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Design and Analysis of Three Different UWB Antennas

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Abstract: *In this article, the design and analysis of three different UWB antennas, such as microstrip feedline, coplanar waveguide (CPW) feed and asymmetrical coplanar strip (ACS) feed UWB antenna are carried out.all antennas are fabricated on a FR-4 substrate of thickness h = 1.6mm having loss tangent of 0.02 and dielectric constant of čr = 4.4.We first design microstripfeed line UWB antenna, which consists of circular radiating patch of radius R, microstrip feedline of length Lp and width Wp and destructive ground structure (DGS) of length Lg and width Wg. The optimized dimensions of the structure are: Lsub = 24mm, Wsub = 20mm, Wf = 2mm, Lf =10mm, R = 5.65mm, g = 1.25mm, L1 =2mm, W1 = 2mm.Then design a CPW feed Ultra wideband Antenna, with optimized dimensions of: Lsub = 24 mm, Wsub = 20 mm, Wf = 2 mm, Lf =10mm, gap between radiating patch and ground plane g = 1.25mm, gap between CPW feed line and ground plane h = 0.25mm, Lg = 8.75mm, Wg = 9.75mm.Finally design an ACS feed UWB Antenna, which can approximately reduce 50% size as that of the traditional CPW feed antenna. The final ACS feed UWB antenna provides as impedance bandwidth of VSWR ≥2 over the frequency band of 2.4-11GHz providing services in various applications such as Bluetooth, WiMax, WLAN, Cband satellite, X band satellite and ITU-T band. .The proposed antenna provides astable peak gain of 3.8 dB over the entire UWB frequency band*

Keywords: UWB antennas

I. INTRODUCTION

The Federal Communication Commission (FCC) assigned unlicensed use of 3.1-10.6 GHz (7.5 GHz) frequency spectrum for UWB system. Bluetooth is the license free frequency band assigned by IEEE 802.11/g standard in the Industrial Scientific and Medical (ISM) frequency band operating from 2.40- 2.484 GHz widely used inportable devices. This license free frequency band can be integrated with another license free UWB frequency band to facilitate the advantages of both Bluetooth and UWB frequency band for different applications in limited available space.

Hence to integrate both Bluetooth and UWB band in a single device operation, it is necessary to designed and develop dual band antenna. Dual band antenna operating in Blue-tooth and UWB band is proposed by [1]-[5].The design of multi-band antenna for Bluetooth, WiMAX, WLAN and HIPERLAN2, due to its wide range of usability in almost all commercial communication devices such as smart-phones, laptops, tablets, phablets, etc. is especially demanding. Antennas, an integral part of such wireless communication systems, are subjected to very stringent specifications such as light weight, compact structure, low profile, robustness and conform-ability and are expected to grab as much spectrum as possible to provide multi-band or broadband operation [6–9].The design of several UWB antenna satisfying some of these specifications have been reported in [10–15]. In general, an ACS feed antenna provides about 50% size reduction as compared to the traditional CPW feed antenna as only one half the ground plane of the CPW structure is considered [16].the proposed UWB antennas are design by using different feed techniques such as coplanar waveguide (CPW) feed and asymmetrical coplanar strip (ACS) feed. The ACS feed UWB antenna provides impedance bandwidth of VSWR ≥2 over the frequency band of 2.4-11 GHz providing services in various applications such as Bluetooth, WiMax, WLAN, C band satellite, X band satellite and ITU-T band. The proposed antenna provides a stable peak gain of 3.8 dB over the entire UWB frequency band.

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II. ANTENNA DESIGN

In this chapter, the analysis ofCoplanar waveguide (CPW) feed and asymmetrical coplanar strip (ACS) feed UWB antenna is designed and investigated.

