# An Overview: Various Slots Shapes of Micro-Strip Patch Antenna

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***Abstract*-The micro-strip patch antenna are used for various applications in many high performance wireless communication system. They have several drawbacks such as low efficiency, low bandwidth ,low gain and can only be used at microwave frequency. Due to these above parameters, there is complexity in tunings. Thus to improve them, different slots are introduced. Variety of shapes of slots are available- E,H,V,U,L shapes etc. which make patch antenna suitable for high frequency applications.This paper provides a brief overview of work done in field of single layer rectangular micro-strip patch antenna for enhancing bandwidth ,gain and various other parameters.**

***Keywords :Micro-strip patch antenna, Bandwidth ,Gain, Slots***

## I. 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, the micro-strip patch antenna have been proposed because of its low profile, light weight and low cost. However, the micro-strip antenna inherently has a low gain and a narrow bandwidth. To overcome its inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested [1].

There are several key advantages over conventional wire and metallic antennas ,micro-strip antennas have been used for many applications such as Direct broadcasting satellite (DBS) systems, mobile communications, global positioning systems(GPS) and various radar systems.

## II. MICROSTRIP PATCH ANTENNA

A microstrip patch antenna (MPA) consists of a conductingpatch of any planar or nonplanar geometry on one side of a dielectric substrate with a ground plane on other side. It is a popular printed resonant antenna for narrow-band microwave wireless links that require semi-hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been heavily studied.

A large number of microstrip patch antennas have been studied to date. An exhaustive list of the geometries along with their salient features is available [2]. When they are applied in the frequency range below 2 GHZ, size of conventional rectangular patch is seem to be too large which makes it difficult for them to be installed on televisions, notebook computers or other handheld terminals, etc.

Several techniques thus have been proposed to reduce the sizes of conventional micro-strip patch antennas .Material of high dielectric constant has been used.There are numerous and well-known methods to increase the gain of antennas, including decrease of the substrate thickness, size reduction, VSWR improvement by introducing slots. [3-4].

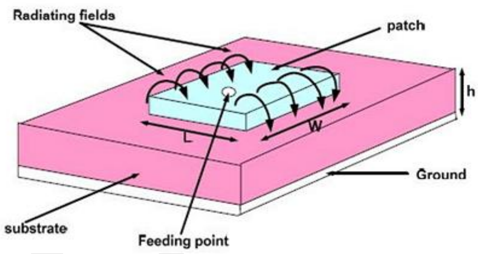


Fig 1: Structure of rectangular microstrip patch antenna

| Sr. No. | Characteristics | Microstrip Patch Antenna | Microstrip Slot Antenna |
|---|---|---|---|
| 1. | Profile | Thin | Thin |
| 2. | Fabrication | Very easy | Easy |
| 3. | Polarization | Both linear and circular | Both linear and circular |
| 4. | Dual-Frequency operation | Possible | Possible |
| 5. | Shape flexibility | Any shape | Mostly rectangular and circular shapes |
| 6. | Spurious radiation | Exists | Exists |
| 7. | Bandwidth | 2-50% | 5-30% |

Table 1 :Characteristics of patch antenna

*Transmission Line Model*

This model represents the microstrip antenna by two slots of width *W* and height *h*, separated by a transmission line of length L. The microstrip is essentially a non-homogeneous line of two dielectrics, typically the substrate and air.

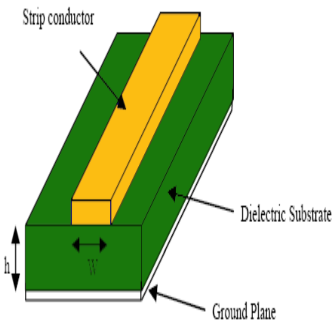


Fig 2 Microstrip Line

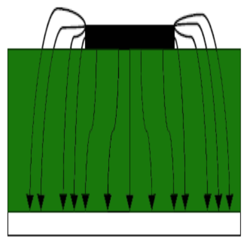

Fig 3 Electric Field Lines

Hence, as seen from Figure 3, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electricmagnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (*εreff*) must be obtained in order to account for the fringing and the wave propagation in the line. The value of *εreff*is slightly less then*εr*because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 3 above.

In order to operate in the fundamental *TM*10 mode, the length of the patch must be slightly less than λ/2 where λ is the wavelength in the dielectric medium and is equal to λ*o*/√*εreff*where λ*o*is the free space wavelength. The *TM*10 mode implies that the field varies one λ/2 cycle along the length, and there is no variation along the width of the patch. In the Figure 2.10 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.

## III. DESIGN EQUATIONS

In a dielectric substrate, the effective dielectric constant is calculated using following equation:

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

Where εr is the dielectric constant of the substrate
H is the thickness of the substrate
W is the width of the patch

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

Where $f_0$ is the centre frequency of the antenna.

