Design of 3-Side Truncated Patch Antenna with Semi-Circular Open Slot for UWB Applications

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ABSTRACT
A 3-sided truncated microstrip patch antenna with semicircular open slot for ultra-wideband (UWB) and SHF (Super High Frequency) applications has been presented in this paper. The proposed antenna is compact in size and designed on FR4 substrate. From the simulation and measurement results, it is shown that the corner-truncated With Semi Circular open slot patch scheme is an excellent approach, which can be used to make the proposed antenna match well over an enhanced impedance bandwidth of 12.13 GHz (2.26~14.39GHz), for a - 10dB return loss**.** The results of proposed antenna are presented by using HFSS. The proposed antenna is feasible for WLAN, WIMAX, Wi-Fi and other various wireless applications.

Keywords
Patch Antenna, Return Loss, UWB

1. INTRODUCTION
In the changing world scenario of wireless communication systems, a wideband antenna has been playing a very important role for wireless services. Because of their low profile, wide bandwidth, compact size, low cost, and ease of fabrication slot antennas are attractive candidates for broadband and ultra wideband (UWB) applications. Enhancement of bandwidth by introducing slots in radiating patch [1,3,5,6] is one of the best method for enhancing bandwidth of microstrip patch antenna . Another Corner truncated microstrip patch antenna at frequency 3.4GHz [4] is designed to achieve circular polarization. The resonant behavior analysis of small-size slot antenna with different substrates [2] provides another method for improving resonating behavior. Bandwidth improvement of microstrip patch antenna using A-shaped patch [13] provide 120MHz bandwidth at 10 db. These slot antennas can achieve a good broadband characteristic. Size reduction and bandwidth enhancement are becoming major design considerations for practical applications of microstrip antenna. Because of these reasons, studies to achieve compact and broadband operations of microstrip antennas have greatly increased. A rectangular microstrip antenna is designed based on the transmission line model, circular and rectangular patches are designed based on cavity model. The impedance versus frequency behavior of all microstrip patches limit the operating frequency range.. There is huge range of UWB applications including wireless communication system, radars, satellite communication and lot more .In the presented work semicircular slot three side truncated antenna has been employed for UWB and SHF applications.

2. DESIGN AND STRUCTURE
Figure 1 shows the geometry of the three corner-truncated rectangular patch antenna with open semicircular slot fabricated on the FR4 Substrate. The dielectric constant of substrate ε_r= 4.4 and a loss tangent of 0.02 and thickness of the substrate h= 0.8mm have been used to design microstrip patch antenna. The dimensional parameters of the proposed antenna are detailed in Table. 1. In this work semicircular slot has been introduced to further enhance the bandwidth of antenna. Slot on ground also helps in enhancing the bandwidth. The rectangular patch fed by microstrip-line has three truncated corners with a open semicircular open slot corners. The effect of different radii of semicular slot has been analyzed to get the best possible bandwidth and gain. The proposed antenna is simulated using Ansoft High Frequency Structure Simulator (HFSS), which is full wave electromagnetic simulation software for the microwave and millimeter wave integrated circuits. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give an unparalleled performance and insight to all of the 3D EM problems [11, 12]. The 3D model of proposed antenna generated in the HFSS is shown in Figure 2.

Table 1: Antenna Dimensions

Parameters	Dimensions
Length Of Patch(L_p)	6 mm
Width Of Patch (W_p)	9 mm
Thickness of substrate	0.8 mm
Length of substrate (L)	35 mm
Width of substrate (W)	30 mm
Width of feed (x)	1.53 mm
Length of feed (L_f)	14.55 mm

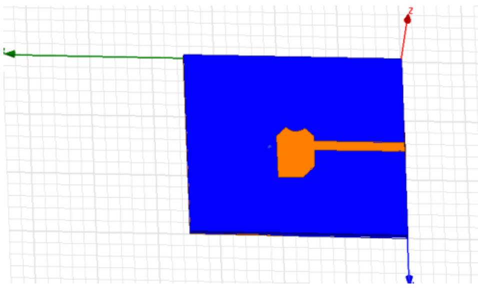

Figure 1: Geometry of proposed antenna showing patch and substrate

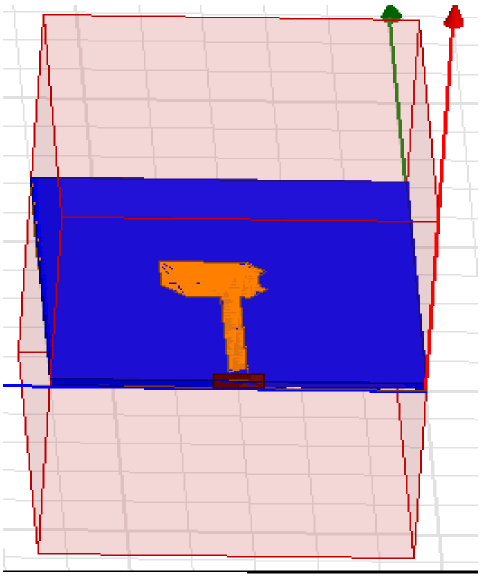

Figure: 2 3D Ansoft HFSS generated model of proposed antenna

3. RESULTS AND DISCUSSION

3.1 Return Loss

Return loss is the loss of signal power resulting from the reflection caused at a discontinuity in transmission line. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. In the proposed work, figures 3, 4, 5 and 6 show different graphs for return loss with circular slot of radius 2 ,2.4 ,2.6 and 2.7 respectively. For different values of radii of circular slot antenna shows different bandwidth and gain which are compared in Table 2. Best results are evident at radius of 2.6 with band width of 12.17 GHz

