Slot Cut Ultra Wide Band Antennas

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ABSTRACT
The ultra wide band antennas are required in applications where larger bandwidth for the transmitting signal is needed. They cover wide bandwidth in the range from 500 MHz to the frequencies above 8000 MHz. In this paper, a review of various techniques to realize ultra wide band microstrip antennas (MSA) is presented. They are realized by using different techniques like basic planar monopole antenna and the variations of the same by using different shapes of radiating monopole antenna, like, bi-conical, Bowtie, etc. They are also realized by using modifying the feeding strip shape or by cutting the slot inside the patch. The ultra wide band (UWB) response has also been realized by using fractal shapes in the radiating monopole antenna. Towards the end of paper, the scope of future work is proposed, wherein the exact formulation of resonant length is needed for planar monopole antenna at its fundamental and higher order modes as well as the explanation for the ultra wide band response in terms of operating modes in slot cut and fractal geometries.

Keywords
Ultra wide band microstrip antenna, planar monopole antenna, slot cut Ultra wide band microstrip antenna, Fractal microstrip antenna.

1. INTRODUCTION
Since federal communication commission (FCC) declared 3.1-10.6 GHz as ultra wide band frequency range, there have been many UWB antenna studies. Recently, in UWB application, monopoles of various configurations have attracted more and more attentions because of their attractive merits, such as nearly omnidirectional radiation patterns, simple structure and low cost. Recently, due to the miniaturization of the personal communication devices, the need of compact antennas has become a necessity. Moreover, the growth of wireless systems operating in multiple independent bands or wide bands leads to the use of multi-functional antennas such as UWB. Due to their capabilities for high data rate information transmission, ultra-wide band communication systems are highly promising. In addition, these systems have low power consumption and low interference and immunity to multipath fading.

2. PLANAR MONOPOLE UWB ANTENNA
The configuration shown in Fig 1[1] is a planar monopole antenna. Thicker substrate with lower dielectric constant results in increase in the BW of MSA up to 10%. The large *h* increases the probe inductance, and the input impedance becomes too inductive to obtain impedance matching. The MSAs with edge probe feeding are used to avoid impedance mismatch. The formula for rectangular microstrip antenna (RMSA), to calculate resonance frequency is given by [1]:

$$f_0 = \frac{c}{2\sqrt{\in re}} \sqrt{(\frac{m}{Le})^2 + (\frac{n}{We})^2}$$

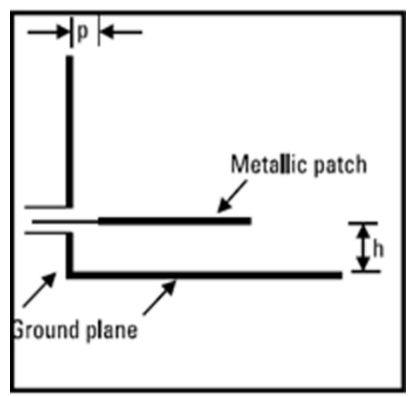

Fig.1: Planar Monopole Antenna [1]

If *h* is very large (> 0.1λ), the bottom ground plane will have a negligible effect and hence can be removed. Therefore, for a large *h* tending to infinity, the MSA configuration reduces to that of a planar monopole antenna which acts as a quarter wavelength resonator.

For planar monopole,

$$f_0 = c/(4Le) \quad (since, \varepsilon_r = 1)$$
$$L_e = L + \Delta L + p$$

3. SLOT CUT UWB ANTENNAS

Slot antennas are currently under consideration for use in UWB systems due to the attractive advantages such as low profile, light weight, ease of fabrication and wide frequency bandwidth. This type of antenna has been realized by using microstrip line and CPW feeding structures.

3.1 Arrow Shaped UWB Antenna

The arrow shaped UWB antenna is shown in Fig.2 [2]. An UWB antenna radiating at 3-15 GHz is designed. The antenna is designed using a dielectric material which size of 41x36 mm. The dielectric constant of the material is ε=6, 15 and the thickness is t=0,508 mm. The arrow shaped patch is fed by a strip line. The dimensions of antenna are as given: D1=D2=10 mm, D3=23 mm, D4=5 mm, D5=31.5 and R=3.5 mm. The RCS (radar cross section) of the antenna is reduced by modifying the geometry of the antenna. Simulation results in Fig.3 [2] shows that, when the electric field of the incident wave is in x direction, RCS of the antenna reduced about 10 dB. RCS is reduced up to 25 dB at 5 GHz. When the electric field of the incident field is in y direction, RCS of the antenna is reduced about 10 dB at the frequencies higher than 10 GHz. RCS of the antenna is reduced up to 25 dB [2].

