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Bandwidth Enhancement of Microstrip Slot Antenna

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***Abstract*— Microstrip Patch Antenna is generally used in modern communication devices due to its low cost and small area. But have narrow bandwidth so they have limited applications. Bandwidth enhancement is done by using various slot shapes in combination with different feed geometries. The slots can be of various shapes such as 'U' shaped, 'E' shaped and rectangular shaped slots.**

Here, the proposed wide-slot antennas employ E-shaped slot. The E-shaped radiating slot is etched on a rectangle substrate with a relative dielectric constant. A substrate of low dielectric constant is selected to obtain a compact radiating structure that meets the demanding bandwidth specification. The characteristic impedances of the microstrip lines are nearly 50Ω. This design is simulated using ''Integral Equation three Dimensional'' (IE3D) software package of Zealand. The simulated results show that the antenna resonates at 2.66GHz and has bandwidth upto 12%.

***Keywords*—Microstrip patch antenna; E- shaped slot; IE3D software; bandwidth enhancement**

I. Introduction

The rapid development of wireless communication technology has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip Patch Antennas (MPA) are very advantageous because of their low cost, small size, light weight and simple realization process. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth, low efficiency, etc. [1]

Enhancement of performance to meet the demanding bandwidth is necessary. There are numerous and well known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, slotted patch antenna, the use of various impedance matching and feeding techniques. [1]

When a slot is introduced in a MPA the current path increases thus increasing the bandwidth of an antenna. There are other techniques to increase bandwidth such as decreasing the dielectric constant. This can be done by increasing the height of the antenna but this method makes the antenna bulkier and also reduces the efficiency of the antenna. Hence we have used the slotting technique in our project, which increases the bandwidth without affecting the antenna size.

Wireless communications have progressed very rapidly in recent years, and many mobile units are becoming smaller and smaller. To meet the miniaturization requirement, compact antennas are required. Planar printed antennas have the attractive features of low cost, small size and conformability to mounting hosts.

The idea of microstrip antenna was first proposed by Deschamps in 1953 [11] and a patent in 1955. However, the first antenna was developed and fabricated during the 1970's when good substrates became available [11, 12].

Very recently, especially after the year 2000, many novel planar antenna designs to satisfy specific bandwidth specifications of present-day mobile cellular communication systems, including the global system for mobile communication (GSM: 890–960MHz), the digital communication system (DCS: 1710–1880MHz), the personal communication system (PCS: 1850–1990MHz), and the universal mobile telecommunication system (UMTS: 1920–2170MHz), have been developed and published in the open literature. Planar antennas are also very attractive for applications in communication devices for wireless local area network (WLAN)/ WiMAx.

There are many softwares available for antenna design like HFSS (High Frequency Spread Spectrum), IE3D (Integral Equations three Dimensional), etc. Designing in IE3D is easier as compared to HFSS. IE3D is an integral equation and method of moment based EM simulator. IE3D mainly focuses on general planar and 3D metallic structures in layered dielectric environments. It is very efficient, accurate and flexible for such structures. IE3D can also model 3D dielectric structures such as patch antennas with finite substrates and dielectric resonator antennas.

Basic design is the part which shows that we have designed and simulated three designs.

The simulated results of these designs are showed on the results part .

II. Basic Design

A rectangular shaped MPA is used. Simulated results of "E" shaped slot, "U" shaped slot and rectangular shaped slot are observed on IE3D. Microstrip line feeding is used here. The antenna has ground plate of the dimensions 56.11mm* 37.83mm and patch of the dimensions 42.345mm * 28.23mm. The dielectric constant for the antenna is 4.4 with substrate thickness of 1.6mm.

A. Design 1

This design has a 20mm*5mm slot on the radiating patch. The slot is slightly towards the right side of the patch. Microstrip line feeding is given on the right edge of the antenna. Simulated results are observed.

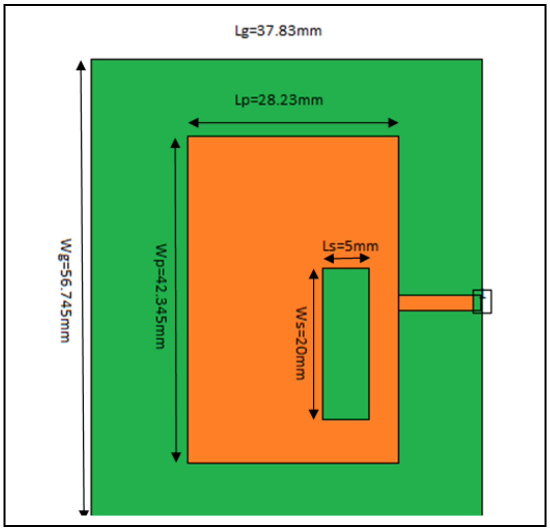

Fig 1 Design of rectangular slot antenna

B. Design 2

A ‘U’ shaped slot is created on the patch of the antenna. This slot is asymmetrical. Microstrip line feed is given at the bottom edge of the patch. Simulated results are observed on software.

