

PERFORMANCE OF A RECTANGULAR MICROSTRIP PATCH ANTENNA ON DIFFERENT DIMENSIONS

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Abstract -The sizes and weights of various wireless electronic systems (e.g. mobile handsets) have rapidly reduced due to the development of modern integrated circuit technology. A Microstrip antenna (MSA) is well suited for wireless communication due to its light weight, low volume and low profile planar configuration which can be easily conformed to the host surface. However, MSAs suffers from low bandwidth. MSA bandwidth is greatly affected by the geometry and dimensions of the radiating microstrip patch. In this paper, the effect of various dimensions on rectangular microstrip patch antenna performance is investigated. By keeping the substrate thickness constant over various dimensions, simulations were carried out using IE3D software and EM Talk software. The results show that the dimensions effectively determine the performance of Microstrip Patch antenna.

Keywords: Microstrip Patch Antennas

1.0. INTRODUCTION

With the wide spread proliferation of wireless communication technology in recent years, the demand for compact, low profile and broadband antennas has increased significantly. To meet the requirement, microstrip patch antennas (MPAs) have been proposed. MPAs are widely used in wireless communication applications because of their low profile, lightweight, low cost and compatibility with integrated circuits (Guney and Sirikaya, 2004). However, the conventional MPA has a disadvantage of a narrow bandwidth. There are numerous and well-known methods of increasing bandwidth of this type of antennas, and amongst the most common ways varying the different dimensions of the radiating patch of antenna. However, the bandwidth and the size of an antenna are generally mutually conflicting properties, that is, improvement of one of the characteristics normally results in degradation of the other. A thick dielectric substrate having a low dielectric constant is more desirable as it provides better efficiency, larger bandwidth, and better radiation (Indrasen Singh et al,2011).

There are numerous geometries and dimensions of the radiating patch that can be used for the design of MPAs and their dielectric constants are usually in the range of $2.2 \leq \epsilon_r \leq 12$. The radiation increases with frequency increase and using thicker substrates with lower permittivity, and originates mostly at discontinuities. The dielectric constant is the ratio between the stored amount of electrical energy in a material and to that stored by a vacuum. It is also a measure of the degree to which an electromagnetic wave is slowed down as it travels through the insulating material (Mutiara et al, 2011). Dielectrics are used in capacitors to store more electrical charge than vacuum. The lower the dielectric constant is, the better the material works as an insulator, and the better an insulator, the better it resists electrons from being absorbed in the dielectric material, creating less loss (Mutiara et al, 2011; Balanis, 1997). Radio frequency (RF) applications are characterized by the need for low dielectric losses, low leakage, and low and uniform dielectric constant accompanied by a low layer count. Choosing a material based on its dielectric constant characteristics and losses usually dominates over other considerations.

2.0. RECTANGULAR MICROSTRIP PATCH ANTENNA DESIGN

In its most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side as shown in Figure 1. The bottom surface of a thin dielectric substrate is completely covered with metallization that serves as a ground plane.

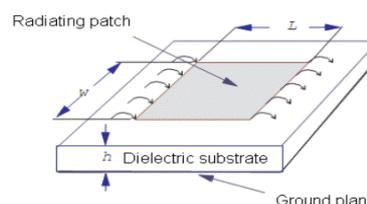


Figure 1: Structure of a Rectangular Microstrip Patch Antenna
 The rectangular MSA is made of a rectangular patch with dimensions width (W) and length (L) over a ground plane

with a substrate thickness (h) and dielectric constant as shown in Figure 1. There are numerous substrates that can be used for the design of MSAs, and their dielectric constants are usually in the range of $2.2 < \epsilon_r < 12$.