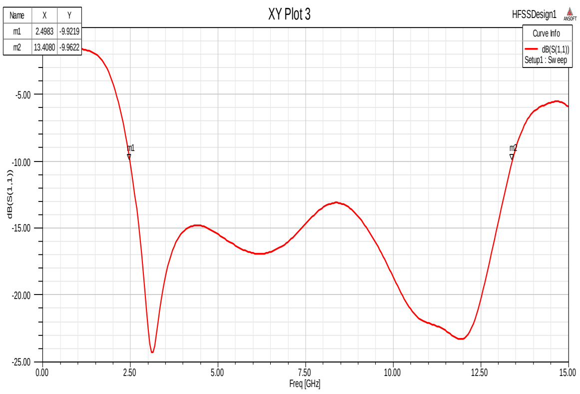

Figure 3: Return loss for antenna with semi circular slot of radius 2mm

3.2. VSWR

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR may be express in terms of the reflection coefficient, which describes the power reflected from the antenna. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. Figure 7 shows the VSWR which is well below 2.

Table 2: Bandwidth And Return Loss For Different Radii

Radius of slot	Bandwidth	Return Loss
2 mm	10.9 GHz	A return loss of -24 dB at 3.1 GHz and -23.1dB at 12 GHz is obtained
2.4 mm	11.56 GHz	A return loss of -24dB at 3GHz and -45dB at 12.50 GHz is obtained
2.6 mm	12.17 GHz	A return loss of -29 dB at 2.90GHz and -26 dB at 12.50 GHz is obtained
2.7 mm	12.12 GHz	A return loss of -28 dB at 2.90GHz and -21 dB at 12.60 GHz is obtained

