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Research Article

Printed Modified Circular Disc UWB Monopole Antenna

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Abstract

This paper presents a modified circular disk monopole antenna which work for the entire UWB bandwidth from 3.34 GHz to 14.11 GHz. Here circular disk monopole antenna performance is improved by cutting a rectangular and cylindrical slot from the circular disk patch. This proposed antenna is fed by 50 ohm rectangular microstrip line. The proposed antenna is resonating at 5.59 GHz in the WiMax band. Further this antenna has compact size of 40mmx30mm. The value of VSWR is <2 for the entire UWB range. The proposed antenna is simulated on HFSS V11.1 software.

Keywords: *UWB, Monopole antenna*

1. Introduction

In this age of communication large bandwidth and high data rate are important parameter for an antenna. To meet these specification the ultra wide band (UWB) communication systems have receivedgreat attention from industrial sectors as well as form the academics and for indoor and hand-held wireless communication (Ali Foudazi, Hamid Reza Hassan iandSajad Mohammad alinezhad,2012).UWB communications system or signal has either large relative bandwidth or a larger absolute bandwidth(RamuPillalamarri, JyotiRanjan Panda and Rakhesh Singh Kshetrimayum,2009).

UWB is a revolutionary approach for short-range high-bandwidth wireless communication. This technology differs from traditional narrow band radio systems (bandwidth usually less than 10% of the center frequency) which transmitsignals by modulating the amplitude, frequency or phase of the sinusoidal waveforms.UWB systems is a form of transmission that occupies a very wide bandwidth. Typically the bandwidth will be many Giga hertz, enables it to carry data rates of Gigabits per second. By generating radio energy at specific time instants in the form of very short pulses causing information to occupy very large bandwidth and enabling time modulation. The transmission of non-successive and very short duration pulses causes very high data rate which may be up to several hundred Megabytes per second, and this high speed data transmission is difficult to track which highly ensures the data security. The power consumption of UWB systems is extremely low in comparison with that of traditional narrowband radio systems due to the same reason mentioned above. Multipath fading is also avoided as the reflected signals do not overlap with the original short duration signals. Because of these attractive features UWB technology finds applications in indoor positioning, radar/medical imaging and target sensor data collection(Eng Gee Lim, Zhao Wang, Chi-Un Lei, Yuanzhe Wang, K.L. Man,2010).

Federal Communications Commission (FCC) has made it necessary that ultra wideband transmissions can legally operate in the range from 3.1 GHz to 10.6 GHz and transmitted power should be limited to -41dBm/ MHz.With this transmissions must occupy a bandwidth of at least 500 MHz, as well as having a bandwidth of at least 20% of the center frequency [FCC, 2002].

Monopole antennas with different patch shaped such as rectangular, circular, elliptical, and triangular are considered suitable for ultra wide band communication systems (Osama Ahmed and Abdel-RazikSebak,2008). In this paper circular patch shaped planer monopole antenna is studied.

The circular disc monopole UWB antenna with all design parameters is shown in figure 1. This circular disk monopole antenna is modified by cutting a rectangular slot and an offset circular slot. This modified circular disk monopole antenna is shown in figure 2. These modifications has improved the results of the proposed antenna.

2. UWB antenna designs

The design parameters of Both Circular Disc UWB Monopole Antenna and Modified Circular Disc UWB Monopole Antenna are shown in table 1.

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The radius of circular patch as shown in fig. 1 is 9.4mm and a slot of dimension 12mmX7.5mm is cut from the circular patch to upper side resulting in slot of dimension of 4.74mmX12mm. A circular slot of radius 0.5mm is also cut from the circular patch. FR4 epoxy with relative permittivity of 4.4 and loss tangent of 0.02 with thickness of 1.53mm is used as a substrate for the proposed antenna. Circular patch is feed by a microstrip line of length L_2 = 20.70 mm and width W_2 = 2.8 mm.