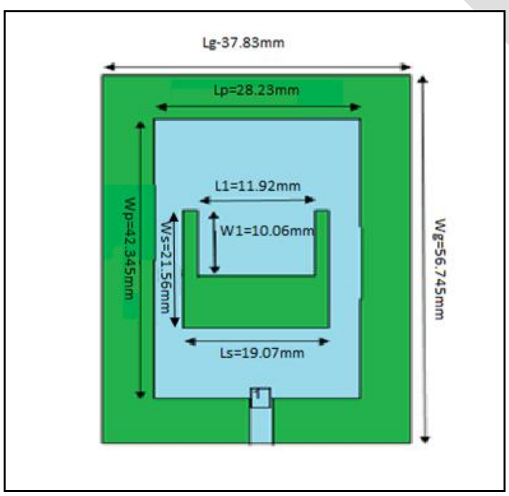

Fig 2 Design of ‘U shaped’ slot antenna

C. Design3

The slot used in this design is ‘E’ shaped. The simulated results are observed. Due to more number of slots the current path increases. This ‘E’ shaped slot is horizontally symmetrical. Microstrip line feed is given at the bottom edge of path. Simulated as well as fabricated results for this design are observed.

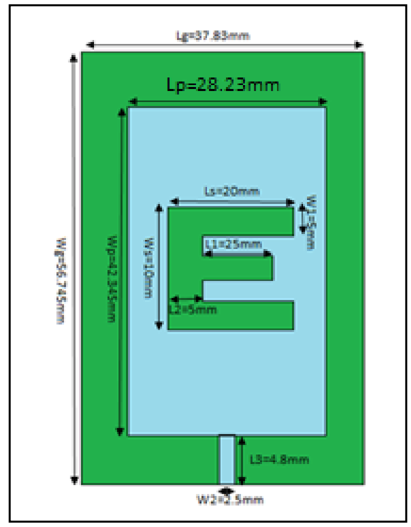

Fig 3 Design of ‘E shaped’ slot antenna

III. Results

Simulated results of this antenna are observed on IE3D.

A. Design 1: Rectangular slot

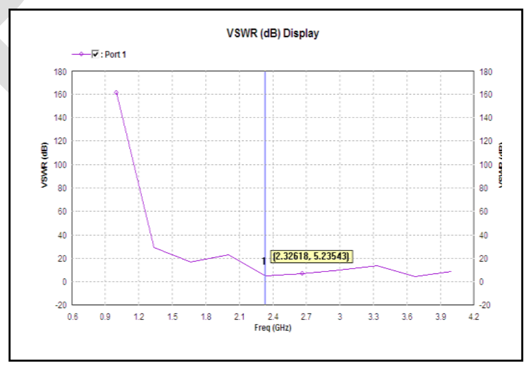

Fig 4 VSWR of rectangular slot antenna

VSWR observed is 5.23dB at 2.32 GHz. The antenna should resonate at 2.5GHz but the results show that it resonates at 2.3 GHz.

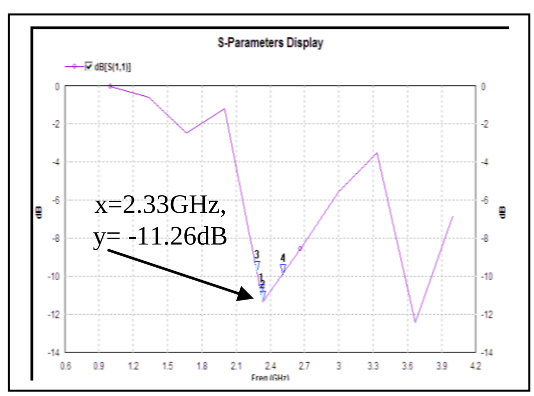

Fig 5 S-parameters of rectangular slot antenna

The reflection coefficient at 2.3GHz is -11.26dB. The S-Parameter display shows that the bandwidth for this antenna is approximately 7%.

