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CPW Fed Ultra Wideband Strip Antenna

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Abstract

A compact CPW-fed planar monopole antenna for UWB applications is presented and investigated. The proposed antenna with a size of 17.7 mm x26 mm x 1.6 mm fed with a CPW feed and a slotted ground plane is developed. The antenna yields a -10dB bandwidth ranging from 3.1 to 10.6 GHz with monopole like radiation pattern and stable gain. Design equations for the proposed antenna are derived and validated with different substrates. From the investigation of frequency domain and time domain characteristics, it is observed that over the entire operating band, antenna exhibits good transient characteristics.

1. Introduction

Ultra-wideband (UWB) system design and application have become the focus of wireless communication since the Federal Communications Commission (FCC) released the band 3.1-10.6GHz for commercial applications in 2002 for UWB radio system [1]. Particularly, antennas are the challenging aspect of UWB technology. The design requirements of UWB antenna include stable response in terms of input impedance, radiation pattern, gain, etc.

Compact-size planar antennas have played key roles in achieving optimal performance in portable and mobile applications [2], [3]. Among them, various coplanar waveguide (CPW)-fed monopoles with differently shaped radiators are drawing more and more attention due to their unique characteristics of compact structure, omnidirectional radiation pattern, and compatibility with the printed circuit board (PCB) technique. U-shaped, circular and elliptical patches have been investigated to achieve a UWB bandwidth [4] – [7].

In this paper, apart from designing a CPW-fed single-layer UWB monopole radiator, two symmetrical open-circuit stubs extended from the CPW's ground plane are introduced to implement an ultra wideband radiation with a compact size. The two open-circuit stubs not only expand the original small-sized ground plane of the CPW, but also help to produce resonance at lower frequencies. The proposed antenna introduces only three resonances within the operating band. Antenna design and results are discussed elaborately in the following sections.

2. Antenna Geometry

The geometry of the proposed antenna fabricated on a substrate of dielectric constant (ε_r) 4.4 and thickness (h) 1.6mm is shown in Fig.1. The antenna consists of a CPW fed monopole of length $L_1+T+L_3+L_4$ and width W. The ground plane dimensions are optimized as $L_1 x W_1$. The ground plane is extended by side arms of dimension $L_2 x W_2$. A rectangle of dimension $L_3 x W_3$ is embedded on the monopole at a distance T from the ground plane. All the dimensions are critical and are optimized to get the maximum bandwidth for a compact low profile antenna. The top and bottom view of the proposed compact antenna is shown in Figure 1(a) and 1(b) respectively.

The simulation studies are carried out using full wave electromagnetic simulation software Ansoft HFSS. Dimensions of the final antenna are given by L_1=4mm,W_1=7mm, W=3mm,L_2=22mm,W_2=1mm, L_3=7mm,W_3=13.8mm,L_4=3mm,T=0.4mm,G=0.35mm,h= 1.6mm,ε_r=4.4.

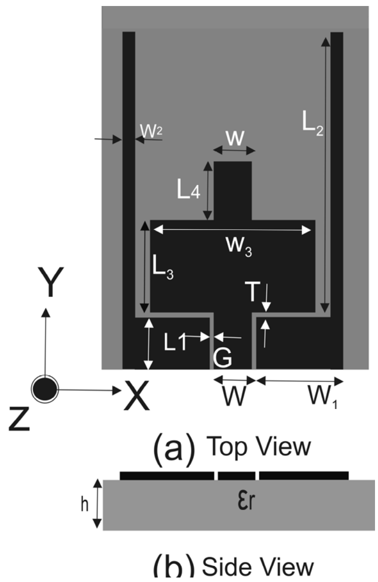

Figure 1. Geometry of the proposed antenna

3. Results and Discussion

The optimized antenna is fabricated on a substrate having relative dielectric constant ε_r =4.4 and thickness h = 1.6 mm with dimensions 17.7 mm x 26 mm x 1.6 mm. Figure 2 shows the comparison of the simulated and measured reflection coefficients of the proposed antenna. A -10dB bandwidth from 3.1 to 10.6GHz is obtained with resonances centered at 4.9GHz, 7.9GHz and 9.57GHz.