Radius of circular patch antenna (R) is given by

$$\frac{F}{\sqrt{1+\frac{2h}{\pi * F * \epsilon_r}[\ln(\frac{\pi * F}{2h})+1.7726]}}$$

Where $F = \frac{8.791 * 10^9}{f_r \sqrt{\epsilon_r}}$

2.1 Design of CPW feed UWB Antenna

As stated earlier, the CPW feed provides easy integration and assembling of antennas with existing MMIC technology on a single sided PCB board. The structure of CPW feed UWB antenna is shown in Figure 1. It consists of the same circular radiating patch and ground plane both deployed on the same side of substrate. The antenna is fabricated on a low cost FR-4 substrate of height 1.6mm, dielectric constant (ξr) =4.4 and loss tangent of 0.02. The theoretical antenna dimensions are carried forward following approach given in earlier section. The optimized dimensions of the CPW feed UWB Antenna are as follows: Lsub = 24 mm, Wsub = 20 mm, Wf = 2 mm, Lf =10mm, gap between radiating patch and ground plane g = 1.25mm, gap between CPW feed line and ground plane h = 0.25mm, Lg = 8.75mm, Wg = 9.75mm.

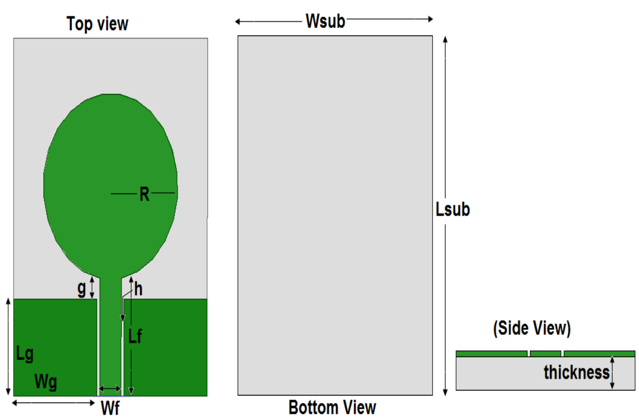

Figure 1. Design of CPW feed UWB Antenna

Parametric study of CPW feed UWB Antenna

The parametric study of radius R of the radiating patch, gap g between the radiating patch and ground plane and gap h between the CPW feed and ground plane is carriedout to understand their influence on the UWB characteristics. The radius R of theradiating patch mainly affects the lower edge resonance frequency of the UWB band. As the patch radius goes on increasing, the lower edge resonance frequency of the UWB band goes on decreasing. The variation of VSWR Vs frequency for different patch radius is shown in Figure 2.

Further the gap g is varied from 1mmto 1.5mm through optimized value 1.25mm. As stated earlier the gap mainly affects the center frequency band of the UWB band. Changing the gap changes the RLC tuning of the antenna causing impedance mismatch. Similarly the gap h is varied from0.15mm to 0.35mm through optimized value of 0.25mm.

Changing either of the gap causes impedance mismatch thereby affecting the UWB performance. The gap g and h mainly affects the higher edge frequency of the UWB band. The parametric study of variation of gap g and gap h for VSWR Vs frequency is shown in Figure 3.

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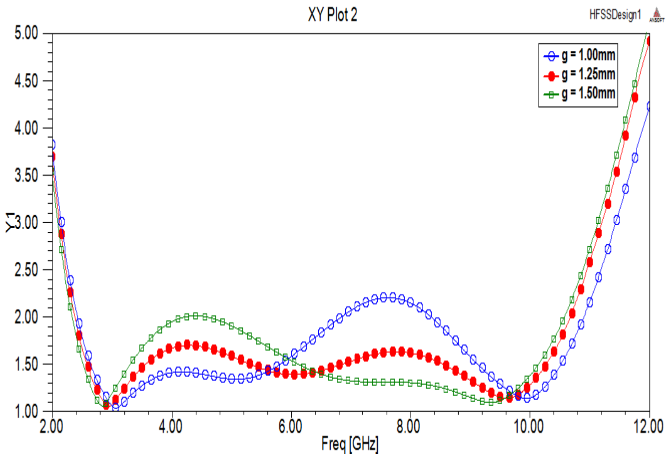

