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# Compact Microstrip fed slot antenna for multiple frequency

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***Abstract:*** Antennas have lot of attraction in the field of Wireless communication. Due to the requirements, and improvements in technologies, devices become smaller in size and light-weighted with new applications. Here four slot antennas are designed at different frequencies which are smaller in size. This paper presents comparative analysis of four microstrip Patch and Slot antenna. These four antennas are designed at different frequency and simulated by High frequency structure simulator (HFSS) software. All these four antennas are implemented using RT DUROID dielectric substrate which has $\epsilon_r$ = 2.2 and h = 1.575mm and made to resonates at 2.5 GHz,3.5 GHz,5 GHz and 5.8 GHz frequency. Comparison is based in terms of return loss, bandwidth and size.

## I. INTRODUCTION

### Microstrip Patch Antenna

A micro strip 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. 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. Low dielectric constant substrates are generally preferred for maximum radiation. Other configurations are complex to analyze and require heavy numerical computations. A micro strip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns.

### Microstrip feed Slot Antenna

Narrowband resonant slot antenna can be made using long narrowslots, cut on the ground plane conductors. The space requirements can therefore be very small, which provides an opportunity to design multiband antennas on a single substrate. Such slot antennas can be excited using microstrip lines etched on the surface of the substrate dielectric resulting in a very compact structure. Important feature of a narrow-width slot antenna is its flexible shape so the slot can be bent to any shape to accommodate it in the available space, or achieve a desired polarization. Since, in a narrow slot, the polarization of the radiated field is normal to the slot length, the slot shape can be used to alter, or fix, the polarization. For instance, to achieve 45deg. polarization directions, the slot may be bent orthogonally in its middle point and is designed for operation in WLAN and WiMax bands, the desired current wireless communication bands.

Table.1Comparison of microstrip patch and microstrip feed slot antenna

| **Characteristics** | **Patch** | **Microstrip feed Slot** |
|---|---|---|
| Analysis and design | Easy | Easy |
| Fabrication | Very easy | Very easy |
| Tolerance in fabrication | Critical | Not very critical |
| Profile | Thin | Thin |
| Shape Flexibility | Any shape | Limited |
| Radiation fields | Unidirectional | Unidirectional and bidirectional |
| Polarization | Linear and circular | Linear and circular |
| Bandwidth | Narrow | Wide |
| Dual frequency operation | Possible | Possible |
| Spurious Radiation | Moderate | Low |
| Isolation between radiating elements | Fair | Good |
| Frequency scanning | Easily possible | Possible |
| Cross-polarization level | Low | Very low |
| End-fire antenna | Not possible | Posssible |

## III. ANTENNA DESIGNTHEORY

### A.Choice of substrate

Different researchers have used different dielectric substrates to fabricate micro strip patch antenna. So a question arises that which dielectric substrate among the common substrates available gives better performance. Dielectric constant of substrates affects antenna performance. A thick dielectric substrate which has a low dielectric constant will give better radiations than the substrate which has a high dielectric constant because bandwidth is directly proportional to antenna dimensions or antenna size and bandwidth is inversely proportional to dielectric constant or permittivity.

### A.Choice of type of feeding

Micro strip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a micro strip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the micro strip line and the radiating patch. The four most popular feed techniques used are the micro strip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

### B.Micro strip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the Micro strip patch as shown in Fig.12. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

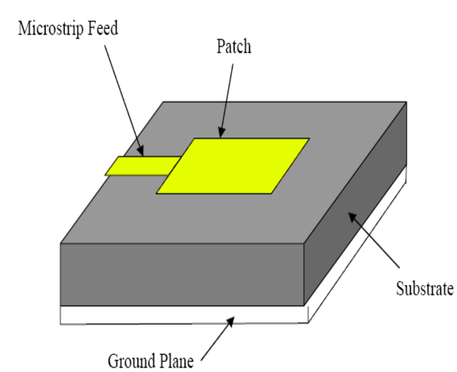


Fig. 1 Microstrip design

### C. Design of microstrip line to slot line transition

Due to the simplicity in design and manufacturing, microstrip line is chosen as the feed line. The microstrip line to slot line transition is considered. The geometry of the transition is shown in Figure

