Printed Circular Monopole Antenna for UWB Applications

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ABSTRACT
Antenna is very essential component in wireless communication system. Since need of compact devices is increasing day by day, antenna plays very important role in developments of such devices. Printed antennas are known as microstrip antennas which are low profile & having more advantages over the conventional antennas. Though this antenna provides compactness but they have narrow bandwidth. Hence these antennas can be used for high frequencies by using feeding techniques. There is a growing demand for small and low cost UWB antennas that can provide satisfactory performances in both frequency domain and time domain.[15],[16] Printed monopole antennas have large attention among all the printed antennas. This paper consists of mathematical analysis & partial implementation of circular monopole antenna which is basically microstrip antenna with partial ground plane & rectangular microstrip feed line. The simulation is done by using IE3D for Ultra Wide Band applications.

Keywords
Printed Antenna or Microstrip Antenna (MSA), Printed Monopole Antenna, UWB.

1. INTRODUCTION
A band of 3.1GHz to 10.6 GHz is covered by the Ultra Wide Bane which is allotted by Federal Communication Commission (FCC). Demand of UWB antennas is increasing since there is rapid growth in the Ultra Wide Band communication. Ultra wide band systems have some fundamental differences from conventional narrow band systems as it has larger bandwidth which offers specific advantages with respect to signal robustness, information content and/or implementation simplicity.[1]

An antenna is a very essential element in UWB system because it acts as a band pass filters to reshape the pulse spectra. So antennas should be carefully designed to avoid unnecessary distortions. Designing of an antenna is one of the most important challenges for the designers.

Printed antenna has features like low profile, small size, low weight and hence exploited for the compact applications such as mobile phones, other personal communication devices which becoming smaller and low weight day by day. The telemetry and communications antennas on missiles need to be thin and conformal and are often MSAs. Radar altimeters use small arrays of microstrip radiators. Other aircraft-related applications include antennas for telephone and satellite communications. Microstrip arrays have been used for satellite imaging systems. Patch antennas have been used on communication links between ships or buoys and satellites. Smart weapon systems use MSAs because of their thin profile. Pagers, the global system for mobile communication (GSM), and the global positioning system (GPS) are major users of MSAs[11].

Printed Monopole antenna offers large bandwidth & hence they have large attention among the all type of Printed Antennas recently. Microstrip antenna consists of radiating patch printed on grounded low loss substrate.[15] The printed antenna can be of various shapes but rectangular and circular shapes are mostly used. .Several UWB printed monopole antennas with various shapes have been used in simple and hybrid forms. These antennas feature controllable bandwidth, good radiation properties, low profile and simple structure.[2]

There is great demand for UWB antennas that offer miniaturized planar structure, so the vertical disc monopole is still not suitable for integration with a PCB. This drawback limits its practical application. For this reason, a printed structure of the UWB disc monopole is well desired, which consist on printed radiator disc on substrate. Printed CDM antennas can be fed simple microstrip line, coplanar waveguide (CPW), or slotted structures.[8]

In this paper design of circular monopole antenna is implemented for UWB applications, which consists of ground plane which is etched one & simple rectangular microstrip feed line is used. All the simulations & results are obtained by using IE3D software.

2. GEOMETRY

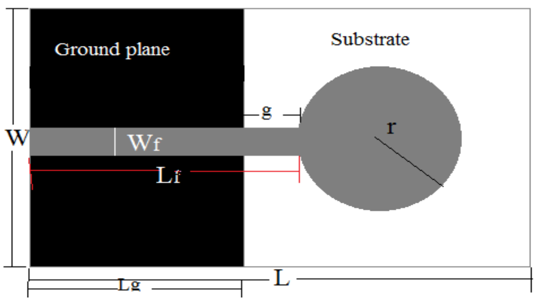


Fig1: Geometry of Printed Circular Monopole Antenna

A circular disc monopole antenna is a planner structure. It consists of a circular patch having radius ‘r’ and rectangular microstrip feed line both are printed on dielectric substrate. All the parameters are as follow In figure 1,

L & W denotes the length and width of substrate.

Wf= width of the microstrip feed line .

Lf =length of microstrip feed line.

Lg&Wg are the length and width of the partial conducting ground plane respectively.

g = gap between circular disk and ground plane.