Figure 2. Variation of gap-g between radiating patch and ground plane

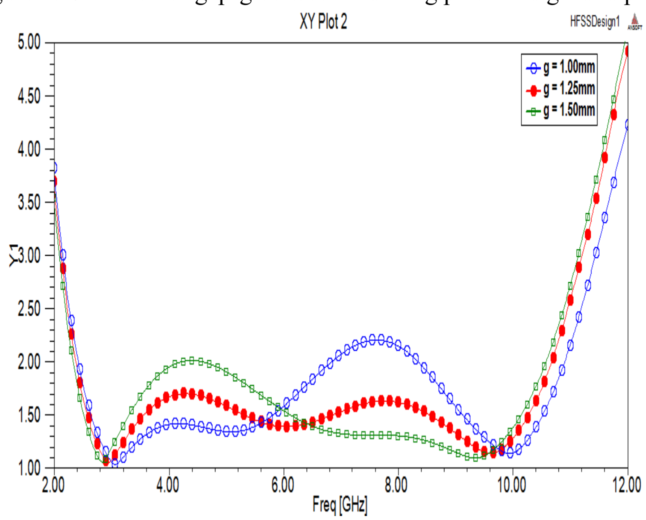

Figure 3. Variation of gap-g between CPW feedline and ground plane

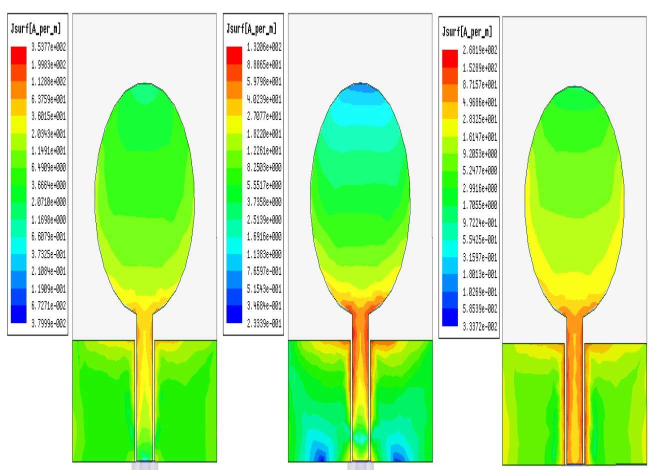

Figure 4. Surface current distribution at (a) 3.2 GHz, (b) 5.5 GHz and (c) 7.5 GHz

Furthermore, current distribution and simulated radiation patterns along E plane and H plane have been investigated at sampling frequencies of 3.2 GHz, 5.5 GHz and 7.5 GHz. The current distribution is nearly constant along the feedline while increases along the radiating patch as the frequency goes on increasing. The simulated surface current distribution on the CPW feed UWB Antenna is shown in Figure 4.

The radiation patterns have not significantly changed due to use of CPW feed. The radiation patterns are almost omni directional along H plane and directional along E plane as shown in Figure 5.

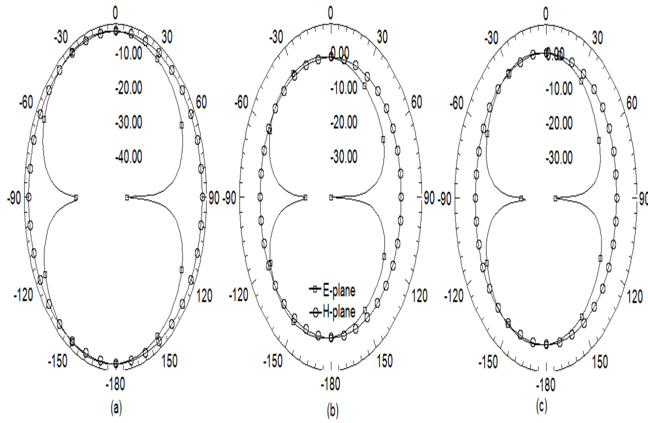

Figure 5. Simulated radiation patterns at (a) 3.2 GHz, (b) 5.5 GHz and (c) 7.5 GHz

