Printed Half - Circular Monopole Antenna for UWB Applications

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Abstract: ***In this paper, a printed half - circular monopole antenna fed by a simple rectangular Microstrip line is investigated. This antenna was designed on Taconic RF-30 (tm) substrate, High-frequency structure simulator (HFSS) that evolved over a period of years with input from many users and industries was used to design, optimize, and simulate this antenna. The structural properties and performance characteristics of this antenna is investigated through numerical simulations. Then the design process, parametric study, optimization as well as simulated results such as return loss, radiation patterns and VSWR are provided. We found that the -10dB return loss bandwidth of the simulated antenna is approximately 7.1GHz (3.2GHz – 10.3GHz). The proposed half - circular patch UWB Monopole antenna is having better performance and good bandwidth than the conventional circular patch UWB monopole antennas.***

Keywords: Half - Circular Monopole Antenna, Radiation Pattern, Return Loss, VSWR, HFSS

1. Introduction

UWB is the most secure means of wireless transmission for transmitting large amount of digital data over a wide spectrum of frequency bands with a very low power for a short distance. UWB characteristics are well suited to short distance applications such as PC peripherals. It has the number of encouraging advantages that are the reason why it presents a more eloquent solution to wireless broadband than other technologies. The bandwidth of UWB exists in 3100MHz-10600MHz frequency range with an allowed power of -41dB. The major step in the development of UWB technology for wireless communication is ANTENNA.

Some UWB antennas are much more complex than other existing single band, dual band and multi-band antennas [1] [2]. In this paper the design of semicircular printed monopole antenna was analyzed by using one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines and packaging called High

Frequency Structure Simulator, (HFSS) software package and it was found to be a good candidate for use in UWB wireless technology because of their wide impedance bandwidth and nearly Omni-directional azimuthal radiation pattern.

2. UWB Spectrum

The regulation for UWB was officially released in 2002 by Federal Communications Commission (FCC) of the United State and it can legally operate in the range 3.1GHz up to 10.6GHz at spectral density of -41.3dBm/MHz throughout the frequency band. According to FCC, We can also define UWB as any system having spectrum that occupies a fractional bandwidth greater than 20% of the center frequency which complements other longer technologies e.g. cellular wide area communications, Wi-Fi, WiMAX. The center frequency of the UWB bandwidth is designated as:

$$f_c = \frac{f_h + f_l}{2} \tag{3.3}$$

The fractional BW is defined as

$$FBW = 2\frac{f_h - f_l}{f_h + f_l} * 100\%$$
$$FBW = \frac{f_h + f_l}{f_c} * 100\% \tag{3.4}$$

The higher operational frequency f_h and lower operational frequency f_l are defined were the power is reduced by -10dB from the frequency with maximum power f_m.

UWB has a number of encouraging advantages that are the reasons why it presents a more eloquent solution to wireless broadband than other technologies. However, UWB has to share the spectrum with several other radio communication systems in the market. The UWB transmitted power is much lower than the other systems which make it appear as noise to the narrowband applications which transmission power is high. The spectrum sharing between UWB and other important narrowband systems is shown in Fig. 1.