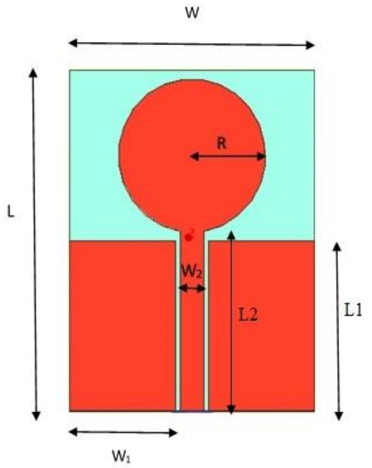


Fig.1 Circular disk monopole antenna

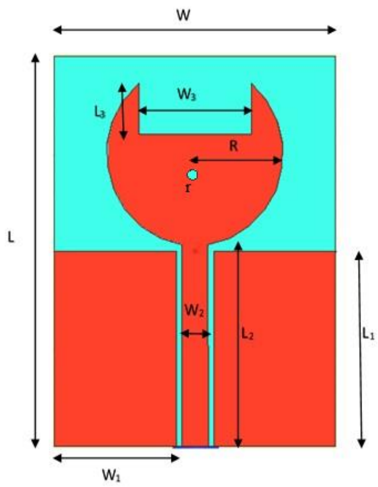


Fig.2 Modified Circular disk UWB monopole antenna

Table 1 Parameters of modified circular disk monopole antenna

Parameter	Dimensions (mm)
L	40
W	30
L_1	20
W_1	13
L_2	20.70
W_2	2.8
L_3	4.74
W_3	12
R	9.4
Substrate height	1.53
Radius of center hole (r)	0.5

3. Simulated results and discussion

This proposed antenna is simulated by Ansoft HFSS V11.1 software and different results are plotted. Different results such as return loss, VSWR, radiation pattern, gain versus frequency curve and impedance are plotted for modified circular disk monopole antenna.These are results are discussed in the following section.

3.1 Return loss and bandwidth

The return loss show that how much energy is reflected back from antenna. So the value of return loss should be minimum and it is measured in dB. Fig. 3 shows a comparison of return loss plots of circular disk monopole antenna and modified circular disk antenna. It is clear from the return loss curve that the modified antenna has increased the return loss value form -30.06 dB to -64.19 dB. The return loss plot of modified antenna is below -15 dB for the entire operating frequency range while circular disk monopole antenna (base antenna) return loss is above -15 dB and approaching towards -10 dB. Table 2 shows the results of comparison of return loss plot of both the antennas, where f_l, $f_h$and $f_r$are lower frequency, higher frequency and central frequency respectively.

The return loss curve for Modified Circular Disc UWB Monopole Antenna (optimized antenna) is shown in fig.4. The modified circular disk monopole antenna has return loss below -10 dB for the entire UWB range. The maximum return loss of -64.1975 dB occurs at resonant frequency of 5.5912 GHz. The proposed antenna has bandwidth of 10.771 GHz from 3.3474 GHz to 14.1184 GHz.

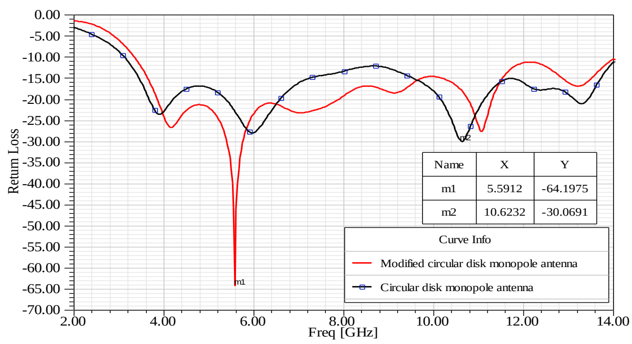


Fig. 3 Comparisons of return loss plot of circular disk and modified circular disk antenna

Table 2 Results of return loss plot of circular disk and modified circular disk antenna

Antenna design	f_l (GHz)	f_h (GHz)	f_r (GHz)	Return loss (dB)	Bandwidth (GHz)
Base antenna	3.1234	14.1432	10.6232	-30.0691	11.0198
Modified circular disk monopole antenna	3.3474	14.1184	5.5912	-64.1975	10.7710

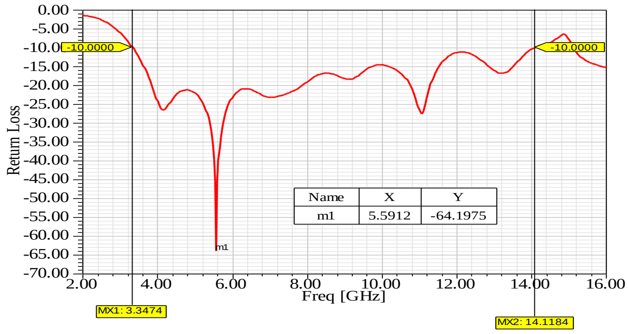


Fig.4 Return loss of Modified Circular Disc UWB Monopole antenna

3.2 VSWR

The VSWR plot of modified circular disk UWB monopole antenna is shown in figure 5.

