Edge Port Excitation Analysis for Semi-Elliptic Monopole UWB Antenna

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ABSTRACT
Excitation methods used in patch antennas have been discussed in this paper. A semi-ellipticmonopole UWBantenna excited using edge port is the focus of this paper. Antennas operating in the UWB range must function in the presence of existingnarrow band communication systems like WiMAX, C-band, WLAN,X-band etc. Thus, appropriate excitation method must be employed to ensure accurate antenna operation. Two methods ofproviding excitation to the antenna namely - inset feed andoutside edge feed excitation have been parametrically analyzedto obtain optimum results. Both methods have utility in providing excitation to an antenna, but do not establish a basis for comparison on similar aspects as they are application dependent.In the inset fed antenna good radiation pattern and return loss was observed while the gain was not consistent for the entire UWB range. The outside edge fed antenna shows a slight improvement in gain.

General Terms
Wireless Communication, Feeding techniques

Keywords
Semi-Elliptic patch antenna, Monopole antenna, Ultra-Wideband, Edge port excitation, Inset feed, MOM

1. INTRODUCTION
Wireless communication refers to the art of transmitting and receiving voice and data signals using electromagnetic waves in open space.The transmission of large amounts of digital data over a wide spectrum of frequency bandwidth employing very low power,which is mainly preferred for short distance applications is referred to as Ultra-Wideband (UWB)communication. This technology has garnered muchattention in research and development since the U.S.Federal Communications Commission (FCC) approved unlicensed use of frequency band 3.1GHz to 10.6GHz forcommercial communications purpose in 2002 [1].

With theavailable wide bandwidth, efficient and hassle free servicebecomes the imperative of every user. Unlike traditional narrowband communication, UWBsystems communicate by generating radio energy atspecific instants in the form of impulses thereby, supporting high data rates with low powerconsumption that is fitting for short-range indoorcommunications. Additionally, a UWB antennamust provide strong signal presence amidst othernarrowband communication systems available in the range3.1GHz to 10.6GHz. Some of the probable interferingbands identifiedin literature are WiMAX (3.3-3.8GHz), WLAN (5.15-5.85GHz), and X-band satellite communication links (7.9-8.4GHz) [2-4].

In the past, varied shapes of microstrip patch antennas like the annular ring, ellipse and circular [5-7] have been designed and simulated. Analysis of a semi-elliptic monopole antenna with edge fedtechnique has been carried out in this paper. The semi-elliptic antenna is relatively compact in size and is also easier to design [3] than the other shapes that were studied. It is understoodfrom literature [8-9] that positioning of the excitation portplays a major role in the performance of the antenna. Thusa parametric analysis of various positions of the feed portinside and outside the antenna was carried out using EMSS's FEKO (5.5) and results analyzed to find the best position of the feed to match the UWB antenna characteristics. Satisfactory performance was observed.

2. ANTENNA CONFIGURATION

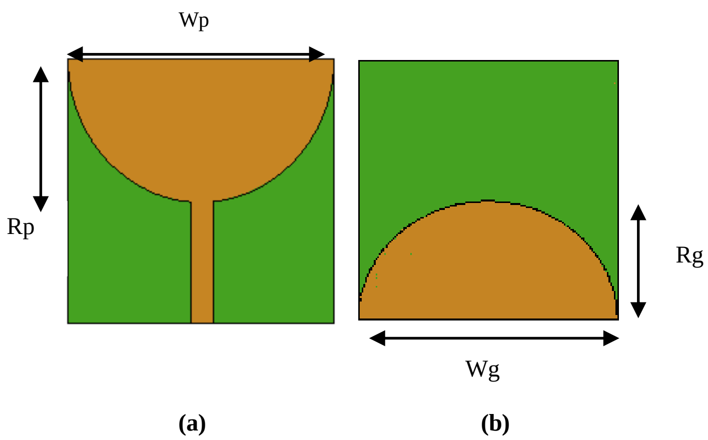


Figure 1: (a) Top view (b) Bottom view of the reference antenna

The semi-elliptic monopole antenna shown in Figure1 is the reference antenna adopted from [3] on which parametric study is performed for proper positioning of the feed port. It is constructed on a 1.6mm thick FR4 substrate withdielectric constant 4.4 and loss tangent 0.02. The semi-elliptic monopole disc in front and behind thesubstrate acts as the radiating patch and the ground plane ofthe antenna respectively. Table 1 shows the dimensions of the antenna. The semi-elliptic top patch major axis radius(Rp) = 19mm and minoraxis diameter (Wp)= 35mm which is placed symmetrically abovethe bottom semi-elliptic ground plane with major axis radius (Rg) =16mm and minor axisdiameter (Wg) = 35mm respectively.Authors in [10] observe that a truncatedground plane design which extends only over the feed lineportion is useful in confining currents between the edges of the patch and the ground plane.

