# Dielectric Thickness Effect on Functioning Of Microstrip Antennas

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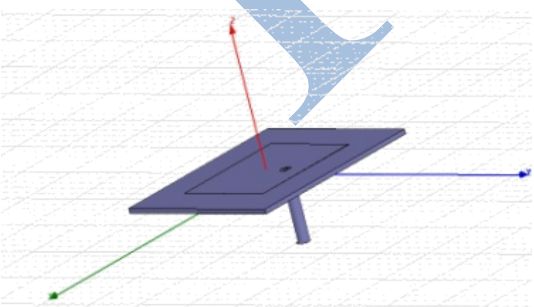
***Abstract:*** **The detailed reviews described in the previous chapter indicate that the environmental effects (such as snow, raindrops, etc...) deteriorate the performance of antenna. Although it is well known that the characteristic effects of dielectric loading on patch antenna includes resonant frequency, and radiating efficiency reduction, however these effects can be eliminated by fine tuning. Effects of environmental conditions to which the antenna may be exposed in due course of its use, should to be taken into account during the design phase of the antenna. If due care is not taken during the design phase, the system may fail to work. Few of such conditions may be the exposure of microstrip patch antennas to snowfall and build-up of snow or ice over its patch surface, or exposure to rain water and accumulation of water over its patch surface. As microstrip patch antenna is generally a narrowband device and hence, even a small shift in its resonant frequency may lie outside the intended band of use of frequency and hence may cause a system failure [1-3].**

***Keywords:*** **Dielectrics Loaded Microstrip Antennas**

## I. INTRODUCTION

Therefore, in present chapter we have focused to analyze the effects of dielectric cover thickness on the antenna performance characteristics, and results for return loss ($S_{11}$), VSWR, impedance, gain, radiation pattern, bandwidth and directivity also are presented. The environmental effects (such as snow, raindrops, etc.) are described in terms of dielectric cover loading on the patch antennas and its effects are analyzed. Here using commercial High Frequency Structure Simulator (HFSS), the rectangular, square, hexagonal and pentagonal patch microstrip antennas have been designed and their performances have also been analyzed. Hexagonal and pentagonal microstrip antennas have smaller size compared to the square and ectangular microstrip antenna for given frequency. The small size is an important requirement for portable communication equipment, such as global positioning satellite (GPS) receivers. The hexagonal patch also has better impedance bandwidth over rectangular and square patch antennas **[4]**. A coaxial cable fed / microstrip line is used which leads to good impedance matching and its operating frequency is 2.4 to 2.4835 GHz (ISM band). The design procedure is based on observations made from the simulated results and



good impedance matching is achieved. In addition, its characteristic effects on resonant frequency, impedance matching, band width, VSWR and gain are also simulated. It has been observed that resonance frequency is shifted toward the lower side of frequency of operation, while other parameters have slight variations in their values with the thickness of loading.

## II. SIGNIFICANCES OF 2.4 GHZ

Since 1986, FCC rules have provided for unlicensed spread-spectrum operation for the 915 MHz (902–928 MHz), 2.4 GHz (2400–2483.5 MHz), and 5.7 GHz (5725–5850 MHz) bands. But a vast number of RF devices currently operate in the 2.4 GHz band (like microwave ovens, cordless telephones, medical devices etc.). Recently there has been proliferation of "*Wi-Fi*" hotspots and wireless computers permitting undeterred internet access by the public and RF identification (RFID) technology. The antenna must operate within the unlicensed 2.4 GHz band. This band is currently being used for the IEEE 802.11b and other industrial, medical and scientific applications. The antenna is proposed to be used as a transmitting as well as receiving antenna in wireless LANs and the mentioned applications **[5]**.

## III. DESIGNING OF PROPOSED ANTENNAS DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA

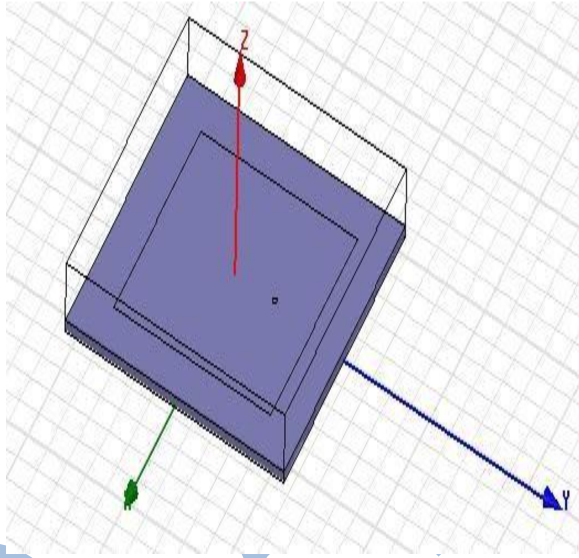
For a rectangular patch, the length $L$ of the patch is usually $0.3333\ \lambda_0 < L < 0.5\lambda_0$, where $\lambda_0$ is the free- space wavelength. The patch is selected to be very thin such that $t << \lambda_0$ (where $t$ is the patch thickness). The height $h$ of the dielectric substrate is usually $0.003\ \lambda_0 \le h \le 0.05$. The dielectric constant of the substrate ($\varepsilon_r$) is typically in the range $2.2 \le \varepsilon_r \le 12$ **[4].**

