac{c}{f} = 0.12\text{m} = 12\text{cm}$

$W = \dfrac{\lambda_0}{2} = 6$ cm, $L = \dfrac{\lambda_0}{2} - 2\Delta\ell \geq 5.6$cm

$$\frac{\Delta\ell}{h} = 0.7218\frac{(W/h + 0.264)}{(W/h + 0.8)}$$

$h = 0.025\text{m} \mp 0.01\text{m}$

$$R_1 = \sqrt{(\frac{W}{2})^2 + (\frac{L}{2})^2} = 4.1\text{cm}$$

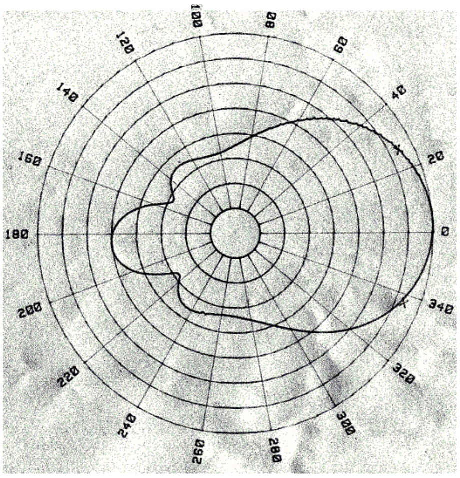
$a = R_1 - \dfrac{L}{2} = 1.3$cm, $b = \dfrac{\lambda_0}{4} = 3$cm, $d = \dfrac{\lambda_0}{16} = 0.75$cm

$$R2 = \sqrt{(\frac{\lambda}{8})^2 + (R_1 - \frac{L}{2})^2} = 2\text{cm}$$

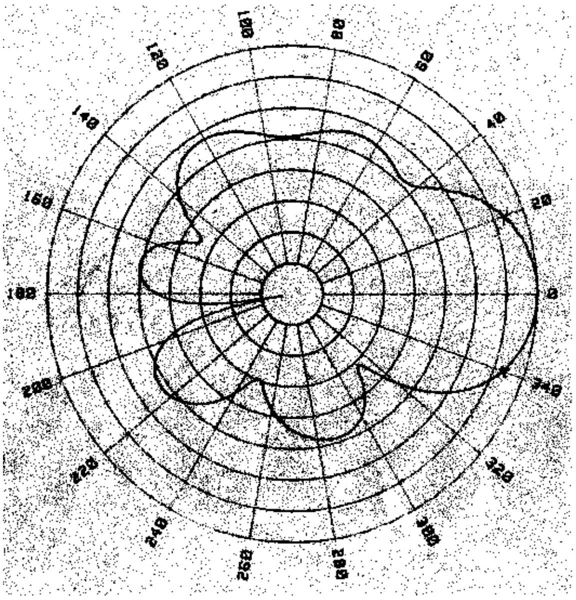
$$R_3 = \frac{\lambda_0}{4} + \frac{\lambda_0}{8} = 4.5\text{cm}$$

## 6. The Figures

### 6.1 3dB Vertical Beamwidth



## 6.2 3dB Horizontal Beamwidth




## 6.3 Return Loss