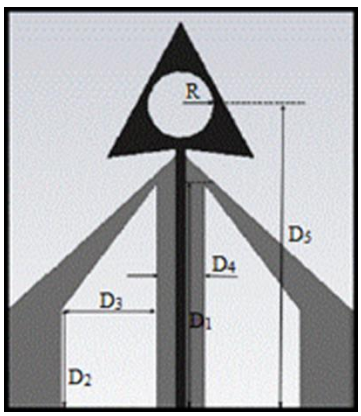

Fig.2: Arrow shaped UWB antenna [2]

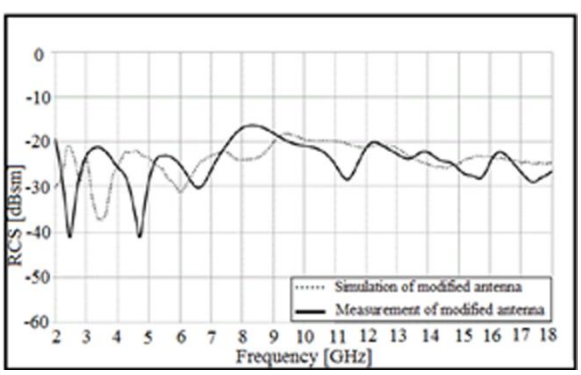

Fig 3: Simulated and measured results of the modified antenna [2]

3.2 Octagonal Shaped UWB Antenna

An octagonal shaped UWB antenna is shown in Fig.4 [3]. The antenna radiates at 2.5-18 GHz with the fractional bandwidth of about 150%.The size of antenna is 60 x 70 mm. The dielectric constant of the material is €=6.15 and the thickness is t=1.27 mm. In order to reduce RCS (radar cross section), some modifications are made of the reference antenna. The radius of the elliptic geometry at y axis is E_y=29mm and x axis is E_x=35mm and a circular shape with R=24mm is extracted from the patch.

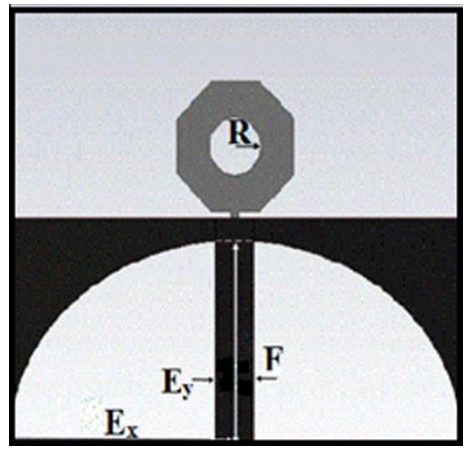

Fig 4: Octagonal Shaped UWB Antenna [3]

A strip line which is located on the ground layer is used to feed the patch. In order to make modifications of the geometry, an elliptic geometry is extracted from the ground layer. The origin of the elliptic geometry is on the middle of the feeding edge of the antenna. When the electric field of the incident wave is in x direction, RCS of the antenna reduced about 10 dB. Especially at 4.5 GHz it's reduced up to 25 dB. When the electric field of the incident field is in y direction, RCS of the antenna is reduced about 10 dB at 4.5-18GHz. As shown in Fig.7 [3] RCS of the antenna is reduced up to 25 dB [3].

3.3 Volcano Smoke Planar UWB Antenna

The volcano smoke planar printed circuits antenna is shown in Fig 5 [4]. The antenna is fed using coplanar waveguide. The dimensions of antenna are as given: H=75 mm, W=75 mm, the central conductor strip width is W_l=2 mm, the slot width is S=l mm, the radius of top arc of the antenna is R_l=20 mm, the radius of both side arc of the antenna is R_2=18 mm, and H_2=10 mm, the neck radius of antenna is R=47.3mm.The six resistances on both sides of the antenna are all 150Ω, however the top resistance is changed when the resistance loop circuit is loaded and the S_{11} value corresponding to the resistance is measured. Since the loop circuit is not connected and due to the coupling of five segment printed circuit with the antenna, stop bands are formed. When the antenna is loaded with loop circuit and without resistance, the value of S_n which is above-10db appears to be at two stop bands. The loading of antenna with appropriate resistance shows that the lower cut-off

frequency of bandwidth expands significantly. Planar antenna fed via the co-planar waveguide has wide bandwidth and after loading the resistance loop circuit, the bandwidth will become wider. Comparison of S_{11} of the antenna in three cases is shown in Fig 6 [4].