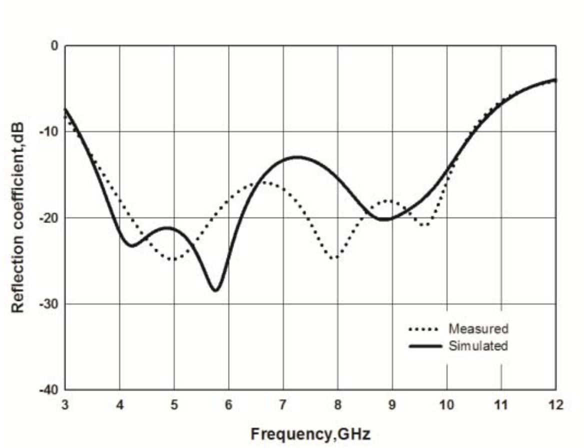

Figure 2. Measured and simulated reflection coefficients of the antenna.

Measured radiation pattern of the antenna at the resonant frequencies in two principle planes are shown in Figure. 3. It can be seen that at all frequencies antenna gives omnidirectional pattern with good cross polar isolation.

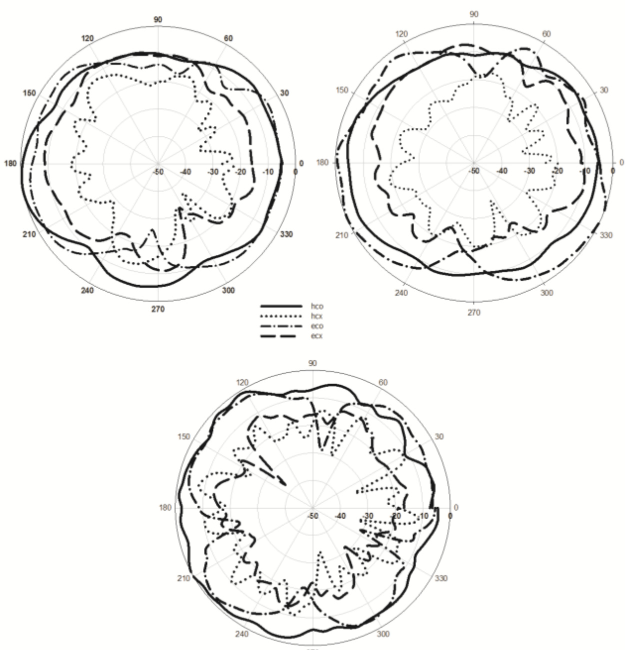

Figure 3 . Measured radiation patterns of the antenna at (a) 4.9GHz (b) 7.9 GHz and (c) 9.57GHz.

The gain of the antenna in the entire band is also measured and is shown in Figure.4. Gain of the antenna is measured using gain comparison method. Almost flat response is obtained over the entire operating band with an

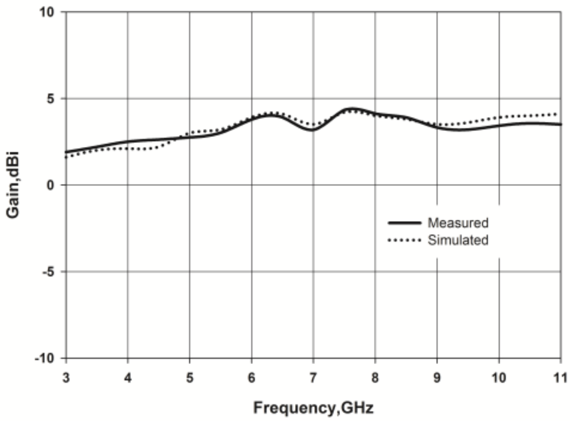

Figure 4. Measured and simulated gain of the antenna

average gain of 3.2. Simulated gain is also shown for comparison.