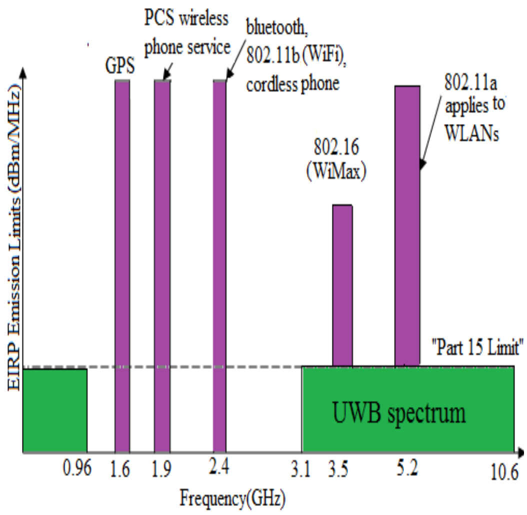

Figure 1: Frequency allocations of UWB and other existing wireless systems

3. Geometry of Half - Circular Printed Monopole Antenna

UWB monopole antenna is designed directly from the circular patch UWB - Monopole antenna with some modifications in the patch shape and the structure of the microstrip - fed printed monopole antenna is printed on Taconic RF-30 (tm) substrate which is very cost effective and ideally suited for UWB technology based low-cost systems [3] [4] with thickness h = 1.6mm, and relative permittivity $\varepsilon_r = 3$ and the width of microstrip line is fixed at 26mm as shown in Fig. 2.The final optimal dimensions of the UWB monopole antenna are:
Dimensions of patch: the radius of monopole antenna R = 13.5mm,
Dimensions of the substrate: W1 = 50mm, L1 = 50mm & thickness h = 1.6mm.
Dimension o the ground: W1 = 50mm, L2 = 20.2mm
Dimensions of Microstrip line: W2 = 3mm, and L3 = 26mm

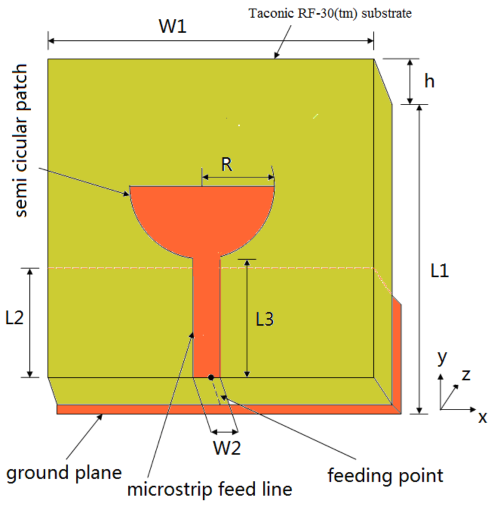

Figure 2: Geometry of Half - Circular Patch Monopole Antenna

4. Simulation Result

The Bandwidth of the proposed antenna is considered for f_L lower start frequency of the antenna BW and f_U higher end frequency of the antenna BW where the amount of power that is loss to the antenna (the return loss, S_{11}) is below -10dB as shown in Fig. 3. It was found that this half - circular patch UWB Monopole antenna is having better performance and good bandwidth than the conventional circular patch UWB monopole antennas. Using a powerful program (HFSS) [5], we found that the simulated plot antenna return loss Vs frequency of the antenna as seen in Fig. 3 works well for UWB frequency band 3.1GHz-10.6GHz except from 6.3GHz to 8.2GHz. It also shows that the the proposed antenna is capable of supporting five resonance modes (f_1 = 3.7GHz, f_2 = 5.7GHz, f_3 = 9GHz, f_4 = 9.3GHz, and f_5 = 9.6GHz distributed across the spectrum, the overlapping of these resonance modes leads to the UWB characteristics. And also we found that the Voltage Standing Wave Ratio (VSWR) is less than 2 as shown in Fig. 4 showing that the operational bandwidth of the antenna is good.

The H-plane radiation pattern located at yz - plane and E-plane radiation pattern located at xz - plane are nearly Omni-directional pattern and dipole shaped respectively as shown in Fig. 5, Fig. 6, and Fig. 7 plotted at different frequencies. The current distribution of half circular monopole antenna is plotted at different frequencies at 3.1GHz, 3.2GHz and 4.5GHz the current is mainly concentrated at the bottom of the half circular patch but it was observed that at high frequency at the bottom of this proposed antenna the current is concentrated more as shown in Fig. 11, Fig. 12 and Fig. 13.