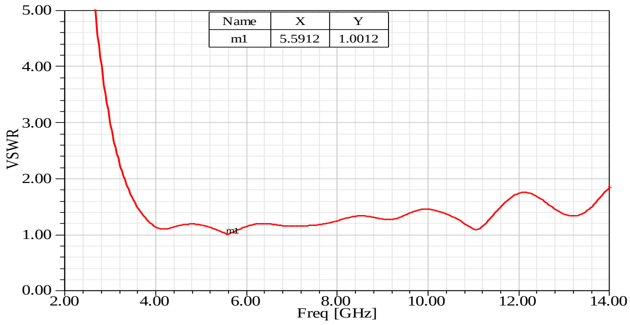


Fig.5 VSWR of Modified Circular Disc UWB Monopole

When a transmitter is connected to an antenna which is fed by any one of the feeding techniques, then the impedance between the antenna and feed must be exactly same or equal for maximum power transfer from feed to antenna. When the matching between the antenna and feed is not achieved, then some of electrical energy is reflected back to transmitter. The reflected wave gets encountered with the forward waves which causes standing wave pattern. The parameter VSWR is a measure that the antenna and feed both are well matched and more electrical energy is delivered to antenna. The value of the VSWR should lie between 1 and 2 for proper impedance matching. Here the value of VSWR is below 2 over the entire UWB range. At resonant frequency of 5.5912 GHz the minimum value of VSWR is 1.0012.

3.3 Antenna impedance

Impedance of the antenna play an important role in radiation of antenna. From maximum power transfer theorem, for maximum power transfer the impedance of the antenna should be matched to feed. In resonance the impedance of the antenna is resistive and the reactive component becomes zero. The real and imaginary part of antenna impedance is depicted in figure 6.14. It is clearly seen from the figure 6.14 that the real part of the antenna impedance is varying around 50 ohm and the imaginary part of the impedance is varying around 0 ohm.

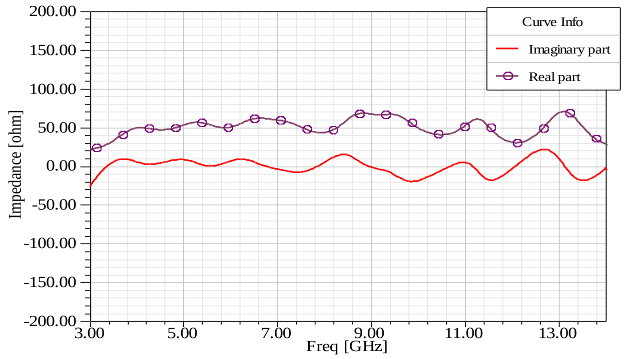


Fig. 6 Antenna impedance

3.4 Gain versus frequency curve

Antenna gain is an important measure that describes the performance of the antenna. In a given direction the gain of an antenna is the ratio of the intensity in a given direction to the radiation intensity obtained when power accepted by antenna is radiated isotropically. Figure 7 shows peak realized gain with respect to frequency. The gain is above 3 dB for the entire range and its value at resonant frequency 5.5912 GHz is 4.3980 dB.

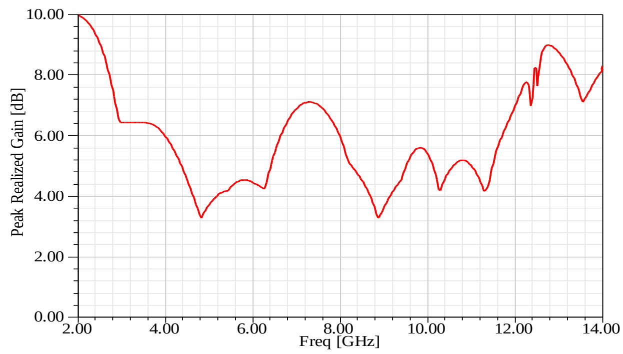


Fig. 7 Gain versus frequency curve

3.5 Polarization Ratio

Polarization ratio of the proposed antenna for LHCP (left hand circular polarization) and RHCP (right hand circular polarization) is shown in figure 8.