The width for the patch Can be calculated by using the following equation

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

$$\lambda = \frac{c}{f_o \sqrt{\varepsilon_{reff}}}$$

For the transmission line ,the length is approximately 0.75.Where λ is the wavelength of the antenna. The real length for the patch can be calculated by

L=Leff-2ΔL where

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

## IV. DIFFERENT SHAPES OF SLOTS

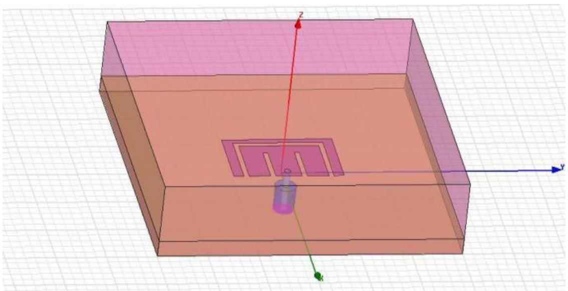

Fig 4:Geometry Of E + U Shape Slot

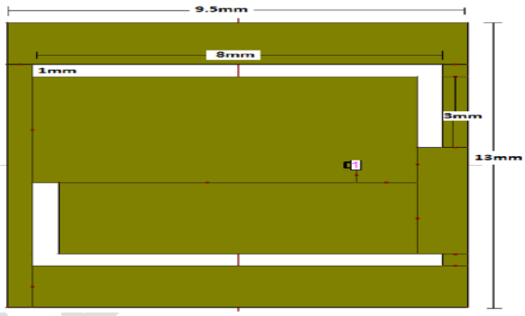


Fig 5:Geometry Of Double U Shape Slot

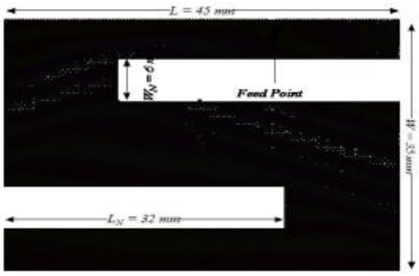


Fig 6:Geometry Of S Shape Slot

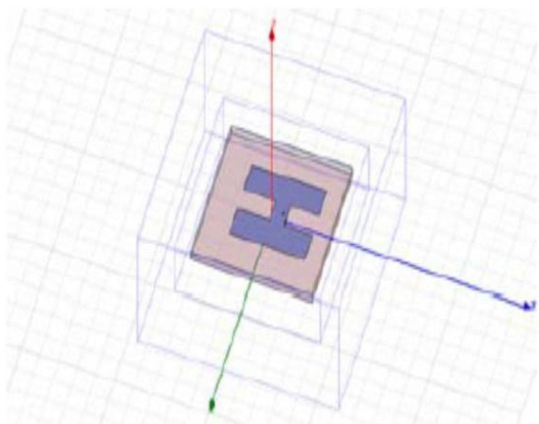

Fig 7:Geometry Of H Shape Slot

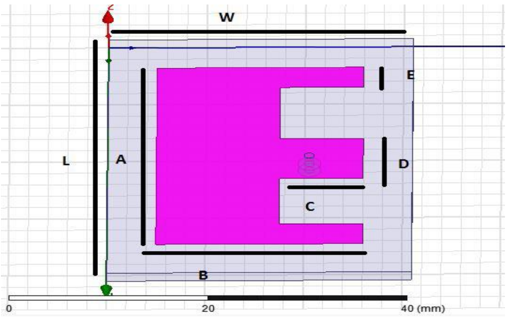


Fig 8:Geometry Of E Shape Slot

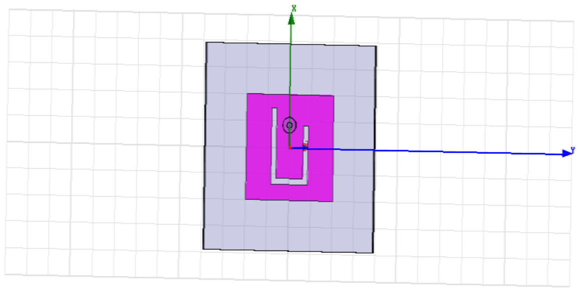

Fig 9:Geometry Of U Shape Slot

## V. COMPARATIVE ANALYSIS OF DIFFERENT SHAPES OF SLOTS

| TITLE | YEAR | CONCEPT | RESULT | MERITS |
|---|---|---|---|---|
| Design and simulation of E shaped microstrip patch antenna for wideband applications. | 2011 | 4 parallel slots & 1 perpendicular slot is inserted,probe feeding is introduced,fed by SMA connector | Freq range-8.59GHz to 13.99 GHz Gain-8.33dB(foam) 7.33dB(air) VSWR-0.217 (air) 1.67 | a) VSWR <=2. b) B.W enhanced by 30%. |