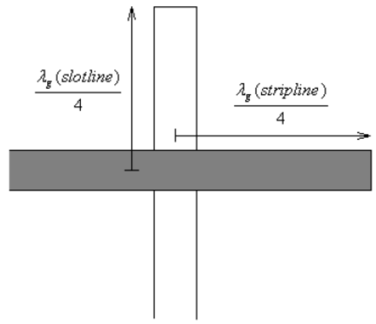


Fig:-2 Orthogonal Microstripline to slot line transition

The transition is employing a microstrip line and a slot line crossing each other at a right angle. The microstrip extends about one quarter of a guided wavelength beyond the slot, and the slot extends about a quarter of a guided wavelength beyond the microstrip.In order to obtain a transition that has low return loss over a wide frequency band, the impedances of the microstrip line and the slot line should be matched to each other to minimize the reflections. large impedance values in order to be able to achieve impedance matching between microstrip line and slot line. The characteristic impedance of a slot line increases with increasing slot width, so the width possible to obtain an impedance value close to 50 limitations, a minimum slot width of 0.254 mm (10 mils) is chosen. To calculate the characteristic impedance and guided wavelength are as following.

The characteristic impedance of a slot line can be calculated as:

$$Z_0 = 60 + 3.69\sin\left[\frac{(\varepsilon_r - 2.22)\pi}{2.36}\right] + 133.5\ln(10\varepsilon_r)\sqrt{\frac{W}{\lambda_0}} +$$
$$2.81[1 - 0.011\varepsilon_r(4.48 + \ln\varepsilon_r)]\left(\frac{W}{h}\right)\ln\left(\frac{100h}{\lambda_0}\right)$$

$$+131.1(1.028 - \ln\varepsilon_r)\sqrt{\frac{h}{\lambda_0}} + 12.48(1 + 0.18\ln\varepsilon_r)\left(\frac{\left(\frac{W}{h}\right)}{\sqrt{\varepsilon_r - 2.06 + 0.85\left(\frac{W}{h}\right)^2}}\right)$$

Where h is the height of the dielectric substrate and w is the width of the slot line.

The guided wavelength of the slot line can be found as:-

$$\frac{\lambda_g}{\lambda_0} = 1.045 - 0.365\ln\varepsilon_r + \frac{6.3\left(\frac{W}{h}\right)\varepsilon_r^{0.945}}{238.64 + 100\left(\frac{W}{h}\right)} - \left(0.148 - \frac{8.81(\varepsilon_r + 0.95)}{100\varepsilon_r}\right)\ln\left(\frac{h}{\lambda_0}\right)$$

The effective dielectric constant and characteristic impedance of a microstrip line can be calculated as:

For w/h<1:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\frac{1}{\sqrt{1 + \frac{12h}{W}}} + 0.04\left(1 - \frac{W}{h}\right)^2\right]$$

$$Z_c = \frac{60}{\sqrt{\varepsilon_{eff}}}.\ln\left(\frac{8h}{W} + \frac{W}{4h}\right)$$

For w/h>1:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{W}}}\right)$$

$$Z_c = \frac{120\pi}{\sqrt{\varepsilon_{eff}}}.\frac{1}{\left[\frac{W}{h} + 1.393 + \left(0.677.\ln\left(\frac{W}{h} + 1.444\right)\right)\right]}$$

Where w is the width of the microstripline.

### D. Dimension of the antenna

The three essential parameters for the design of a rectangular Micro strip Patch Antennaare:

Frequency of operation ( $f_0$): The resonant frequency of the antenna must be selectedappropriately. The Personal Communication System (PCS) uses the frequencies rangefrom 1850-1990 MHz Hence the antenna designed must be able to operate in thisfrequency range.

Dielectric constant of the substrate ($\varepsilon_r$):A substrate with a high dielectric constanthas been selected since it reduces the dimensions of the antenna.Height of dielectric substrate ( $h$ ): For the micro strip patch antenna to be used in cellularphones, it is essential that the antenna is not bulky.

## E.ANTENNA DESIGN

Four slot antennas are designed at 2.5GHz,3.5GHz,5GHz and 5.8GHz on RT DUROID, the substrate with thickness (t) of 1.575mm and dielectric constant ∈r of 2.2.The geometry and detailed dimensions of the proposed antenna resonating at 2.5GHz,3.5GHZ,5GHz and 5.8GHzis depicted in fig. 1,2,3 and 4and tab. 1,2,3 and 4. Here Ls, Ws are length and width of the ground plane respectively. L1, W1 are length and width of the Slot respectively. W2 is width of microstrip. *l* is microstrip offset and *l'* is feed offset.

