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# Design of a Printed Circular-Slot Antenna for UWB Application

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*Abstract*— **In this paper, design presents a study of a novel printed circular-slot antenna for ultra wide-band (UWB) applications is presented and investigated. Experimental result shows the proposed antenna meets the requirement of UWB bandwidth of 3.1-10.6 GHz with VSWR < 2. Radiation pattern like monopole observed in both H-Plane and E-Plane. The proposed antenna has a good radiation characteristics, ultra-wide bandwidth, compact size and good time domain characteristics to satisfy the requirement of the present wireless communication systems.**

*Index Terms* — **Circular - Slot UWB antenna, time domain, transfer function.**

## INTRODUCTION

With the definition and acceptance of the ultra wide-band (UWB) impulse radio technology in the USA [1], there has been considerable research effort put into UWB radio technology worldwide. However, the non digital part of a UWB system, i.e., transmitting/receiving antennas, remains a particularly challenging topic. The UWB communication systems has more importance because of its many advantages like the low-spectral-density radiated power and potential for achieving high data rates. For the development of UWB technology, many UWB antennas have been designed and studied. Among them, the printed slot antennas have become the best choice for UWB applications because of their attractive merits, like the ultra-wideband characteristics, near omni-directional radiation patterns, simple structure, and low cost. Various printed slot antennas with different slot shapes and feeding structures have been presented for UWB applications [1]–[3].

It is well known that the UWB technology for commercial applications will mainly be applied in low-power, high-data-rate, and short-range wireless communications. The small size of the UWB antenna is needed, so that most of the research has been dedicated to the miniaturization of UWB antennas till now [4]–[7]. The structure of self-complementary is used in [4] and [5]. A compact UWB antenna with tapered radiating slot with a G-shaped quasi-self-complementary structure is presented in [4]; the antenna dimension is 19 ×16 mm in physical size. In [5], the dimension of 16× 25 mm is obtained. The half-cutting method has been used in UWB antenna designs [6], [7]. A monopole antenna is miniaturized in [6], but the volume is still too large.

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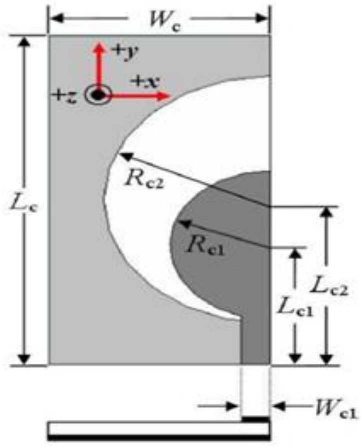


Fig.1. Geometry of proposed Circular – slot UWB antenna

In this paper, the design of a Circular-Slot antenna based on UWB antenna is studied and investigated. It is found that the lower frequency of the operation band decreases when the antenna is half cut, so that a smaller size of the antenna is obtained. Study of the radiation pattern, VSWR, time domain characteristics and transfer function indicate the wideband operation characteristics of the antenna, even with the small in size.

## ANTENNA DESIGN

The proposed Circular-slot antenna is illustrated in Fig. 1. It is seen that the proposed antenna is fabricated on a substrate with the relative dielectric constant of $\varepsilon_r$ =4.4 and thickness of h= 1.4 mm with width and length of $W_c$ and $L_c$. The radiation element is a half-circular disc that is fed by micro-strip line. The half-circular disc has a radius of $R_{c1}$. Width of the micro-strip feed-line is fixed at $W_{c1}$ in order to achieve 50 Ω characteristic impedance. The ground has a same size as the substrate, and the inner profile of the ground is a half-circular cut with radius of $R_2$. Dimensions of the proposed antenna are shown in Table I.

Table I
Dimension of the proposed Circular-Slot Antenna

| Parameter | $W_c$ | $L_c$ | $W_{c1}$ | $L_{c1}$ | $L_{c2}$ | $R_{c1}$ | $R_{c2}$ |
|---|---|---|---|---|---|---|---|
| Value | 10 | 20 | 1.3 | 7.25 | 10 | 4.5 | 7.5 |

The simulations will perform using the IE3D software or HFSS software.