The steps followed in the design of rectangular MSAs as discussed in (K. Guney and N. Sirikaya, 2004; Balanis, 1997; Saedi and Sabira, 2005; Dafalla, 2004) are as follows;

The Patch Width (W) for efficient radiation is given as;

$$W = \frac{v_0}{2f_0} \sqrt{\frac{2}{\epsilon_r + 1}}$$

where, W is the patch width, v_0 is the speed of light, f_r is the resonant frequency, and ϵ_r is the dielectric constant of the substrate

The Effective Dielectric Constant (ϵ_{reff}) - Due to the fringing and the wave propagation in the field line, an effective dielectric constant (ϵ_{reff}) must be obtained.

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

where, ϵ_{reff} is the effective dielectric constant, h is the height of the dielectric substrate

The Effective Length (L_{eff}) for a given resonance frequency f_r is given as;

$$L_{eff} = \frac{L}{2 f_r \sqrt{\epsilon_{reff}}}$$

The Length Extension (ΔL) is given as;

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{2} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{2} + 0.8 \right)}$$

The Patch Length (L). The actual patch length now becomes;

The Bandwidth (BW)

$$BW\% = 3.77 \left(\frac{\epsilon_r - 1}{\epsilon_r^2} \right) \left(\frac{W}{\lambda_0} \right) \left(\frac{1}{\lambda_0} \right) * 100\%$$

where, λ_0 is the wavelength in free space.

The Feed Co-ordinates. Using coaxial probe-fed technique, the feed points are calculated as;

$$Y_f = W/2$$

$$X_f = \frac{L}{2 \sqrt{\epsilon_{reff}}}$$

where, y_f and x_f are the feed co-ordinates along the patch width and length respectively

The Plane Ground Dimensions:- It has been shown that MSAs produces good results if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery (Balanis, 1997; Dafalla, 2004).

$$L_g = 6h + L \tag{9}$$

$$W_g = 6h + W \tag{10}$$

where, L_g and W_g are the plane ground dimensions along the patch length and width respectively.

3.0. SIMULATION RESULTS AND DISCUSSION

By using IE3D, simulation was carried out to generate the values of various rectangular MSA parameters namely patch width, patch length, and feed points. Also, simulation was carried out using IE3D and EM talk software and the results tabulated and plotted.

Figure 2 to 5 plots various MPA parameters (Patch Width, Patch Length, and Feed Point) with relation to resonant frequency. We have designed three rectangular patch antenna with transmission line feeding technique but the dimensions of all three antennas vary. The shape and dimensions of the patch are as following and named as A1, A2 and A3:

A1-

Parameters-

- Width-47mm
- Length-52mm
- Thickness-1.59mm
- Dielectric constant-4.4
- Feeding technique-transmission line

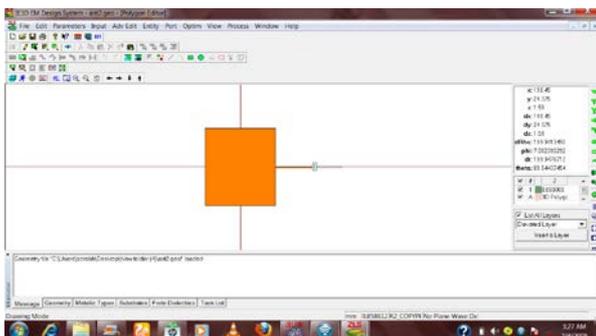


Figure 2: Shape of a Rectangular Microstrip Patch Antenna; A1

Impedance-

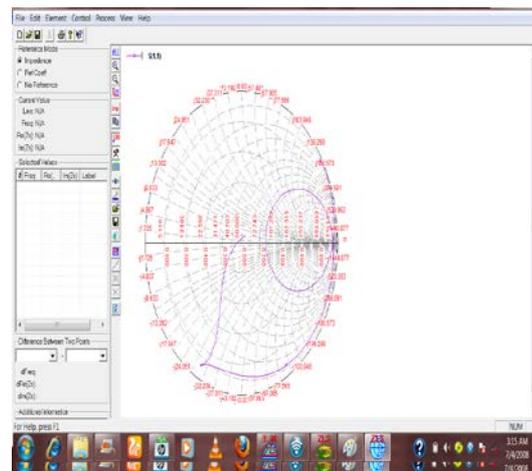


Figure 3: Impedance of a Rectangular Microstrip Patch Antenna; A1

A2-

Parameters-

- Width-49mm
- Length-50mm
- Thickness-1.59mm
- Dielectric constant-4.4
- Feeding technique-transmission line
- Resonant Frequency-1.5Ghz,2.996Ghz