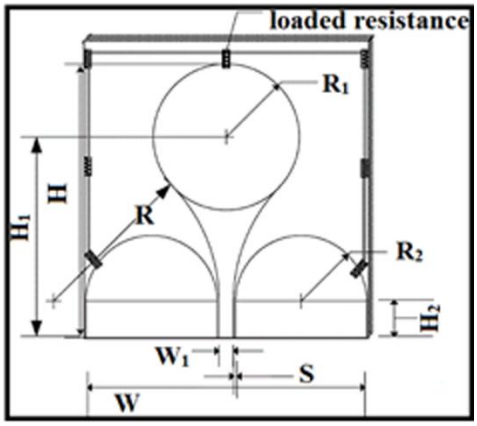

Fig 5: Volcano Smoke Planar UWB Antenna [4]

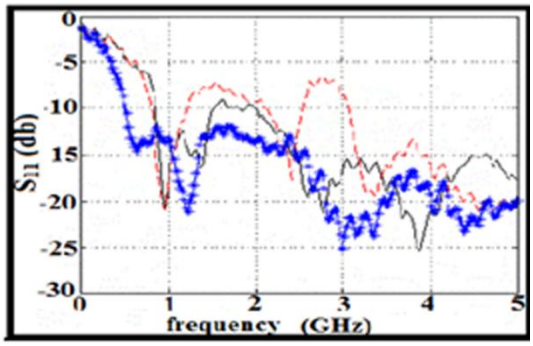

Fig 6: (——) without resistance and loop circuit
(-----) with loop circuits and without resistance
(—*) with resistance and loop circuits

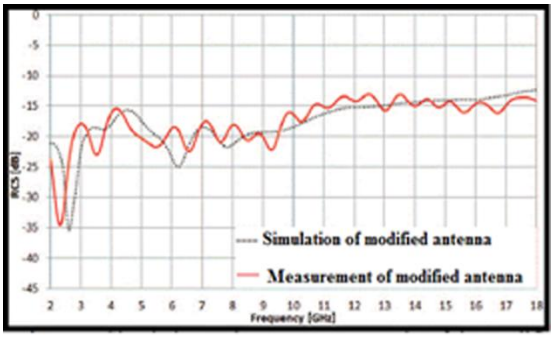

Fig 7: Simulated and measured results of modified antenna [3]

3.4 Multiple Stopbands UWB Antenna

The structure of the CPW-fed circular monopole multiple Stopbands UWB antenna is shown in Fig. 8 [5]. The CPW feed line is connected with all three pairs of quarter wavelength L-shape resonance slots. A single layer substrate with the relative permittivity 2.65 and the thickness of 1mm is used. The dimensions of the antenna are as shown in Fig.8. Three stop bands at 2.4GHz, 3.5GHz and 5.8GHz are observed in Fig. 9 [5] due the three quarter wavelength L-shape slots respectively.

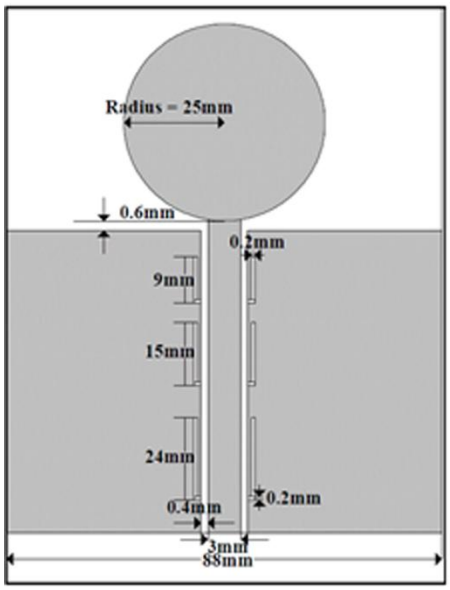

Fig 8: Multiple Stopbands Ultra Wide Band Antenna [5]

The radiation patterns are also measured in microwave anechoic chamber at 2GHz, 3.1GHz and 4.6GHz. Within the passband the antenna has nearly omni-directional radiation patterns. The antenna has the impedance bandwidth defined by S_{11}< -10dB from 1GHz to 6GHz and has three stopbands at 2.4 GHz, 3.5 GHz and 5.8 GHz respectively.