The geometrical configuration of a rectangular patch coaxial cable fed antenna obtained using HFSS is shown in Figure 3.1, where a substrate of finite width and length has been used.

The dielectric constant of the substrate used is 4.4, whereas the operating frequency is chosen to be in range of 2.4 to 2.4835 GHz. The coaxial feeding is given to the point where input resistance is approximately 50 ohms.

**Design of Square Microstrip Patch Antenna**

In the basic form, a square patch antenna is similar to a rectangular patch antenna, and consists of a radiating patch of square shape on one side of the dielectric substrate, which has a ground plane on the other side. The resonant length of the antenna determines its resonant frequency. In fact the patch is electrically a bit larger than its physical dimensions due to the fringing fields. The basic geometrical configuration of a square patch antenna is shown in Figure 3.2. The proposed antenna has been designed using the following expressions **[4]**;




$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_e}} - 2\Delta \quad (3.1)$$

where $$\Delta = 0.412h \frac{(\varepsilon_e + 0.3)\left(W/_h + 0.264\right)}{(\varepsilon_e - 0.258)\left(W/_h + 0.8\right)} \quad (3.2)$$

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 10\frac{h}{w}\right] (3.3)$$

with

$$w = \frac{c}{2f_0\sqrt{\varepsilon_r}} (3.4)$$

Where all the parameters have their usual meaning. The length _*L*' and width _*w*' should choose to be equal.

**Design Specifications**

Design parameters for designing of rectangular, square, hexagonal and pentagonal patch antennas are given in Table (3.1-3.4).

Table 1 Design parameters of rectangular patch antenna

| *Geometry* | *Rectangular* |
|---|---|
| Dimension | $L$= 28.5 mm, $w$ = 36.4 mm |
| Substrate (FR4 epoxy) | $\varepsilon_r$ = 4.4, $h$ = 0.8, $tan\delta$ = 0.02 |
| Centre frequency | 2.45 GHz |
| Feed Location (From center) | 11.4 mm |
| Coaxial cable dimension | Inner radius: 0.6 mm |
| | Outer radius: 2.1 mm |
| Dielectric (Distilled water) | $\varepsilon_r$ = 81, $h$ = 0.1 to 0.5 mm |

Table 2 Design parameters of square patch antenna

| *Geometry* | *Square* |
|---|---|
| Dimension | $w$ = $L$= 28.04 mm |
| Substrate (FR4 epoxy) | $\varepsilon_r$ = 4.4, $h$ = 0.8, $tan\delta$ = 0.02 |
| Centre frequency | 2.45 GHz |
| Feed location (From center) | 8.17 mm |
| Coaxial cable dimension | Inner radius: 0.5 mm |
| | Outer radius: 0.9 mm |
| Dielectric (Distilled water) | $\varepsilon_r$ = 81, $h$ = 0.1 to 0.5 mm |

Table 3 Design parameters of hexagonal patch antenna

| *Geometry* | *Hexagonal* |
|---|---|
| Side arm length | 16.64202 mm |
| Substrate (FR-4) | $\varepsilon_r$ = 4.4, $h$ = 0.8, $tan\delta$ = 0.02 |
| Centre frequency | 2.45 GHz |
| Feed location (From center) | 8.5 mm |
| Coaxial cable dimension | Inner radius: 0.5 mm |
| | Outer radius: 0.9 mm |
| Dielectric (Distilled water) | $\varepsilon_r$= 81, $h$ = 0.1 to 0.5 mm |

## IV. CONCLUSIONS

In the present report one of the known environmental element; *water* has been selected as dielectric cover and the effects of its varying thickness on rectangular, square, hexagonal and pentagonal patch antennas has been analyzed. The main emphasis is given for the height of the water levels. The obtained results show that the resonance frequency of the proposed antenna changes with increase in the height of dielectric layer. In particular resonance frequency shifted toward lower side of the band however the values of return loss, VSWR and impedance decease with the height of the layer. It is also observed that gain and radiation characteristics of the antenna decrease with the height of the layer. In order to describe the performance variations of the microstrip antenna under various climatic conditions such as snow, dust…etc, the next chapter is dedicated to study the effects of various dielectrics loaded on the patch antennas.

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