## Slot antenna at 2.5GHz

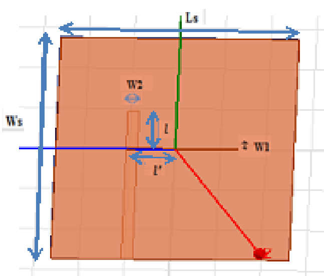


Fig. 3 Slot Antenna at 2.5Ghz

Table.2 Parameter values

| Parameter | Value(cm) |
|---|---|
| **Ls** | 11 |
| **Ws** | 10.5 |
| **Slot length(L1)** | 4.9 |
| **Slot width(W1)** | 0.08 |
| **Microstrip offset(l)** | 1.8 |
| **Microstrip Width(W2)** | 0.5 |
| **Feed offset(l')** | 1.88 |

## Slot antenna at 3.5GHz

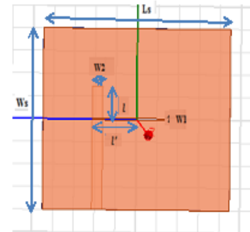

Fig. 4 Slot Antenna at 3.5Ghz

Table.3 Parameter values

| Parameter | Value(cm) |
|---|---|
| **Ls** | 9 |
| **Ws** | 8 |
| **Slot length(L1)** | 3.51 |
| **Slot width(W1)** | 0.07 |
| **Microstrip offset(l)** | 1.4 |
| **Microstrip Width(W2)** | 0.5 |
| **Feed offset(l')** | 1.88 |

## Slot antenna at 5 GHz

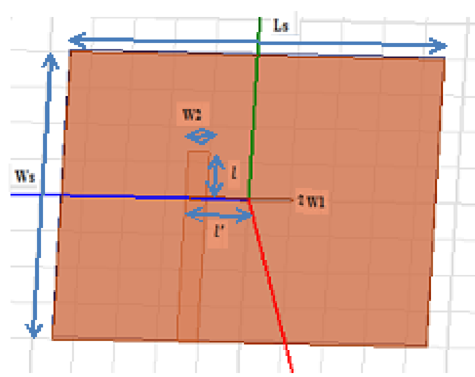


Fig. 5 Slot Antenna at 5 Ghz

Table.4 Parameter values

| Parameter | Value(cm) |
|---|---|
| Ls | 9 |
| Ws | 8 |
| Slot length(L1) | 2.48 |
| Slot width(W1) | 0.07 |
| Microstrip offset(l) | 1.2 |
| Microstrip Width(W2) | 0.5 |
| Feed offset(l') | 1.25 |

## Slot antenna at 5.8 GHz

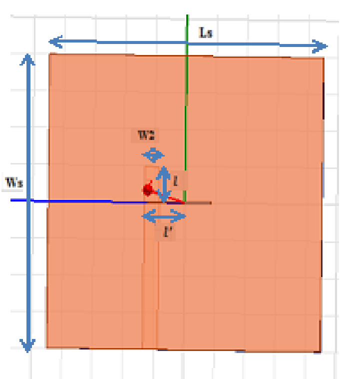


Fig. 6 Slot Antenna 5.8Ghz

Table.5 Parameters value

| Parameter | Value(cm) |
|---|---|
| Ls | 9 |
| Ws | 8 |
| Slot length(L1) | 2.085 |
| Slot width(W1) | 0.05 |
| Microstrip offset(l) | 0.95 |
| Microstrip Width(W2) | 0.49 |
| Feed offset(l') | 1.10 |