2.2 Design of ACS feed UWB Antenna

In avinash, pier author suggested that the ACS feed antenna can approximately reduce50% size as that of the traditional CPW feed antenna. However, these antenna undergoslight variation in radiation characteristics behavior due to the asymmetrical nature of the antenna. Hence, use of these antenna for application where radiation pattern doesnot significantly affect the performance of the system is advised. Figure 6 showsthe structure of the ACS feed UWB antenna. As observed from Figure 6, we can see that the ACS feed antenna is approximately cut in two half pieces while only onehalf piece is retained.

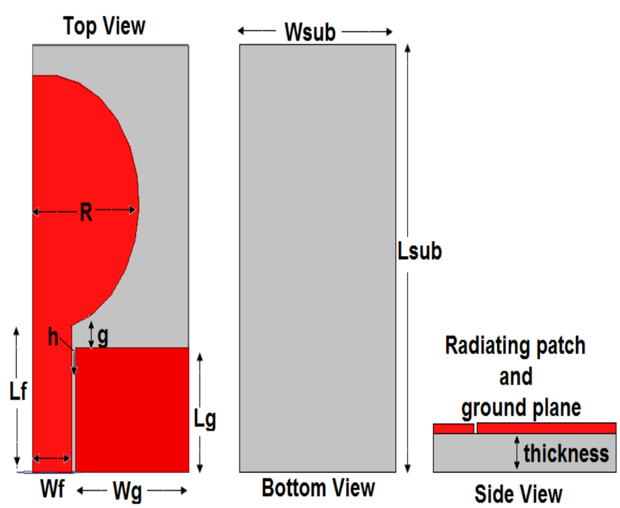

Figure 6. Antenna design of ACS feed UWB Antenna

The antenna is modified version of the CPW feed antenna and has some optimization in dimensions as that of the CPW feed antenna.

The ACS feed antenna consist of half circular radiating patch, ACS feedline placed close to the ground plane. The antenna is again fabricated on a low cost FR-4 substrate of thickness 1.6mm, dielectric constant (ξr) =4.4 and loss

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tangent of 0.02. The parametric study of the ACS feed UWB antenna is further carried out to investigate its performance on UWB characteristics

Parametric study of ACS feed UWB Antenna

The parametric study of radius R of the radiating patch, gap g between the radiating patch and ground plane and gap h between the ACS feed and ground plane is carriedout to understand their influence on the UWB characteristics. The radius R of the radiating patch mainly affects the lower edge resonance frequency of the UWB band. As the patch radius goes on increasing, the lower edge resonance frequency of the UWB band goes on decreasing. The radius of ACS feed antenna has been slightly increased as compared to that of CPW feed UWB Antenna. The variation of VSWRVs frequency for different patch radius is shown in Figure 7.

Further the gap g is varied from 1mm to 1.5mm through optimized value 1.25mm. As stated earlier the gap mainly affects the center frequency band of the UWB band. Changing the gap changes the RLC tuning of the antenna causing impedance mismatch. Similarly the gap h is varied from 0.15mm to 0.35mm through optimized value of 0.25mm. Changing either of the gap causes impedance mismatch thereby affecting the UWB performance.

The gap g and h mainly affects the higher edge frequency of the UWB band. The parametric study of variation of gap g and gap h for VSWR Vs frequency is shown in Figure 8 and 9respectively.