| | | | | |
|---|---|---|---|---|
| Analysis of S-shape micro-strip patch antenna for Bluetooth application | 2013 | Loaded with 2 notches ,causes 2 currents to flow resulting in 2 resonance frequency | S shaped patch at f=2.62 GHz with Gain - 8.1 dBi(theoretical) 8.2(simulated) Max efficiency-91.75(thereotical) 92.04(simulated) | Improved gain and better efficiency. S shape depends upon length,width and height of notch. |

| | | | | |
|---|---|---|---|---|
| Asymmetrical u-slotted Rectangular microstrip Patch antenna | 2013 | 2 different dielectric material i.e Rogers RT /Duroid 5880(2.2) PEC (1.0) Probe feeding is used | B.W. is increased by introducing slot of u shape.**(f=5.76 ghz& 6.48 ghz)** | Loading of slots result in size reduction ,gain & B.W. improvement |

| | | | | |
|---|---|---|---|---|
| Design of an H-shaped Microstrip Patch Antenna for Bluetooth Applications | 2013 | H shaped for Bluetooth at f=**2.4 ghz.** | Gain obtained is 8.93 db. Vswr is about 1.50 which is considerably | VSWR reduced & gain improved. |

| | | | | |
|---|---|---|---|---|
| Double L shaped slot loaded microstrip with wideband | 2014 | Double **L** slot loaded patch antenna for C band.**(f =6.987 ghz)** | VSWR is less than 2, bandwidth improved. | Enlarge impedance b.w. |

| | | | | |
|---|---|---|---|---|
| Design of single layer E shaped microstrip patch antenna.**(4.5-8.5 ghz)** | 2005 | **E** shaped patch is used instead of rectangular one. | Bandwidth is about 57.36% , VSWR is less than 2.s | Significant size reduction and remarkable bandwidth. |

| | | | | |
|---|---|---|---|---|
| Broadband microstrip patch antenna with v-slot. | 2004 | **V** shaped slot introduced for improving impedance bandwidth | Bandwidth as high as 54%. | Suitable gain and bandwidth. |

## VI. APPLICATIONS

Microstrip antennas are spreading widely in all the fields and areas and now they are booming in the commercial aspects due to their low cost of the substrate material and the fabrication. It is also expected that due to the increasing usage of the patch antennas in the wide range this could take over the usage of the conventional antennas for the maximum applications. the applications are in the various fields such as in the medical applications, satellites and of course even in the military systems just like in the rockets, aircrafts missiles and various wireless applications such as Bluetooth,wimax,wlan,gsm,gps,etc. S and H shape is used basically for Bluetooth applications. E AND U shape is basically used for Wi-max , WLL and WLAN. L shape slot antenna finds it application in field of wireless and mobile communication.

Some of these applications are discussed as below:

*Mobile and satellite communication application*: Mobile communication requires small, low-cost, low profile antennas. Microstrip patch antenna meets all requirements and various types of microstrip antennas have been designed for use in mobile communication systems. In case of satellite communication circularly polarized radiation patterns are required.

*Global Positioning System applications*: Nowadays microstrip patch antennas with substrate having high permittivity sintered material are used for global positioning system. Millions of GPS receivers are used by general population for land vehicles, and aircraft to find there position accurately.

*Radio Frequency Identification (RFID):* RFID uses in different areas like mobile communication.. RFID system generally uses frequencies between 30 Hz and 5.8 GHz depending on its applications.

*Worldwide Interoperability for Microwave Access (WiMax)*: The IEEE 802.16 standerd is known as WiMax. It can reach upto 30 mile radius theoretically and data rate 70 Mbps. MPA generates three resonant modes at 2.7, 3.3 and 5.3 GHz and can, therefore, be used in WiMax compliant communication equipment.

## VII. CONCLUSION

A theoretical survey on microstrip patch antenna is presented in this paper. Some effect of disadvantages can be minimized. Increasing gain ,bandwidth and lowering VSWR for making patch antenna for application specific is achieved by introducing slots in the geometries of patch antenna. As compared to conventional micro-strip antenna gain is improved, VSWR is reduced so thereby overall efficiency of the antenna increases. Different slots shaped are compared and it is found that bandwidth of conventional rectangular microstrip antenna can be enhanced from 4.81% (100MHz) to 28.71% (610 MHz), 28.89% (630MHz) and 9.13% (110MHz) respectively using U, E and H-patch over the substrate. The E-shaped patch antenna has the highest bandwidth followed by U-shaped patch antenna and H-shaped patch antenna.

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