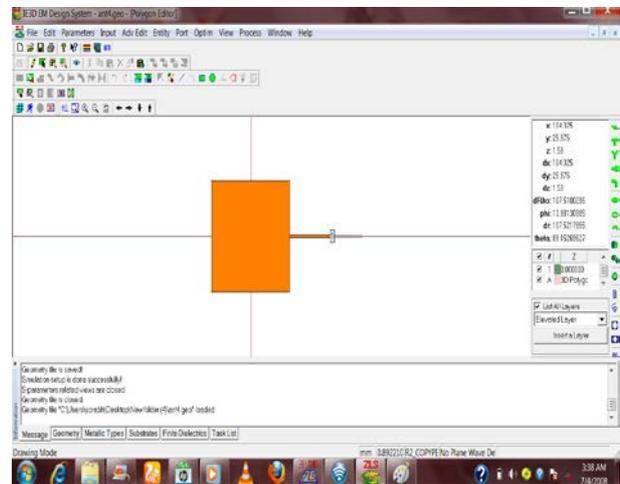


Figure 4: Shape of a Rectangular Microstrip Patch Antenna; A2

Impedance-

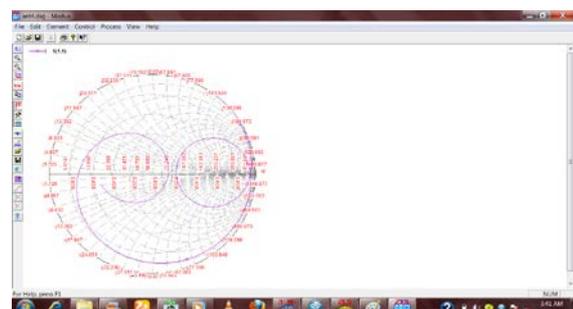


Figure 5: Impedance of a Rectangular Microstrip Patch Antenna; A2

A3-

Parameters-

- Width-45mm
- Length-50mm
- Thickness-1.59mm
- Dielectric constant-4.4
- Feeding technique-transmission line