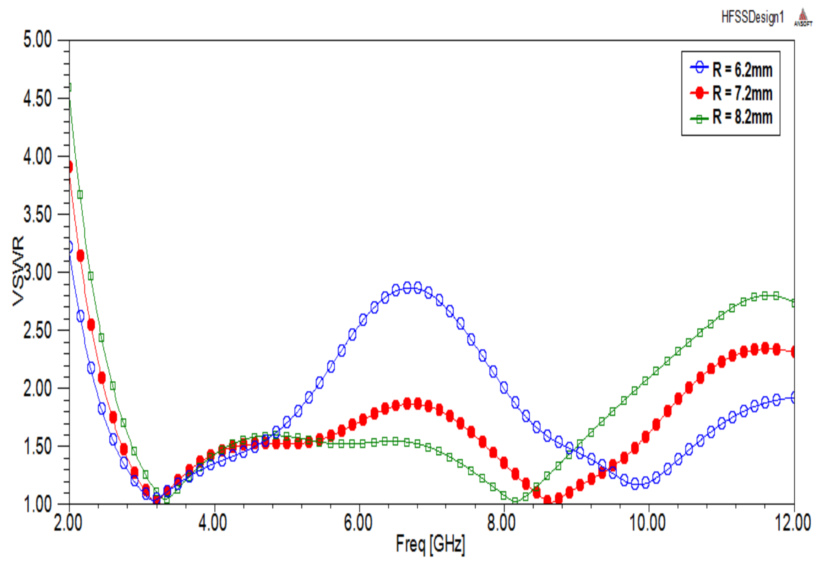

Figure 7. Variation of radius-R of the radiating patch

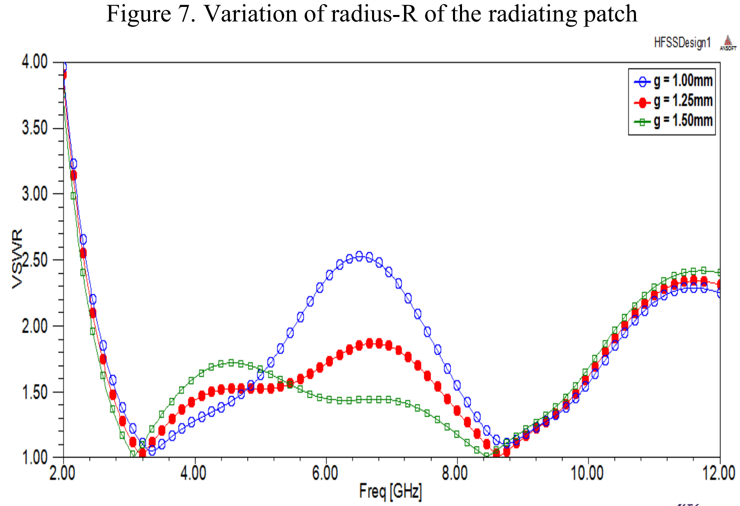

Figure 8. Variation of gap-g between radiating patch and ground plane

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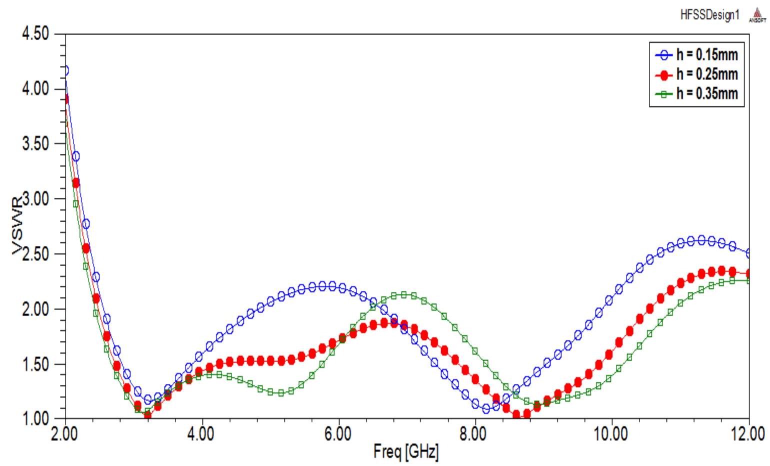

Figure 9. Variation of gap-h between CPW feedline and ground plane

Furthermore, current distribution and simulated radiation patterns along E plane and H plane have been investigated at sampling frequencies of 3.2 GHz, 5.5 GHz and7.5 GHz. The current distribution is nearly constant along the feedline while increases along the radiating patch as the frequency goes on increasing. The simulated surface current distribution on the ACS feed UWB Antenna is shown in Figure 10.