Radiation pattern is a graphical representation of antenna field strength transmitted or received by antenna. The E and H plane radiation pattern of the proposed antenna is shown in fig. 9. The E plane radiation pattern is similar to 8 shape at frequency 5.5911 GHz. H plane radiation pattern is almost similar to the omnidirectional radiation pattern.

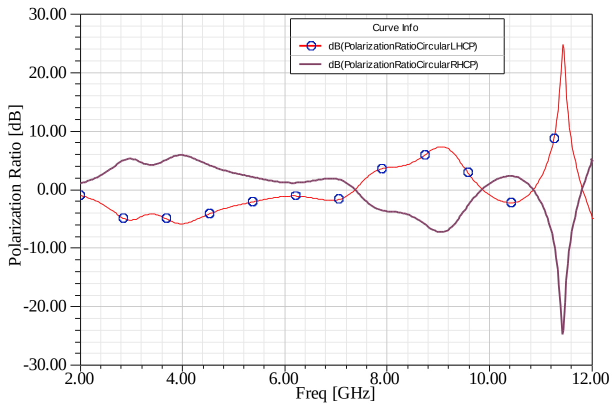
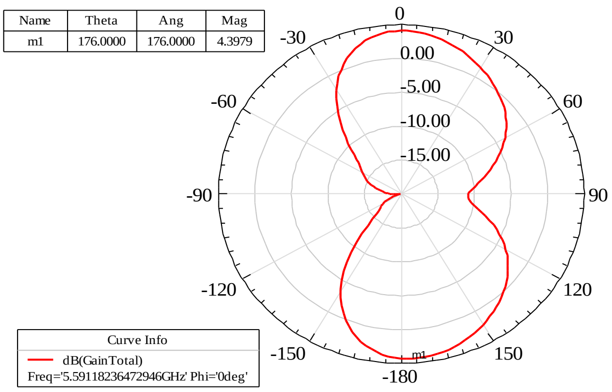
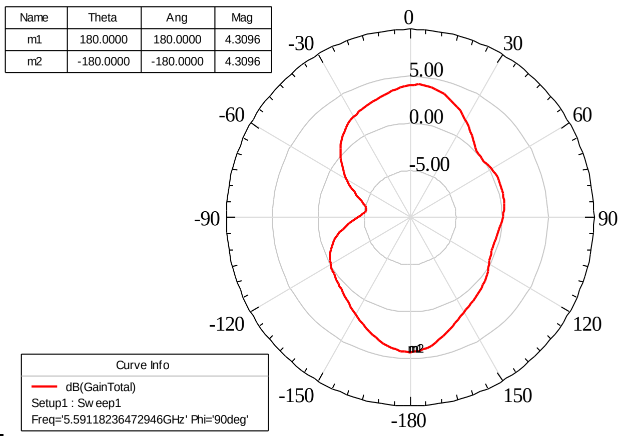


Fig. 8 Polarization ratio



(a)



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(b)

Fig. 9 radiation pattern, (a) E plane (b) H plane at 5.59 GHz

Conclusions

In this paper, a printed monopole UWB antenna is presented, which is modified by cutting a rectangular slot and offset circular slot. The modified printed monopole antenna has improved return loss response form 3.34 GHz to 14.11GHz constituting total bandwidth of10.77 GHz. VSWR response of the proposed antenna is under two for the entire UWB range.The return loss has a dip at 5.59 GHz, which lies in WiMax band.The gain is above 3 dB for the entire range and its value at resonant frequency of 5.5912 GHz is 4.3980 dB.The modified printed circular disk monopole antenna has impedance varying around 50 ohm. The E plane radiation pattern of the proposed antenna is in the form of 8 shape and the H plane radiation pattern is approximately omnidirectional. Simulated results of HFSS software show that the proposed printed modified circular disk monopole antenna is suitable for UWB application.

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