Table1: Dimensions of the semi elliptic monopole antenna

Parameters	Dimensions (mm)
Wp	35
Rp	19
Wg	35
Rg	16

Effective dielectric constantϵ_{reff} is given as [11]

$$\varepsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2\sqrt{1+\frac{12h}{w_f}}} \qquad (1)$$

where, ε_r is the dielectric constant of the substrate, h is the thickness of the substrate and w_f is the width of the feed line.

The fundamental center frequency *fo* corresponding to the desired UWB antenna performance is given by [11]

$$f_o = \frac{c}{\lambda_g\sqrt{\varepsilon_{reff}}} (2)$$

where, c is the speed of light in free space, λgis the guided wavelength andϵ_{reff} is the effective dielectric constant.

From formulas (1) and (2) the width of the feed line is calculated to be 3mm.

The antenna simulation is carried out in FEKO which is a numerical analysis platform based on theMethod of Moments (MOM) integral formulation ofMaxwell's equations that also supports Finite ElementMethod (FEM) and some other hybrid techniques as well. The two main categories of comparison are theinset fed and the outside fed edge port excitations.

3. RESULTS AND DISCUSSION

In this section, results obtained for the two different methods of feeding an antenna with edge port are discussed.

3.1 Inset Fed Monopole Antenna

A semi elliptic monopole antenna with an inset feed is commonly used in array antenna designs. Parametric study of the reference antenna with various inset lengths has been performed using method of moments. To place the edge port inside the antenna some portion of the substrate is etched out to provide perfect isolation between the conducting and dielectric surfaces as depicted in Figure 2 and Figure 3. The width of the substrate etched out is varied and result is optimized.

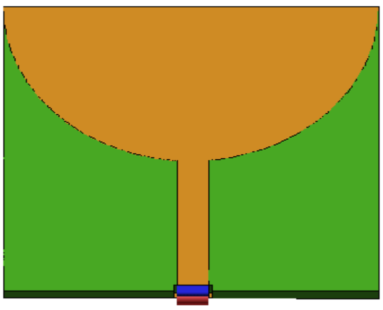


Figure 2: Inset feed port geometry of the antenna

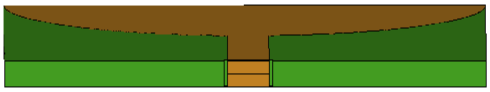


Figure 3: Front view of the substrate etched antenna

Different widths of substrate have been removed varying from 0.1mm to 1mm. Gain and return loss parameters were found to be optimum for width of 0.7mm.

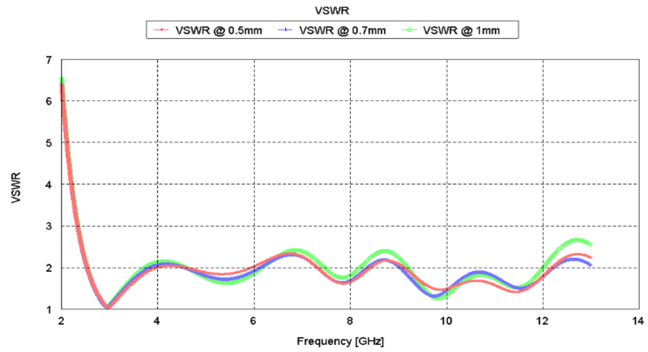


Figure 4: Comparison of VSWR obtained for different widths

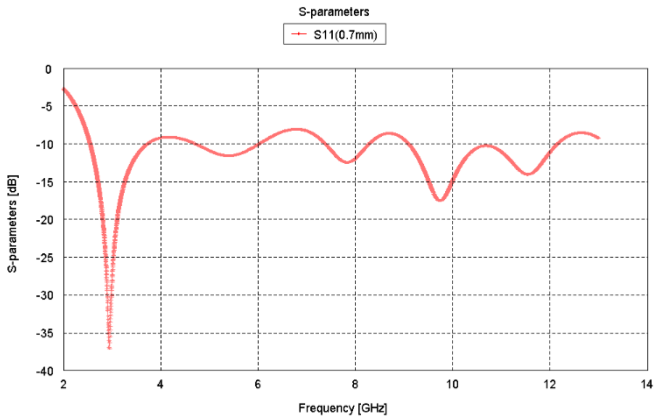


Figure 5: Return loss obtained for 0.7mm

VSWR comparison shown in Figure 4 shows that 0.7mm provides an overall VSWR <2 for the entire UWB range. The reflection coefficient plot in Figure 5shows that theantenna radiates throughout the UWB rangei.e. 3.1GHz to10.6GHz for the width 0.7mm asreturn loss is obtained below -10dB for the entire band of frequencies.