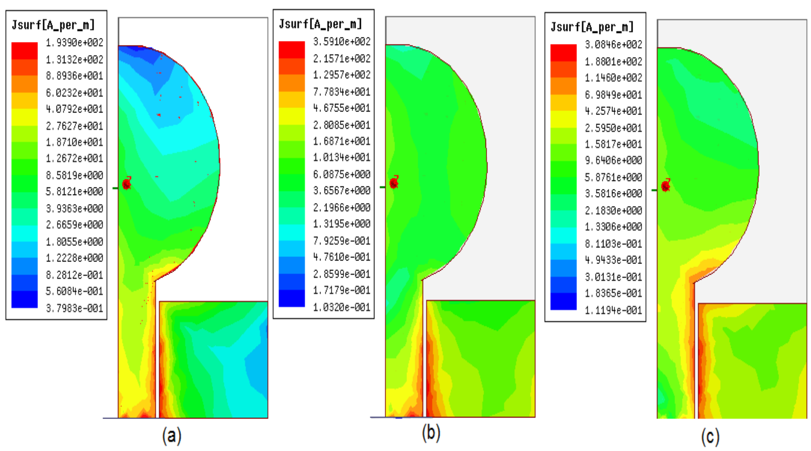

Figure 10. Surface current distribution at (a) 3.2 GHz, (b) 5.5 GHz and (c) 7.5 GHz

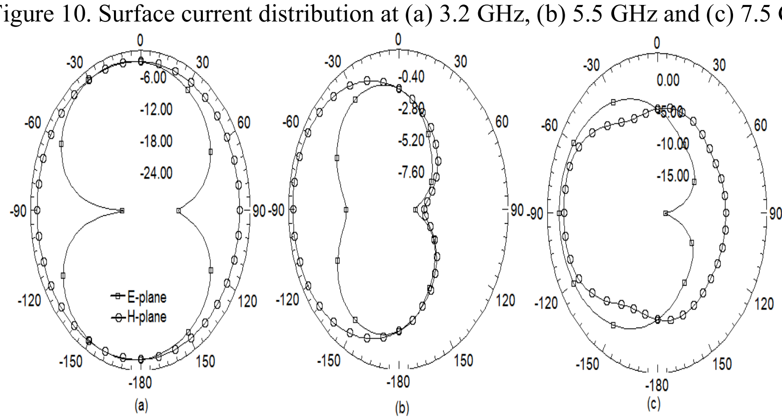

Figure 11. Simulated radiation patterns at (a) 3.2 GHz, (b) 5.5 GHz and (c) 7.5 GHz

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The radiation patterns have significantly changed due to use of ACS feed. The radiation patterns are almost omni directional along H plane and directional along E plane as shown in Figure 11. However, due to asymmetrical structure the radiation patterns along E plane have asymmetrical shape

III. RESULT AND DISCUSSION

In this chapter the performance of microstrip feedline and CPW feed line with ACS feed line is carried out in terms of VSWR bandwidth and peak gain offered by them. Figure 12 shows the variation of VSWR Vs frequency for all these antenna configuration. As depicted in Figure 1 all antenna configurations satisfy the UWB bandwidth criteria. The ACS feed antenna satisfies the UWB impedance bandwidth requirement while reducing the size of antenna almost to 50%.