εr = the dielectric constant for the substrate.

h = the height or thickness of the substrate

3. DESIGNS OFDIFFERENT CIRC-ULAR MONOPOLE ANTENNA FOR UWB APPLICATIONS

By introducing simple microstrip transitions between the 50***Ω*** feed line and the printed circular discs, the impedance BW of the planar monopole can be extended beyond 30 GHz. Design C is basic circular monopole antenna having 50***Ω***microstrip feed line. Design A & Design B are formed by just introducing dual & single microstrip line transitions respectively [1].

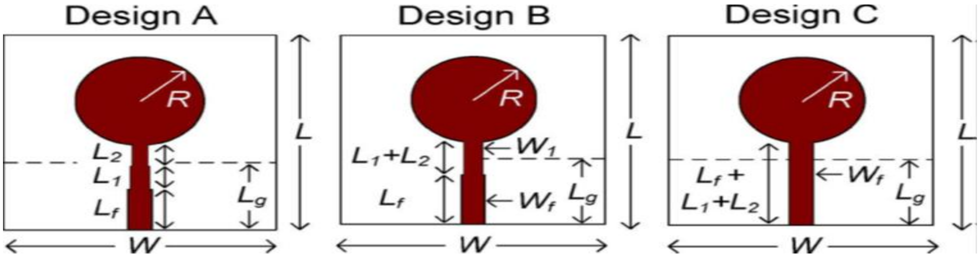


Fig 2:Different 3 designs of circular monopole antennas [1]

4. MATHEMATICAL ANALYSIS OF DESIGN- A

4.1. Center Frequency:

It can be given by,

$$F_C = \frac{F_h + F_l}{2} = \frac{10.6 + 3.1}{2} = 6.85GHz$$

4.2 Dielectric Constant (ε_r) and (ε_e):

For the antenna to be design have FR4 substrate & for this substrate "r=4.4Also thickness of substrate used is h=o.83

Effective Dielectric Constant is given by,

$$\epsilon_e = \frac{\epsilon_r + 1}{2} * (1 + 0.3h) = 2.75$$

4.3 Effective Radius(a_e) and Radius (a):

$$a_e = \frac{8.791}{F_c\sqrt{\epsilon_e}} = 0.78cm = 7.8mm$$

$$a_e = a + h$$

$$a = a_e - h = 0.7cm = 7mm$$

4.4 Width of Ground Plane(W_g):

$$W_g = \frac{1.38 * c}{F_c * \sqrt{\epsilon_e}} = 0.036m = 36cm$$

4.5 Length of Ground Plane(L_g)

$$L_g = \frac{0.36 * c}{F_c * \sqrt{\epsilon_e}} = 0.0095m = 9.5mm$$

4.6 Width of Feed Line(W_f):

$$\lambda_g = \frac{c}{F_c * \sqrt{\epsilon_r}} = 0.02cm = 2mm$$

$$W_f = \frac{\lambda_g}{2} = 1mm$$

$$let\ W_f = 1.8mm$$

4.7 Length of Feed Line(L_f)

$$L_f \gg W_f = 7mm$$

4.8. Width of First Feed Line(W_1) and Width of Second Feed Line(W_2):

$$W_f = W_1 + W_2 (approximately)$$

$$W_1 > W_2$$

$$let\ W_2 = 0.8mm\ , then\ W_1 = 1mm$$

4.9 Lenght of First Feed Line(L1) and Length of Second Feed Line(L2):

$$L_f = L_1 + L_2 (approximately)$$

$$L_1 < L_2$$

$$let\ L_2 = 4mm\ , then\ L_1 = 3mm$$

5. SIMULATIONS AND RESULTS

All the parameters are summarized in following table. By using IE3D simulator all the 3 designs are made & simulated. As all the designs have FR4 substrate & partial ground plane. The thickness of metal is 0.002. The following graphs show the simulated results for design A.