*IE3D*- Mentor's full wave 3D electromagnetic analysis functionality addresses the needs of the industry's most advanced designer of high performance electronic products. The integral equations are formulated with a full dyadic Green's function and the matrix elements are computed completely numerical in the spatial domain. IE3D can model truly arbitrary 3D metal structures; since 2006 also finite 3D dielectric volumes can be modeled with a volume integral equations (VIE) approach.

IE3D SSD is ideally suited for the design of monolithic microwave integrated circuits (MMICs), radio – frequency integrated circuits (RFICs), high–temperature superconducting (HTS) circuits, radio-frequency identification (RFID) antennas, patch antennas, slot antennas, wire antennas, and most other RF and wireless antennas.

*HFSS*- HFSS software is the industry-standard simulation tool for 3D full wave electromagnetic field simulation and is essential for the design of high frequency and high speed component design. This software automatically divides the geometric model into a large number of tetrahedron, where a single tetrahedron is a four sided pyramid. This collection of tetrahedron is referred to as the finite element mesh. Each element can contain a different material.

Therefore, the interface between two different materials must coincide with element boundaries. The value of a vector field quantity (such as the H- field or E – field) at points inside each tetrahedron is interpolated from the vertices of the tetrahedron. The field inside each tetrahedron is interpolated from these nodal values. By representing field quantities in this way, the system can transform Maxwell's equation into matrix equations that are solved using traditional numerical method.

With HFSS, engineers can extract scattering matrix parameters ( S, Y, Z parameters), visualize 3D electromagnetic fields (near and far field) . Each HFSS solver is based on a powerful, automated solution process where you are only required to specify geometry, material properties and the desired output. From there HFSS will automatically generate an appropriate, efficient and accurate mesh for solving the problem using the problem using the selected solution technology.

## SIMULATION BY USING HFSS

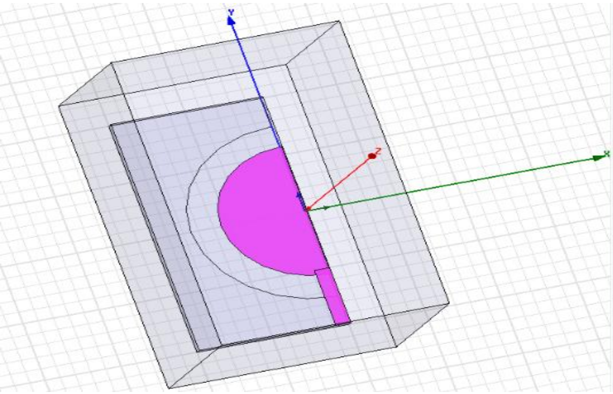

Fig. 2. Designed geometry for Circular – slot antenna

The prototype of UWB Circular-Slot antenna is constructed and simulated. The designed geometry of antenna is shown in Fig.2. by the help of HFSS. The measurement is achieved by using HFSS Software. Figure shows the simulated results. It is clearly seen that simulated results are suitable for 3.1-10.6 GHz UWB applications. The simulated return loss, VSWR and Gain plotted in Fig. 3, 4 and 5 respectively. The simulated radiation patterns at different frequencies plotted in Fig 6(a) and 6(b). It can be seen that the radiation patterns are approximately omni-directional over the entire operation frequencies. The radiation pattern at 4 GHz is similar to a monopole antenna, while it is a little varied at 7 and 10 GHz. The radiation patterns are stable over the operation band, which indicate that the antenna is suitable for the UWB application.