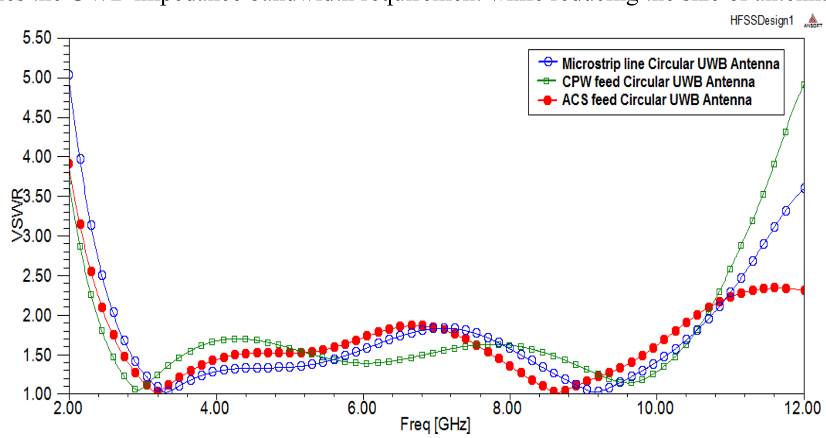

Figure 12. Variation of VSWR against frequency for different feeding techniques

The final ACS feed UWB antenna provides as impedance bandwidth of VSWR ≥2 over the frequency band of 2.4-11GHz providing services in various applications such as Bluetooth, WiMax, WLAN, Cband satellite, X band satellite and ITU-T band

The proposed antenna provides astable peak gain of 3.8 dB over the entire UWB frequency band while slight degrades over the higher edge frequency of UWB band due to lossy nature of the FR-4 dielectric substrates that is used for antenna fabrication. The variation of peak gain Vs frequencyis shown in Figure 13.

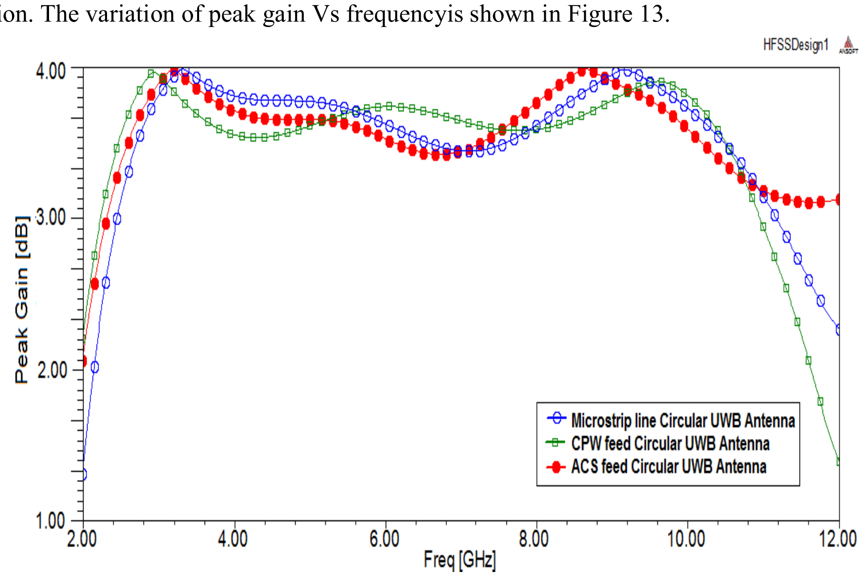

Figure 13. Variation of Peak Gain against frequency for different feeding technique

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IV. CONCLUSION

In this paper, comparison of traditional microstrip feed line, CPW feed line and new ACS feed line UWB Antenna has been carried out and investigated. The CPW feed and ACS feed line provides an added advantage of easy integration of antennas with the existing MMIC technology circuits. Furthermore, the ACS feed UWB antenna provides an advantage of more compact size of antenna in applications where size of the antenna plays a crucial role. However, the asymmetrical structure of antenna hampers the radiation characteristics of ACS feed UWB antenna giving asymmetrical radiation pattern along the E plane at higher edge frequency. All these antenna satisfy the FCC regulation of bandwidth allotted for UWB frequency band making the suitable candidate for wireless applications.