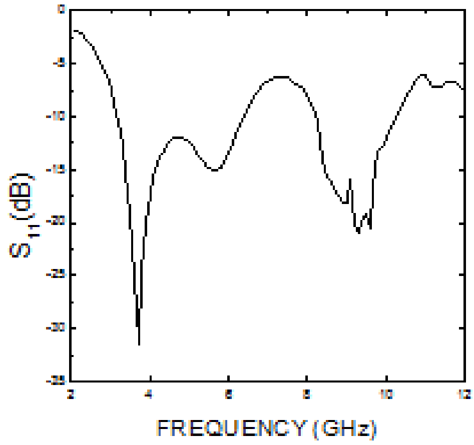

Figure 3: Return loss vs Frequency of Proposed

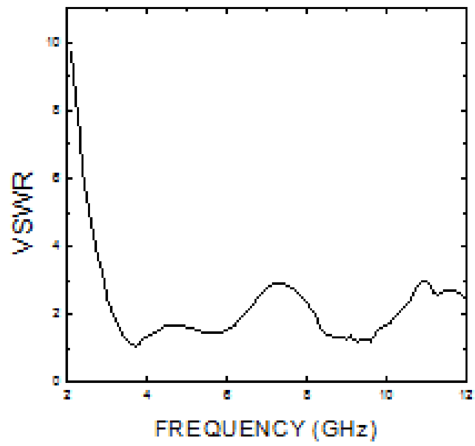

Figure 4: VSWR of Proposed Antenna

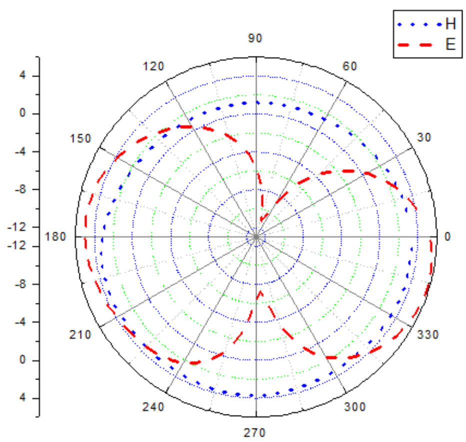

Figure 5: Radiation Pattern at 3.1GHz

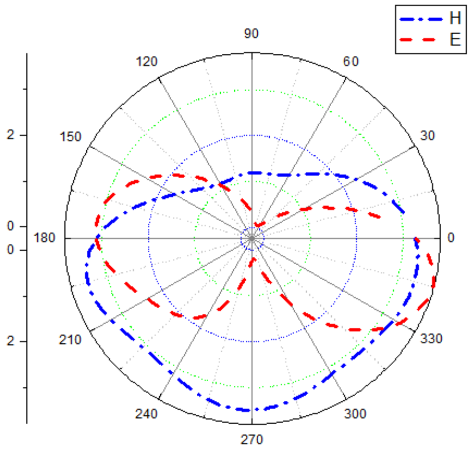

Figure 6: Radiation Pattern at 3.2GHz

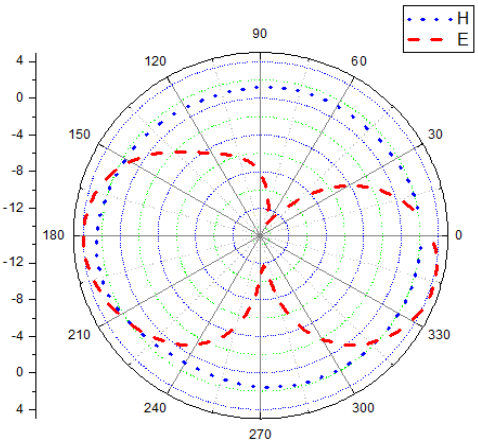

Figure 7: Radiation Pattern at 4.5GHz

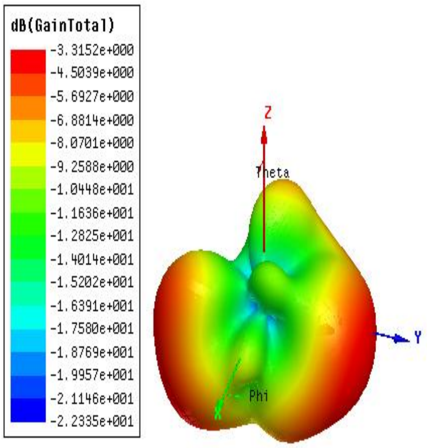

Figure 8: 3D Radiation pattern at 3.1GHz

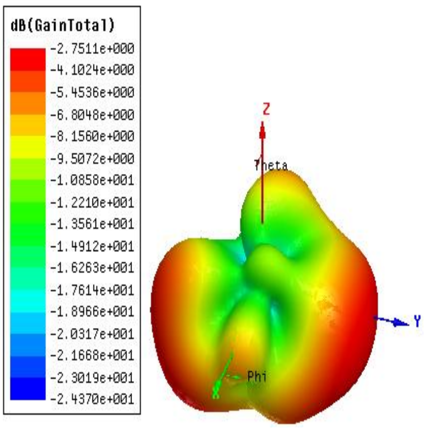

Figure 9: 3D Radiation pattern at 3.2GHz

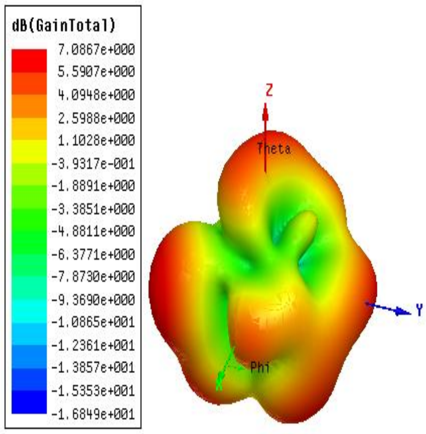

Figure 10: 3D Radiation pattern at 4.5GHz

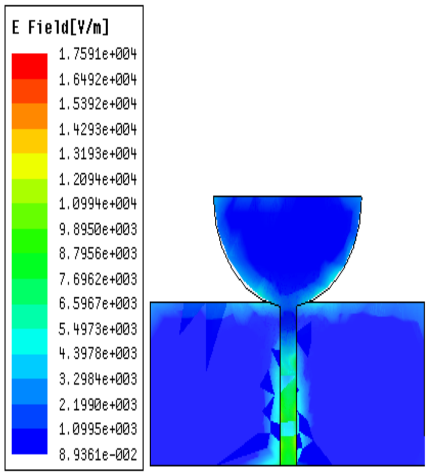

Figure11: Current distribution of the Half Circular Monopole Antenna At 3.1GHz