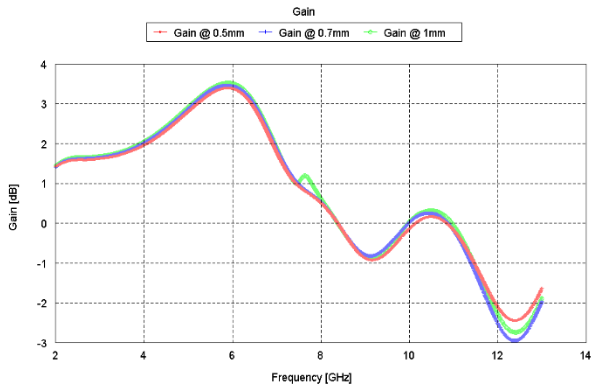
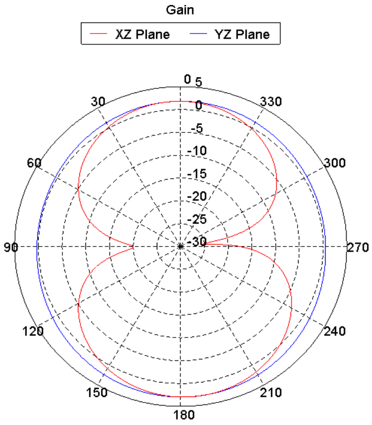
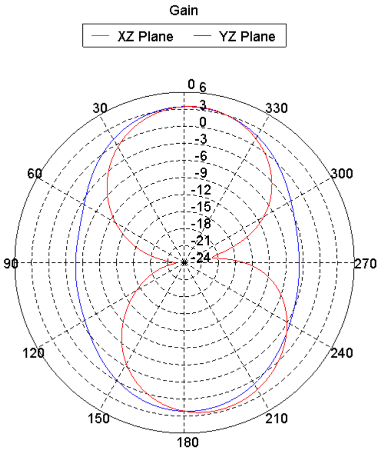


Figure 6: Gain comparison of the antenna

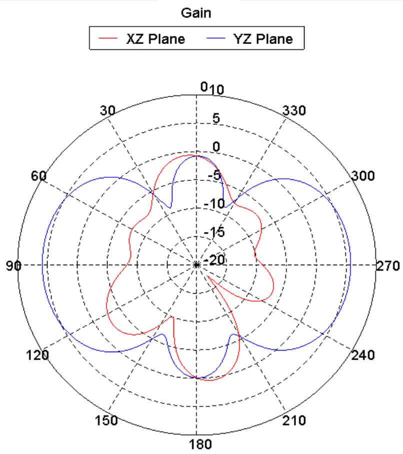
Gain of theantenna in Figure 6 is maximum at 5.8GHz at 3.5dB for the width of 0.7mm depicted by blue line.



(a)



(b)



(c)

Figure 7: Cross and Co-polarized radiation pattern of the antenna at different frequencies (a) 3.5GHz (b) 6GHz (c) 9GHz

2-D radiation patterns for different frequencies are shown in Figure 7. Almost omni-directional pattern is observed in the YZ plane and a dumbbell shaped structure is obtained in the XZ plane.

3.2 Outside Fed Monopole Antenna

The edge port was given outside the model of the monopole antenna at various distances from the antenna feed as shown in Figure 8.

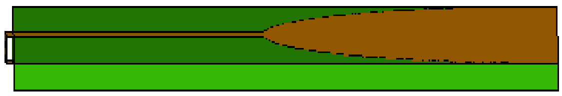


Figure 8: Edge port outside the surface of the antenna

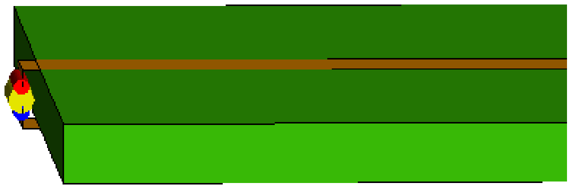


Figure 9: Excitation port

Figure 9. depicts the excitation port given to the feed line at a distance of 0.5mm from the antenna base. The port given outside the model has various advantages over the inset feed mainly in reducing the effect of fringing fields over the patch. In this case, optimum result was obtained at a distance of 0.5mm from the feed line.