## SIMULATION RESULTS

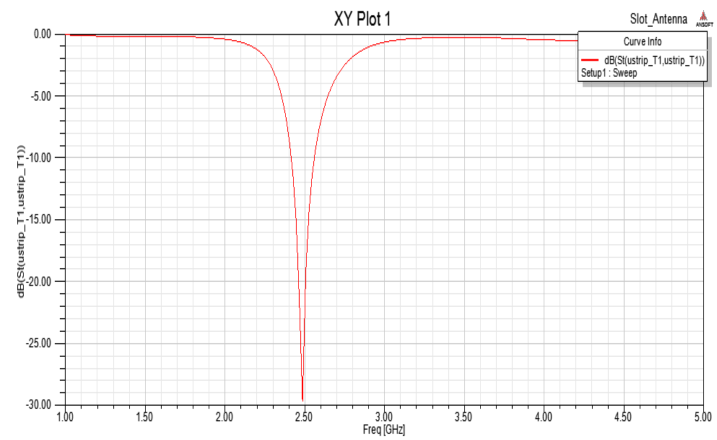


Fig.6 Simulated Return loss curve at 2.5GHz

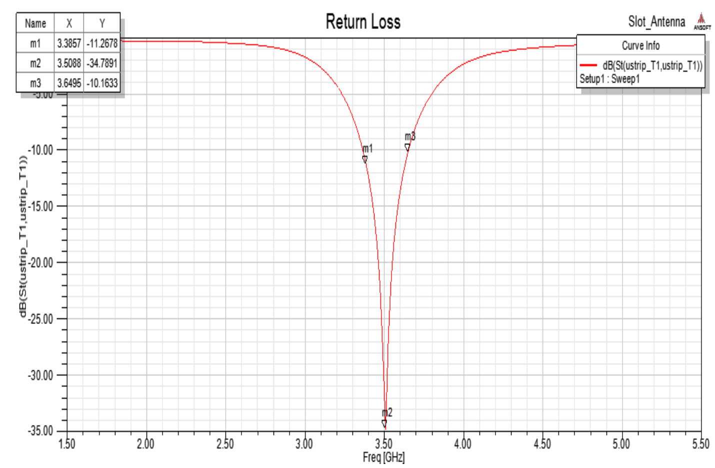


Fig.7 Simulated Return loss curve at 3.5GHz

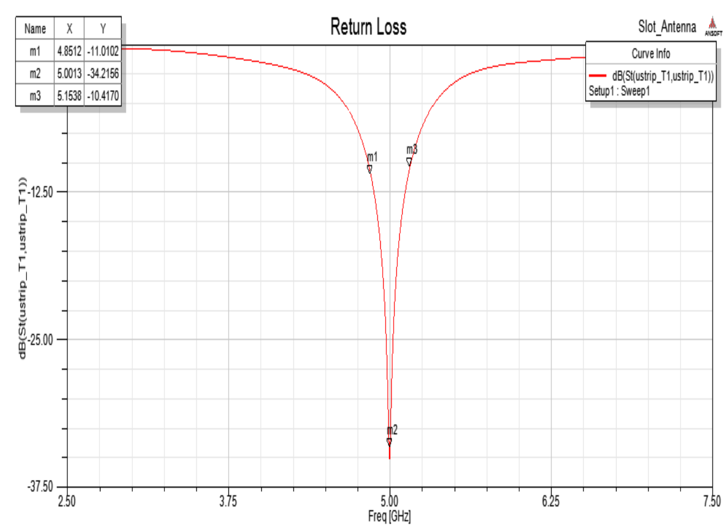


Fig.8 Simulated Return loss curve at 5GHz

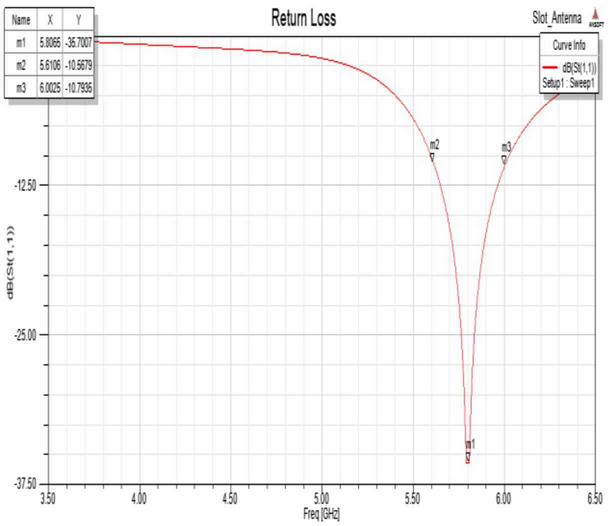


Fig.9 Simulated Return loss curve at 5.8GHz

## IV.CONCLUSION

Low dielectric constant leads to a larger antenna size. In order to design a compact antenna, substrates with higher dielectric constants must be used. With the decreasing length of slot antenna resonant at higher frequency and with number of slot antenna resonant at number of frequency.

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