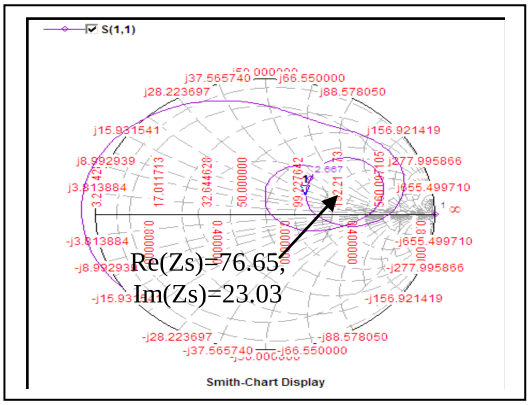

Fig 6 Smith chart display of rectangular slot

Smith chart display is useful to verify impedance of the antenna at the resonating frequency. Here at 2.3GHz frequency the impedance is found to be 76Ω which is higher than required.

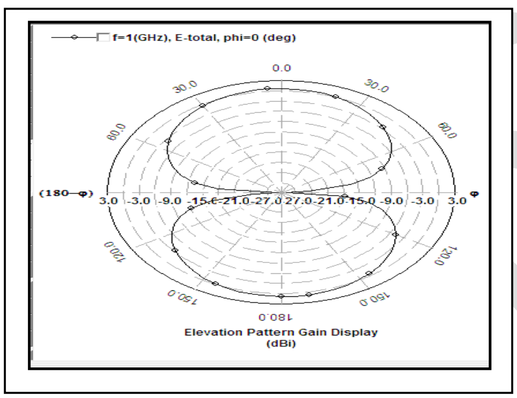

Fig 7 Elevation pattern Gain display

The 2D radiation pattern shows that the antenna is Omni-directional.

B. Design 2:' U' shaped slot

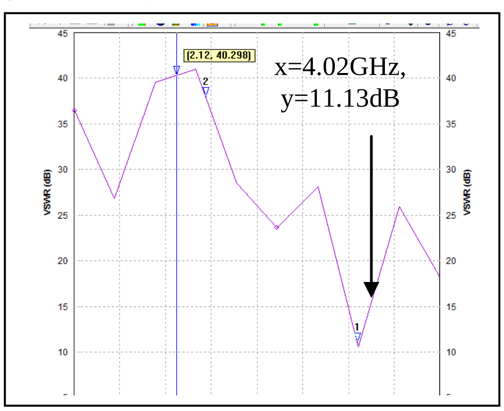

Fig 8 VSWR of 'U' shaped slot

VSWR observed is 11.13dB at 4.02 GHz. This value is higher than that is required. . The antenna should resonate at 2.5GHz but the results show that it resonates at 4.02 GHz.

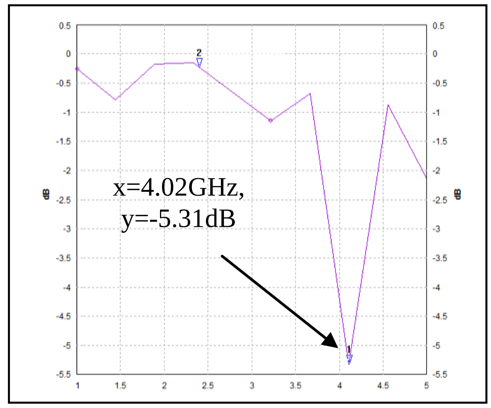

Fig 9 S-parameters of 'U' shaped slot

The reflection coefficient at 4GHz is -5.31dB. The S-Parameter display shows that the bandwidth for this antenna is merely 2%.

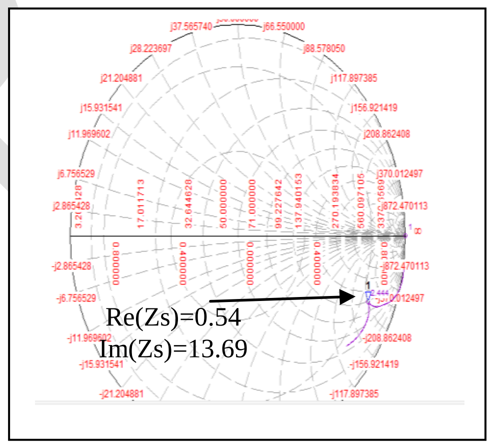

Fig 10 Smith chart of 'U' shaped slot antenna

Smith chart display is useful to verify impedance of the antenna at the resonating frequency. Here at 4.02GHz frequency the impedance is found to be 0.54Ω which is extremely low.