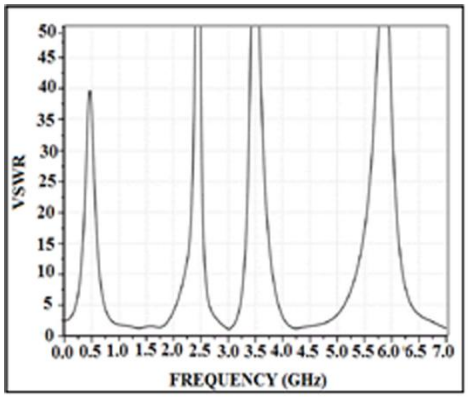

Fig 9 : Simulated VSWR [5]

3.5 Band Notched UWB Antenna

A band notched UWB antenna is shown in Fig.10 [6]. A semicircular wide slot antenna fed using circular microstrip line operates with a band-notched frequency at 5GHz. The band-notched operation is achieved by using a U-slot in the circular microstrip patch. It is constructed on a rectangle substrate with relative permittivity of 2.65 and thickness of 1mm with length and width of 80mm and 50mm, respectively. The dimensions of the antenna are as shown in Fig.10 [6]. The antenna can generate a wide operating bandwidth of 3.1-10.6 GHz covering the UWB. However by cutting a narrow U slot (width 1mm) inside the circular patch, a notched frequency band for the UWB slot antenna can be achieved . In this case the antenna becomes non-responsive at that frequency band, leading to a band notched UWB operation. For the proposed antenna, a sharp, band notched operation is achieved in the 5 GHz band , as shown in Fig.11 [6] with small effects on other frequencies in the UWB bandwidth observed [6].

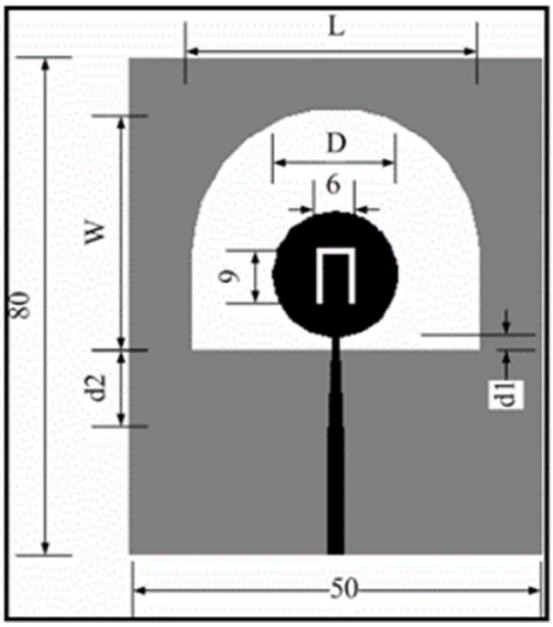

Fig 10 : Geometry of band notched UWB antenna [5]

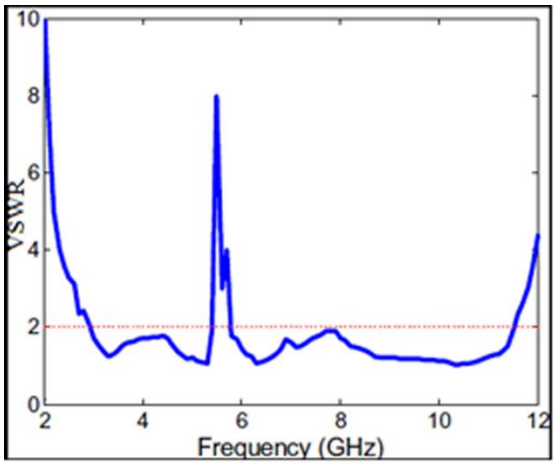

Fig 11: The amplitude characteristic of field distribution for 1GHz [5]

3.6 Rectangular Wide Slot Band Rejection UWB Antenna

A wide slot antenna with fork-shaped microstrip line fed is shown in Fig.12 [7].The dimensions of antenna are as shown below in Fig.12 [7].The bandwidth of a wide slot is intrinsically large. A fork like tuning stub is added so as to expand the impedance bandwidth of the antenna.