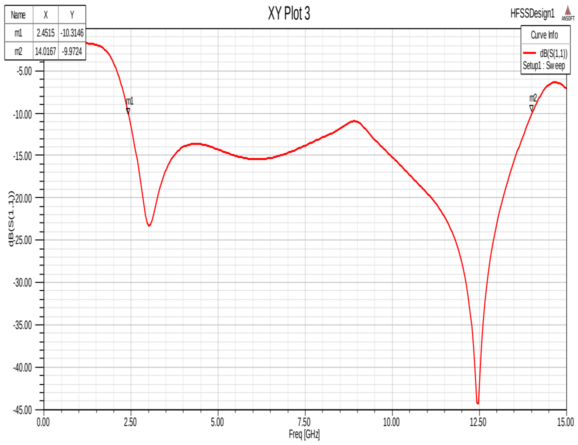

Figure 4: Return loss for the antenna with circular slot of radius 2.4mm

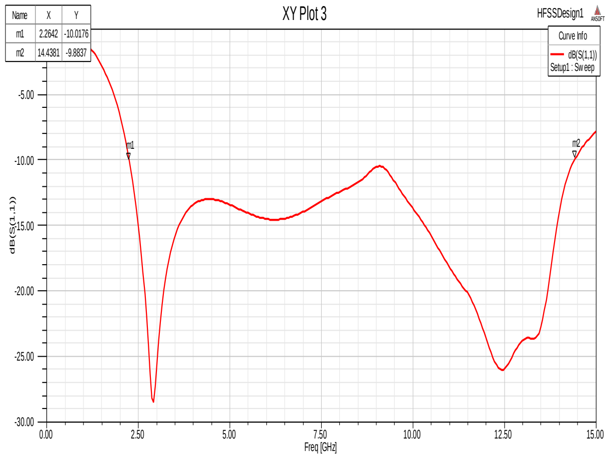

Figure 5: Return loss for the antenna with circular sot of radius 2.6mm

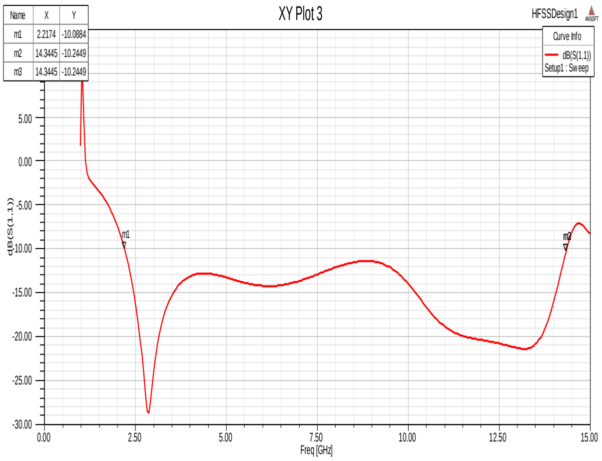

Figure 6: Return loss for the antenna with circular slot of radius 2.7 mm

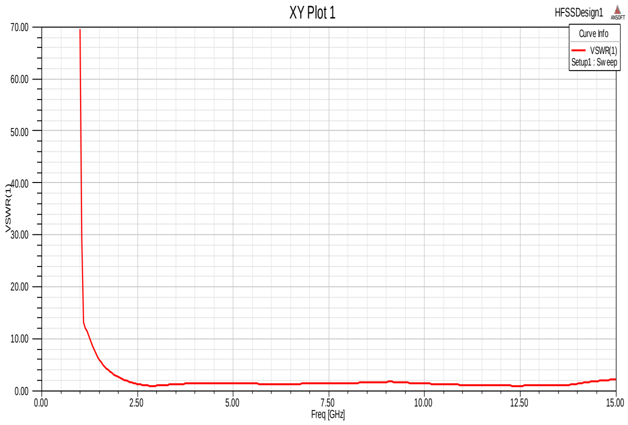

Figure 7: VSWR for Three side truncated patch with circular slot of radius 2.6 mm

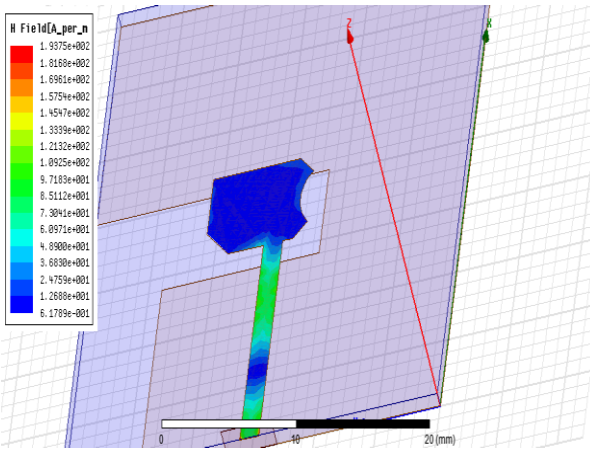

Figure 8: H field distribution for proposed antenna

3.3. H-Field Distribution

It is the plane containing the magnetic field vector and the direction of maximum radiation. The magnetic field or "H" plane lies perpendicular to the "E" plane. The H-plane usually coincides with the horizontal/azimuth plane in case of vertically polarized antenna and in case of horizontally-polarized antenna, it usually coincides with the vertical/elevation plane [13, 14]. The H-field of proposed antenna is shown in Figure 8.

3.4. E-Field distribution

An electric field can be visualized by drawing field lines which indicates the direction and magnitude of the field. The E-plane containing the electric field vector and the direction of maximum radiation [4]. Field lines start on positive charge and end on negative charge. The E-Field of the proposed antenna is shown in Figure 9.

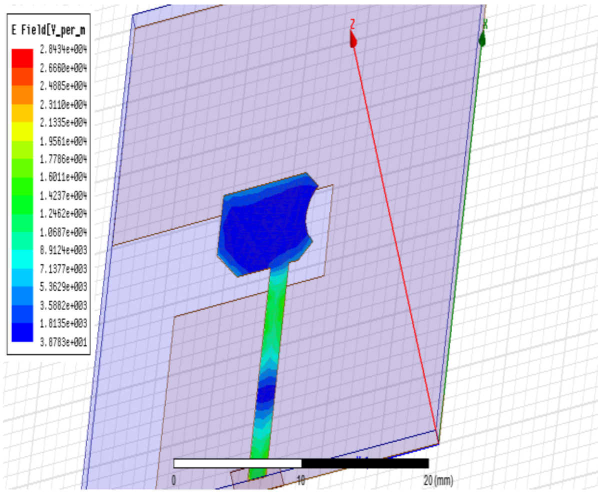

Figure 9: E Field distribution for the proposed antenna

Table 3 Comparision Of Proposed Antenna With Published Work

	2 Side truncated	3 side truncated	3 Side truncated with open semicircular slot
Return Loss	2.77GHz to 12.00GHz	2.28GHz to 12.33 GHz	**2.26 to 14.39 GHz**
VSWR (below 2)	2.70 GHz to 11.50 GHz	2.70 GHz to 12.33 GHz	**2.45GHz to 13.73 GHz**
Bandwidth	9.24	10.05	**12.13**
Appications	UHF (TV Broadcast, Microwave devices, LAN, Bluethooth, GPS	UHF	**SHF(Super High Frequency)(3-30 GHz) Wireless LAN, Modern Radars, Communication Satellites, DBS**

4. CONCLUSSION

UWB antenna printed on FR4 substrate has been described. The simulation results of the antenna show that enhanced impedance bandwidth can be achieved by using L-shaped slot and 3-side truncated corners. Apart from this a semicircular slot has been introduced on one side of truncated faces to further enhance the operation bandwidth of antenna. In this work a comparison has been conducted for various values of radii of semicircular slot and best bandwidth is achieved at R=2.6mm. It is seen that the proposed antenna achieved good performance and compact size, which well meets the requirements of UWB and SHF applications.

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