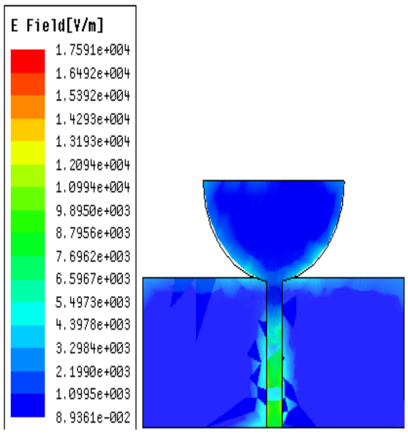

Figure 12: Current distribution of the Half Circular Monopole Antenna at 3.2GHz

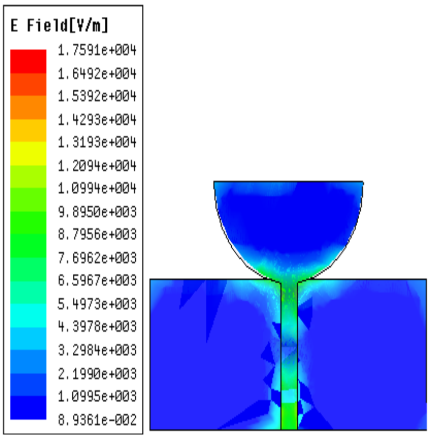

Figure 13: Current distribution of the Half Circular Monopole Antenna at 4.5GHz.

5. Conclusion

The E-Plane radiation pattern of this design is in the form of eight shapes but at higher frequencies is slightly titled and also throughout the frequencies of the bandwidth H-Plane is having uniform radiation in one direction and other direction is not (called Omnidirectional pattern). We concluded that half - circular monopole antenna is well suited for UWB applications due to its wide impedance bandwidth except from 6.3GHz to 8.2GHz and nearly Omni-directional azimuthal radiation pattern.

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