4. Design

A design procedure for the UWB strip antenna will be explained in this section. Since we are interested in the ultra wide band width, centre frequency of operating band (6.85GHz) is taken in to account while deriving the design equations.

Obtained design equations for the antenna are

$$L_1=0.15\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (1)$$

$$W_1=0.262\lambda_0/\sqrt{\varepsilon_{reff}} \quad (2)$$

$$L_2=0.82\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (3)$$

$$W_2=0.037\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (4)$$

$$L_3=0.262\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (5)$$

$$W_3=0.516\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (6)$$

$$L_4=0.112\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (7)$$

and

$$T=0.015\,\lambda_0/\sqrt{\varepsilon_{reff}} \quad (8)$$

where λ_0 is the wavelength corresponding to centre frequency of the operating band and ε_{reff} is the effective permittivity of the substrate.

In order to justify the design equations, the antenna parameters are computed for different substrates are tabulated in Table 1.

Table. 1. Computed Geometric Parameters of the Antenna

	Antenn a 1	Antenn a 2	Antenn a 3	Antenna 4
Laminat e	Rogers 5880	FR4 Epoxy	Rogers RO300 6	Rogers6010L M
h(mm)	1.57	1.6	1.28	0.635
ε_r	2.2	4.4	6.15	10.2
W(mm)	4	3	2.58	2.05
G(mm)	0.17	0.35	0.45	0.5
L_1	5.2	4	3.439	2.75
W_1	9.1	7	6.06	4.84
L_2	28.5	22	18.99	15.17
W_2	1.3	1	0.867	0.69
L_3	9.1	7	6.06	4.84
W_3	17.9	13.8	11.9	9.5
L_4	3.89	3	2.59	2.07
T	0.52	0.4	0.347	0.277

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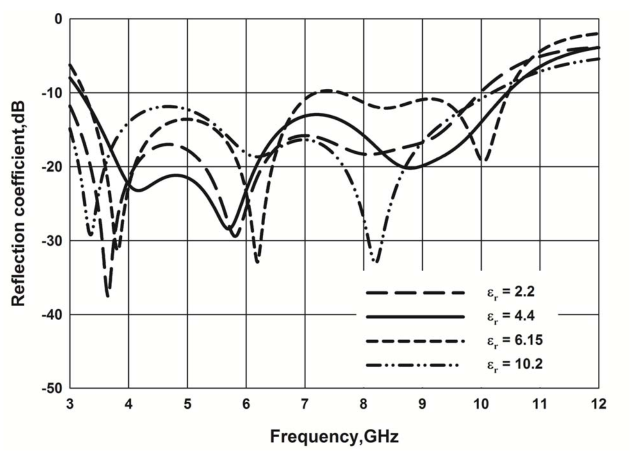

Figure.5. Reflection coefficient of the antenna for different substrates

Figure 6 shows the reflection coefficients of different antennas as given in Table1. In all the cases antenna is operating in the UWB region.

5. Time Domain Antenna Characteristics

The transient characteristics of the UWB antenna are studied by examining the radiated UWB pulses. To do so, the antenna system is modeled as a linear time invariant system and the transfer function is used to evaluate the distortion of the radiated pulse. Thus a convolution approach is exploited to calculate the radiated pulse. The measured transfer functionof the antenna is then transformed to the time domain by performing Inverse Fast Fourier Transform (IFFT). It is then convolved with a source pulse to obtain the radiated UWB pulse. Practically, only the pulses which can be easily generated and have low power consumption is selected as UWB signals. Owing to unique spectral properties, a family of Rayleigh (differentiated Gaussian) pulses is widely used as source pulse in UWB systems [8]. A 4^{th} order Rayleigh pulse as an excitation/ source pulse.

The transmitted and received waveforms for the face to face and side by side orientations of the antenna are shown in Fig.6. It is clear from the figure that shape of the pulse is preserved very well by the antenna.