REFERENCES

[1] Bahadir S. Yildirim, Bedri A. Centiner, Gemma Roqueta and Luis Jofre,“ Integrated Bluetooth UWB Antenna”, IEEE Antenna and Wireless Propagation Letters,Vol.8, pp. 149-152, 2009.

[2] Rekha P Labade, Dr. S. B. Deosarkar, Dr. Narayan Pishoroty and Dr. Akshay Malahotra,“Design and Implementation of an Integrated Bluetooth Ultra-wideb and Monopole Antenna”, .Australian Journal of Basic and Applied Sciences,Vol.8No.15, 60-66, 2014.

[3] Xu, L., B. Yuan, and S. He,“Design of novel UWB slot antenna for Bluetooth andUWB Applications”, Progress In Electromagnetic Research, Vol. 37, pp. 211-221,2013.

[4] K. P. Ray and Y. Ranga,“Ultrawideband Printed Elliptical Monopole Antennas”,IEEE Transaction on Antennas and propagation,Vol. 55, No.4, pp. 1189 1192,2007.

[5] FCC,“Ultra-Wideband Operation FCC Report and Order”, Tech.Rep. US47 CFRPart 15, 2002.

[6] Labade, R., S. Deosarkar, and N. Pishoroty, “A novel integrated Bluetooth dual band UWB antennafor wireless communication,” *International Journal of Microwave and Optical Technology*, Vol. 10,No. 3, 195–201, 2015.

[7] Fabrs, M. C., “Systematic design of antennas using the theory of characteristic modes,” PhDDissertation, Feb. 2007.

[8] Valderas, D., J. I. Sancho, D. Puente, et al., *Ultrawideband Antennas, Design and Application*,Imperial College Press, 2010.

[9] Labade, R., S. B. Deosarkar, and N. Pishoroty, “Design and implementation of an integratedBluetooth ultrawideband monopole antenna,” *Australian Journal of Basic and Applied Sciences*,Vol. 15, No. 8, 60–66, 2014.

[10] Sayidmarie, K. H. and T. A. Nagem, “Compact dual-band dual-ring printed monopole antennasfor WLAN applications,” *Progress In Electromagnetics Research B*, Vol. 43, 313–331, 2012.

[11] Pei, J., A. G. Wang, S. Gao, and W. Leng, “Miniaturized triple band antenna with defected groundplane for WLAN/WiMAX applications,” *IEEE Antennas and Wireless Propagation Letters*, Vol. 10,298–301, 2011.

[12] Lin, C. C., E. Z. Yu, and C. Y. Huang, “Dual-band rhombus slot antenna fed by CPW for WLANapplications,” *IEEE Antennas and Wireless Propagation Letters*, Vol. 11, 362–364, 2012.

[13] Xie, J. J., X. S. Ren, Y. Z. Yin, and S. L. Zuo, “Rhombic slot antenna design with a pair of straightstrips and two-shaped slots for WLAN/WiMAX applications,” *Microwave and Optical Technology Letters*, Vol. 54, No. 6, 1466–1469, 2012.

[14] Li, Y., W. Li, and Q. Yi, “Miniaturization of Asymmetric coplanar strip fed staircase ultra wide band antenna with reconfigurable notch band,” *Microwave Opt. Technol. Lett.*, Vol. 55, No. 7, 1467–1470, Jul. 2013.

[15] Lee, Y.-C. and J.-S. Sun, “A new printed antenna for multiband wireless applications,” *IEEE Antennas Wireless Propag.Lett.*, Vol. 8, 402–405, Aug. 2009.

[16] Naidu, P. V. and R. Kumar, “Design of a compact ACS-fed dual band antenna forBluetooth/WLAN and WiMAX applications,” *Progress In Electromagnetics Research C*, Vol. 55, 63–72, 2014.