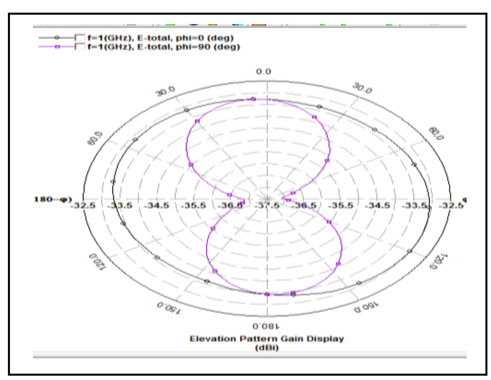

Fig 11 Elevation pattern gain display

The 2D radiation pattern shows that the antenna is Omni-directional.

C. Design 3: 'E' shaped slot.

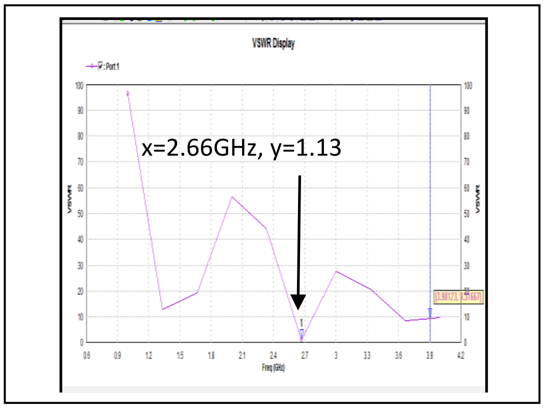

Fig 12 VSWR display of 'E' shaped slot

VSWR observed is 1.13dB at 2.66GHz. The antenna resonates at 2.66GHz.

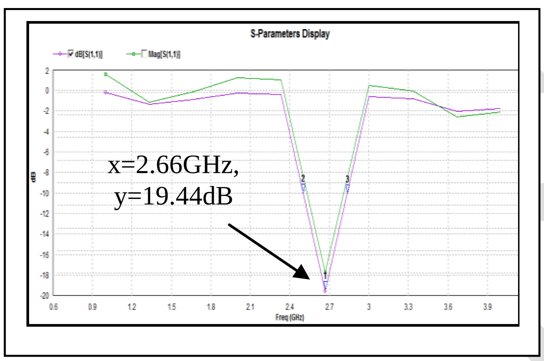

Fig 13 S-Parameters of 'E' shaped slot

The reflection coefficient at 2.66GHz is -19.44dB. The S-Parameter display shows that the bandwidth for this antenna is approximately 12%.

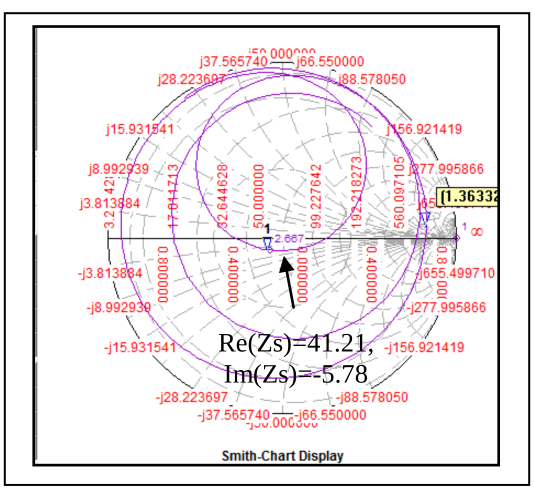

Fig 14 Smith Chart display of 'E' shaped slot

Smith chart display is useful to verify impedance of the antenna at the resonating frequency. Here at 2.66GHz frequency the impedance is found to be 0.54Ω which is extremely low.