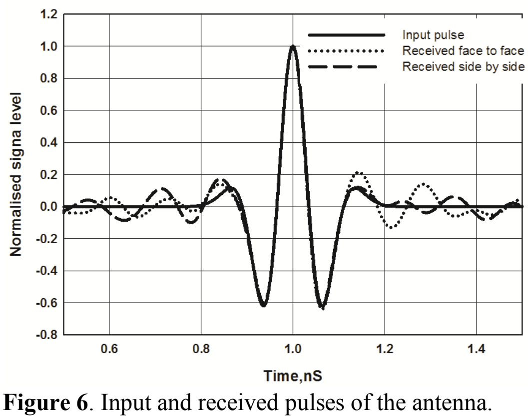

Figure 6. Input and received pulses of the antenna.

Group delay is an important parameter of UWB antenna since it gives the distortion of the transmitted pulses in the UWB communication. For a good pulse transmission, group delay should be almost constant in the UWB band. Fig.7 shows the plot of the measured group delay. It is seen that the group delay remains constant with variation less than two nanosecond for face to face and side by side orientation. This implies that antenna introduces little distortion to the transmitted pulse.

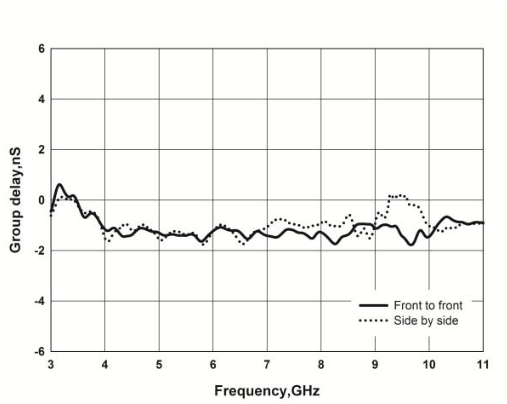

Figure 7. Measured group delay of the antenna for face to face and side by side orientations.

5. Conclusion

In this paper, a CPW fed strip antenna is proposed for UWB applications. The proposed antenna with an extended ground plane offers a bandwidth of 3.1 – 10.6GHz with an overall size of 17.7mm x 26mm x 1.6mm. Performance of the proposed antenna in frequency and time domain are experimentally verified with the help of measured antenna transfer function. The antenna exhibits an impressive time domain response which makes it an attractive candidate for future UWB applications.

6. Acknowledgements

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7. References

1. FCC, 2004,"Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems", ET-Docket 98-153.

2. T. Mitchell, "Broad is the way,"*Inst. Elect. Eng. Rev*., vol. 47, no. **1**, January 2001, pp. 35–39.

3. Z. N. Chen, M. J. Ammann, X. M. Qing, and X. H. Wu, "Planar antennas,"*IEEE Microw. Mag*., vol. 7, no. **6**, December 2006, pp. 63–73.

4.Y. J. Ren and K. Chang, "Ultra-wideband planar elliptical ring antenna,"*Electron. Lett*., vol. 42, no. **8**, April 2006, pp. 447–449.

5. A. S. Abbosh and M. E. Bialkowski, "Design of ultra wideband planar monopole antennas of circular and elliptical shape,", *IEEE Trans. Antennas Propag*., **56**, no. 1, January 2007 ,pp. 17–23.

6. I. K. Joon and J. Yong, "Design of ultra wideband coplanar waveguide-fed LI-shape planar monopole antennas" , *IEEE Antennas Wire-less Propag. Lett*.. **6**, 2007, pp. 383–387.

7. M. Gopikrishna, D. D. Krishna, C. K. Aanandan, P. Mohanan, and K. Vasudevan, "Compact linear tapered slot antenna for UWB applications," *Electron. Lett*., **44**, no. 20, September 2008, pp. 1174–1175.

8. Z. N. Chen, X. H. Wu, H.F. Li, N. Yang, and M.Y. W. Chia, "Considerations for Source Pulses and Antennas in UWB Radio Systems" *IEEE Trans. Antennas and Propag*, **52,** No.7, July 2004, pp.1739-1748.