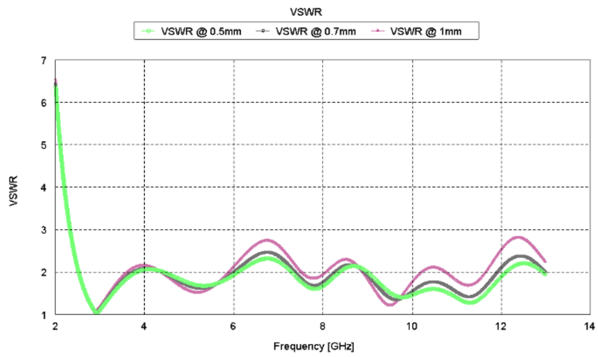


Figure 10: VSWR for varying distance

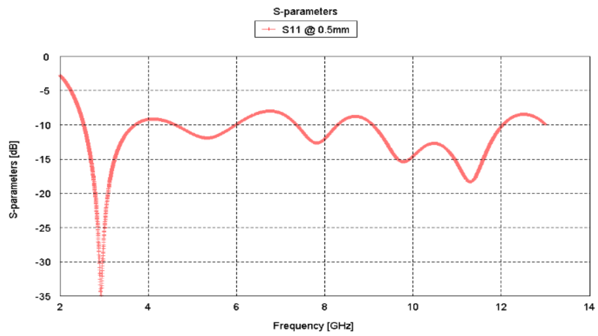


Figure 11: Return loss for 0.5mm

Figure 10 and Figure 11 show the VSWR and reflection coefficient of the outside fed antenna. Figure 10 shows a comparison of the VSWR values for the edge port given at varying distance from the antenna. The green curve depicting a distance of 0.5mm provides a value of VSWR<2 throughout the UWBrange.

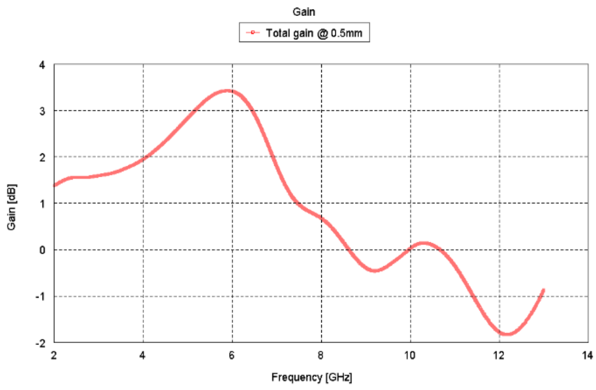
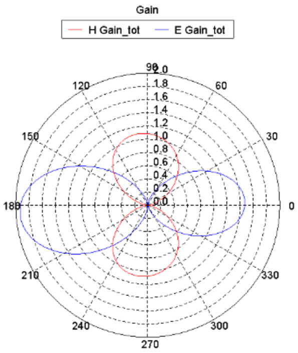
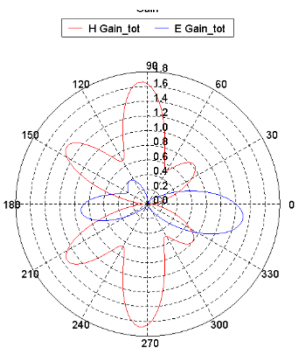


Figure 12: Gain for 0.5mm

Figure 12 shows the gain obtained at a distance of 0.5mm. The higher frequency ranges depict lower gain values. The maximum gain obtained is 3.4dB at 5.9GHz.



(a)



(b)

Figure 13: Cross and Co-polarized radiation pattern at different frequencies (a) 3.5GHz (b) 7.8GHz

From the radiation patterns shown in Figure 13 it is observed that the antenna is able to radiate in almost all directions for the lower frequencies but experiences losses in the higher frequencies.

4. CONCLUSION AND FUTURE SCOPE

A semi-elliptic monopole UWB antenna using edge port excitation was investigatedin FEKO. The excitationmethod of the antenna was varied from an inset feed to anoutside edge fed monopole antenna. The results obtainedshow that the inset fed antenna has optimum performancewhen a width of 0.7mm was etched out of the substrate. Thefar field radiation pattern observed for the inset fed antenna supported the conclusion thus, proving to be aneffective UWB antenna with omni-directional radiation inthe desired range of frequencies. The main drawback of thismethod is that the gain of the antenna was inconsistent forthe UWB range. Another method of providing excitation to the antenna was the outside fed antenna in which the port is placed at a particular distance away from the antenna. After performing analysis the optimum distance was found to be 0.5mm for the semi-elliptic antenna. Thus,from the results it is concluded that the antenna can radiate well in the UWB range and can now be taken ahead for filtering of the undesired bands.

Future scope of the work lies in performing band filtering of the interfering bands within the UWB range. The results drawn from the current analysis will form the base for the future work.

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