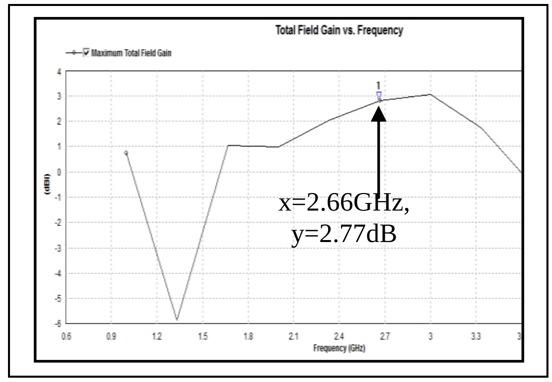

Fig 15 Total Field Gain vs. Frequency

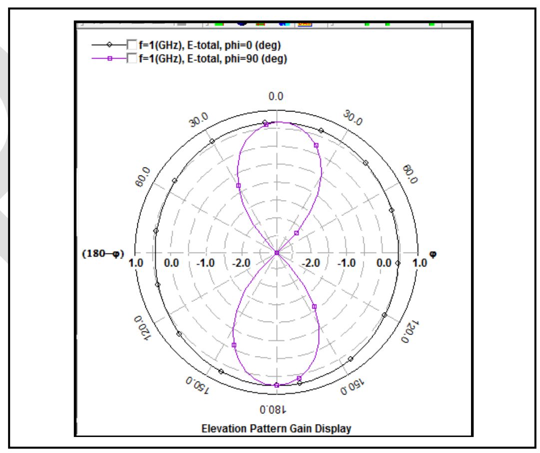

Fig 16 Elevation Pattern Gain Display

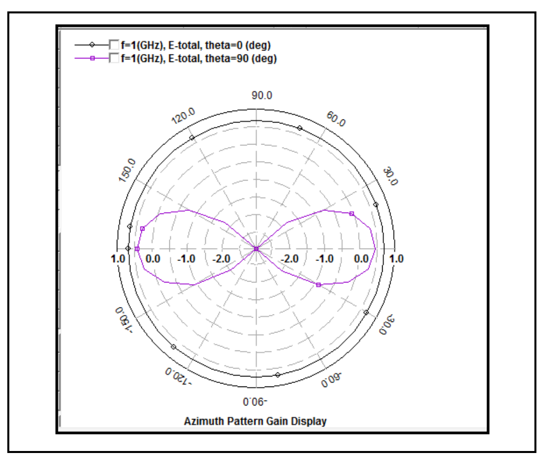

Fig 17 Azimuth Pattern Gain Display

The 2D radiation pattern must be Omni-directional in one plane (circle) and directive in the other (figure of 8). In fig 16, 17 For theta = 0 it shows Omni-directional pattern in the azimuth plane and directive pattern in the elevation plane.

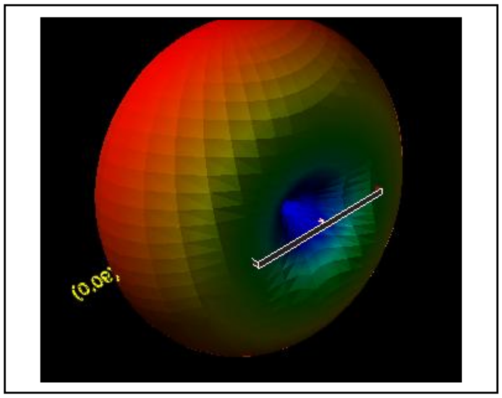

Fig 18 3D Radiation Pattern of 'E' shaped slot

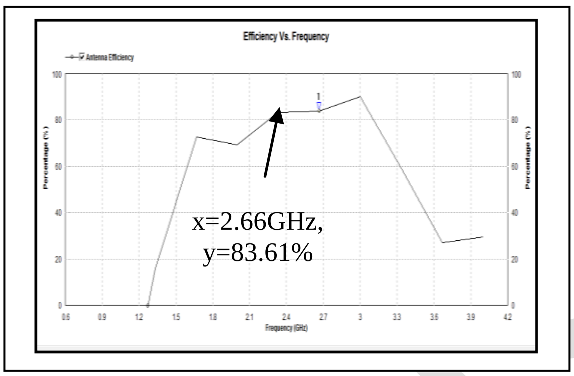

Fig 19 Efficiency vs. Frequency of 'E' shaped slot

The Efficiency is 83.61% for frequency 2.66GHz.

Parameter	Rectangular shape	U-shaped slot	E-shaped slot
Frequency (GHz)	2.33	2.4	2.66
VSWR(dB)	5.23	37.96	1.92
S- parameter	-11.26dB	-0.229dB	-19.44dB
Impedance	23.03	13.69	41.71
Gain	2.01	-	2.77
Efficiency	62.05%	-	83.67%

IV. CONCLUSION

Comparing the simulated results of the three antenna designs, we found out that an 'E' shaped slot provides higher bandwidth and efficiency. The rectangular slot has given broader bandwidth than 'U' shaped slot and has high efficiency. The 'U' shaped slot design can further be improved to give required results.

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