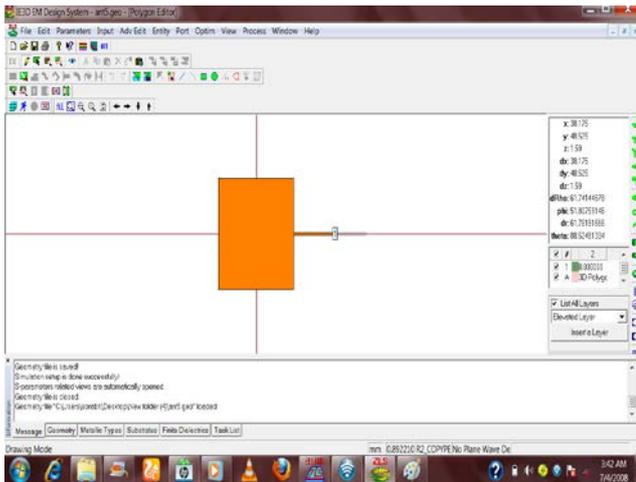


Figure 6: Shape of a Rectangular Microstrip Patch Antenna; A3

Impedance-

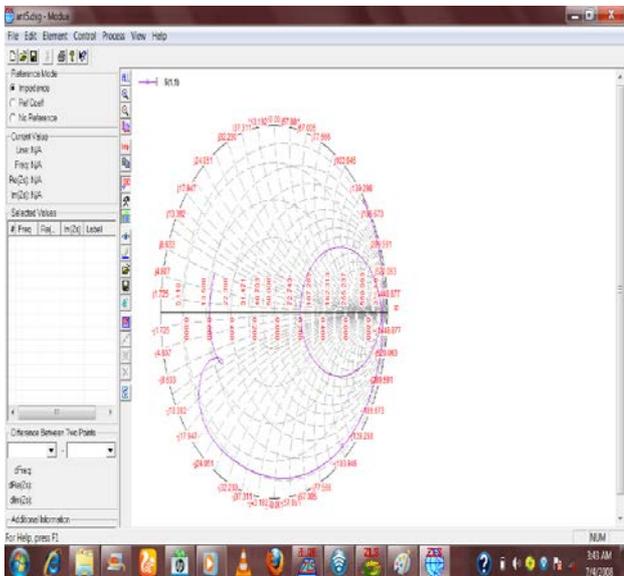


Figure 7: Impedance of a Rectangular Microstrip Patch Antenna; A3

Comparison between VSWR outputs of different antennas A1, A2 and A3-

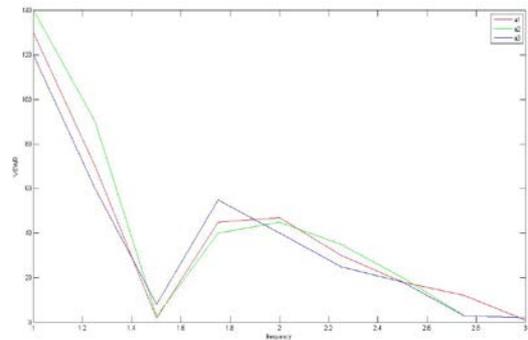
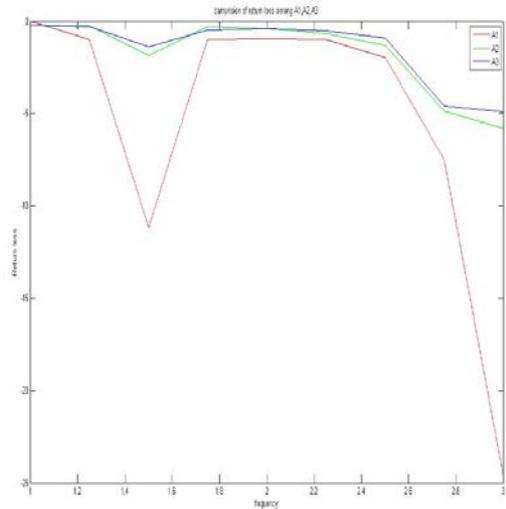


Figure 5: Comparison between VSWR outputs of different antennas A1,A2 and A3

Comparison between Return Loss outputs of different antennas A1, A2 and A3-



Overall comparison between four rectangular patch antenna-

Antenna Name	Width (mm)	Length (mm)	Frequency (Ghz)	VSWR	Return Loss (db)
A1	47	52	1.5, 2.992	1.76263, 1.16509	-11.1554, -24.656
A2	49	50	1.5, 2.996	9.27753, 3.12647	-1.86885, -4.8524
A3	45	50	1.5, 2.996	12.3411, 3.62062	-1.40238, -4.9286

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4.0 CONCLUSION

The performance of antenna depends on its dimensions(length, width and thickness),which can be seen from the above comparison graphs that out of the three different antennas simulated using IE3D software .In antenna A1, the resonant frequency are 1.5 and 2.992Ghz and VSWR is 1.7 and1.16 and the return loss of the same is -11.1557 nad -24.656 but in case of antenna A2 when the width is increased to 49mm and length is decreased to 50mm then the frequency becomes 1.5 and 2.996 and VSW 9.27753 and3.12647 and return loss -1.86885 and -4.8527 and in antenna A3, with length 50mm width 45mm and frequency 1.5 and 2.996 and VSWR 12.3411 and 3.62062 and return loss -1.40238 and -4.9286.

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