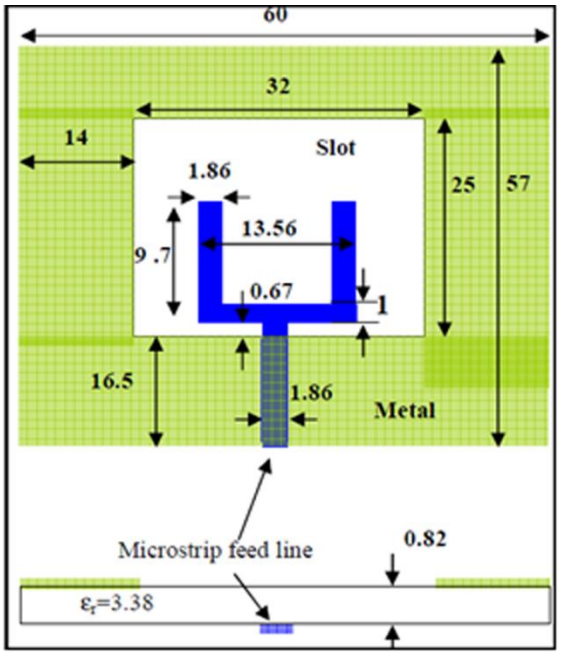

Fig 12: Rectangular wide slot geometry [7]

A limited ground plane is added to this antenna to obtain a directive antenna.Fig.13 [7] shows measured the gain of the directional wide slot antenna. However, the results show that the antenna has a bandwidth where the gain is low. Hence it is necessary to reject this little bandwidth. The bandwidth rejection is achieved with open stub or notch/slot. The solution consists of placing a C-resonant strip on the radiating slot, in front of the fork-shaped tuning stub as shown in Fig.14 [7]. The length of C- strip is a half wavelength at centre frequency of the desired rejected bandwidth. The bandwidth is controlled by the width of the strip.

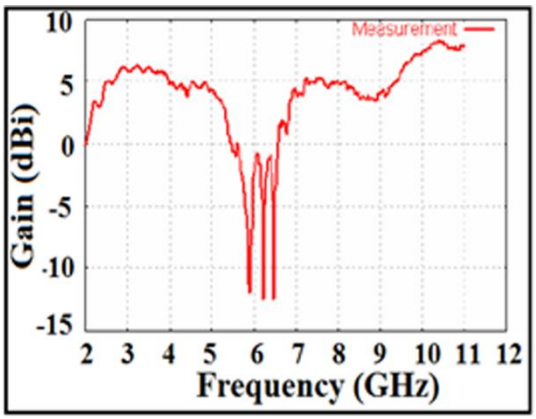

Fig 13: Gain of directional wide slot antenna [7]

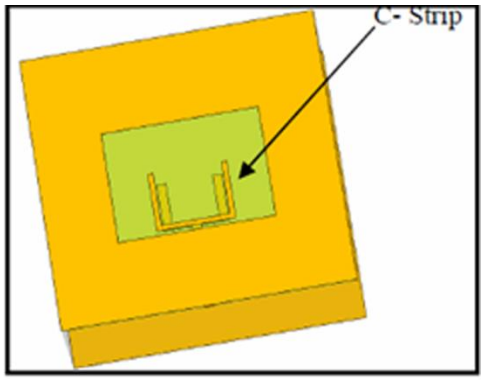

Fig 14: Directional wide slot antenna geometry with C-strip in front of the fork-shaped tuning stub [7]

The placement of the C-strip helps in achieving the objective of rejecting the 5 to 6 GHz bandwidth as shown in Fig.15 [7].

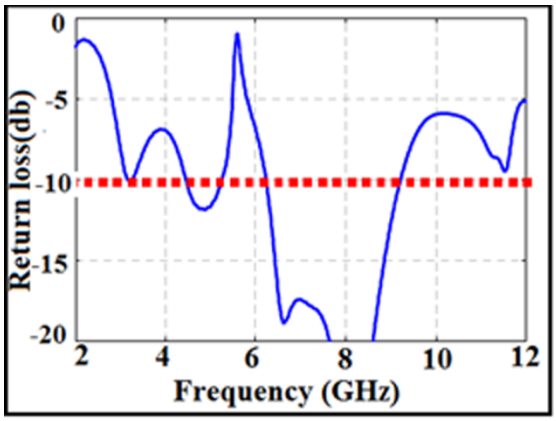

Fig 15: Simulated return loss of directional wide slot antenna geometry with C-strip in front of the fork shaped tuning stub.[7]

4. CONCLUSION AND SCOPE OF FUTURE WORK

This paper briefly reviews, slot cut ultra wide band (UWB) antenna. It summarizes various benefits of using UWB such as bandwidth enhancement, reduced radar cross section, band rejection. The exact formulation of resonant length that is needed for planar monopole antenna at its fundamental and higher order modes and analysis of UWB response in terms of operating modes of slot cut and fractal geometries which has not been reported in the papers reviewed will be explored in future research work.

5. REFERENCES

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