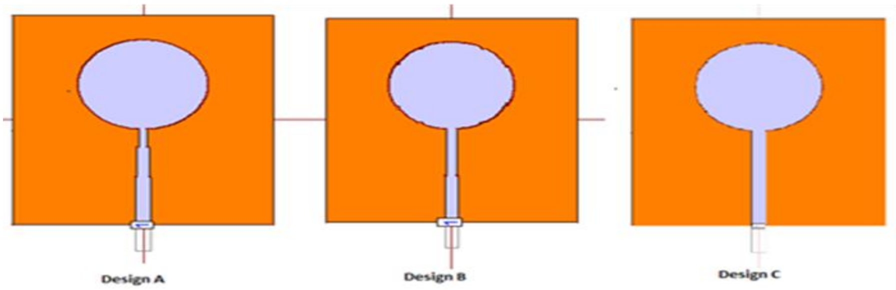


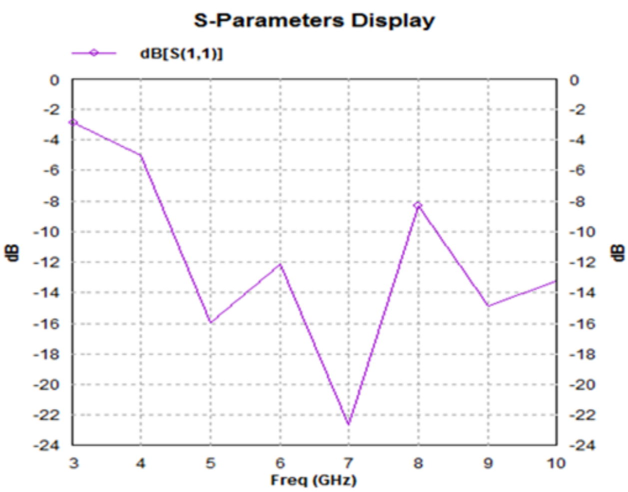
Fig 3: 3 Designs by using IE3D simulator

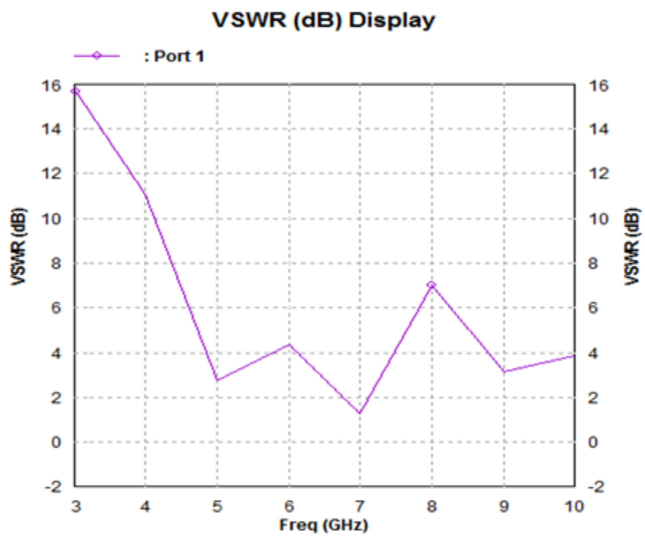
Table 1: Summary of Analysis

Parameter	Designed Value (in mm)	Selected Value (in mm)
Width of substrate(W)	30	30
Length of substrate(L)	35	35
Width of feed line (WF)	1	1.8
Length of feed line(LF)	8	8
Width of first microstrip feed line(W1)	1	1.4
Length of first microstrip line(L1)	4	5
Width of second microstrip feed line(W2)	0.8	1
Length of second microstrip feed line(L2)	3	3
Width of partial ground plane(Wg)	36	30
length of partial ground plane (Lg)	9.5	15.7
Radius of Printed Disk (a)	7	7.5
Substrate thickness (h)	0.83	0.83

S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. In practice, the most commonly quoted parameter in regards to antennas is S11. S11 represents how much power is reflected from the antenna, and hence is known as the reflection coefficient (sometimes written as gamma: or return loss. If S11=0 dB,then all the power is reflected from the antenna and nothing is radiated. accepted power is either radiated or absorbed as losses within the antenna. Since antennas are typically designed to be low loss, ideally the majority of the power delivered to the antenna is radiated.

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function 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. In this case, no power is reflected from the antenna, which is ideal.

The S-parameter results are shown in above figure (4) which shows that S11 parameters are below -10 dBs for 4.5 GHz to 7.9GHz & 8.2GHz to 10.6GHz frequency bands. Also VSWR graph gives has value near to 2dB for same frequency bands, but not for the complete UWB band. It was observed that results of S-parameter for Design B & C are poor than that of design-A

6. CONCLUSION

As this paper is based on partial implementation all the designs having results but not for the complete band. By using optimization process results can be improved for complete UWB frequencies. While doing optimization width & lengths of single & dual lines will get varied since those are introduced to provide large bandwidth. The dimensions of 50 Ω feed line will be kept constant.

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