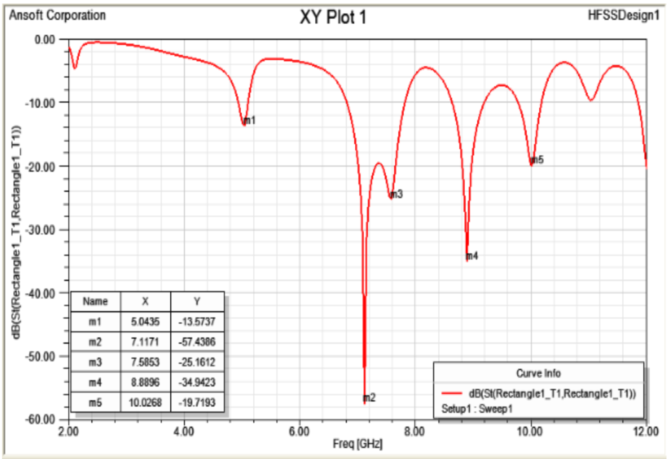


Fig.3. Return Loss at different frequencies

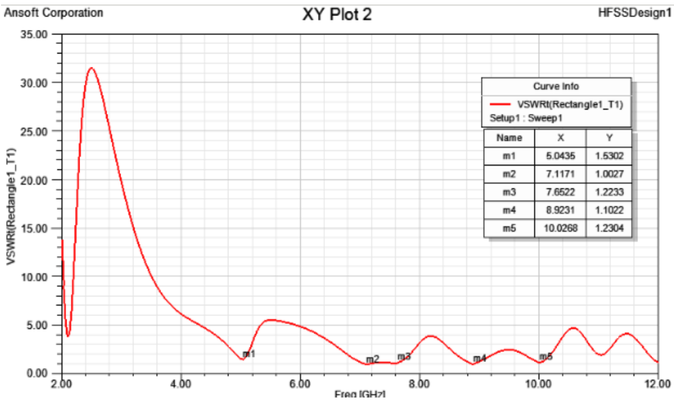


Fig.4. VSWR at different frequencies

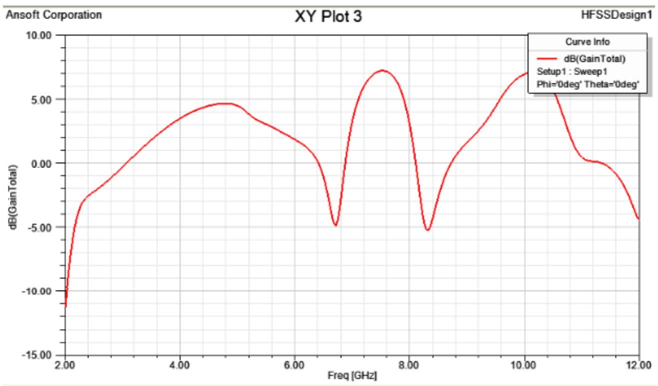


Fig.5. Gain

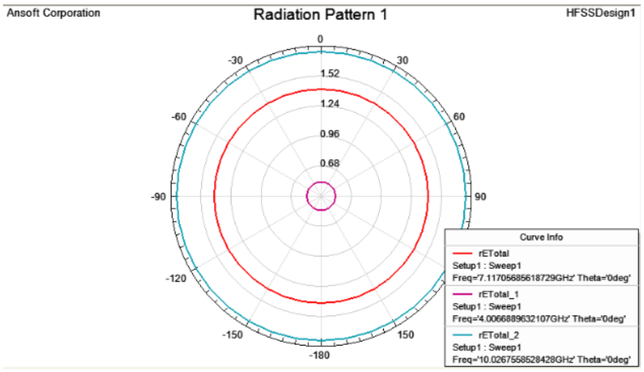


Fig.6(a). Radiation Pattern

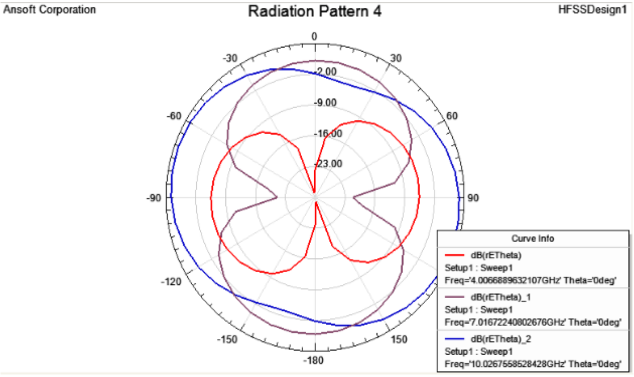


Fig.6(b). Radiation Pattern

## CONCLUSION

A novel miniaturized UWB circular slot antenna is realized from 40 × 40 to 10 × 20 $mm^2$ in this paper. The study of return loss and radiation patterns shows that the antenna has an ultra-wide operation band and monopole like radiation patterns. The result shows the proposed antenna has a good time domain characteristics for UWB signal transmitting and receiving, which correspond well with the VSWR.

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