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BANDWIDTH ENHANCEMENT TECHNIQUES COMPARISON FOR ULTRA WIDEBAND MICROSTRIP ANTENNAS FOR WIRELESS APPLICATION

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ABSTRACT

Since the release by the Federal Communications Commission (FCC) of a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra-wideband (UWB) wireless communications, UWB is rapidly advancing as a high data rate wireless communication technology. As is the case in conventional wireless communication systems, an antenna also plays a very crucial role in UWB systems. However, there are more challenges in designing a UWB antenna than a narrow band one. A suitable UWB antenna should be capable of operating over an ultra-wide bandwidth as allocated by the FCC. At the same time, satisfactory radiation properties over the entire frequency range are also necessary. To choose an optimum antenna topology for ultra wideband (UWB) design, several factors must be taken into account including physical profile, compatibility, impedance bandwidth, radiation efficiency, and radiation pattern. The main challenge in UWB antenna design is achieving the very broad bandwidth with high radiation efficiency and small in size. Accordingly, many techniques to broaden the impedance bandwidth of small antennas and to optimize the characteristics of broadband antennas have been widely investigated in many published papers as listed in this article. Planar monopole antennas are good candidates owing to their wide impedance bandwidth, omni-directional radiation pattern, compact and simple structure, low cost and ease of construction. Further detail on various bandwidth enhancement techniques will be discussed in this paper. This paper focuses on UWB planar printed circuit board (PCB) antenna design and analysis. Extensive investigations are carried out on the development of UWB antennas from the past to present. First, the planar PCB antenna designs for UWB system is introduced and described. Next, the special design considerations for UWB antennas are summarized. State-of-the-art UWB antennas are also reviewed. Finally, a new concept (case studies) for the design of a UWB antenna with a bandwidth ranging from 3GHz-8GHz is introduced, which satisfies the system requirements for S-DMB, WiBro, WLAN, CMMB and the entire UWB .

Keywords: *Microstrip antenna, Wide Band, Ultra Wide Band.*

1. INTRODUCTION

In February 14, 2002, the Federal Communications Commission (FCC) amended the Part 15 rules which govern unlicensed radio devices to include the operation of UWB devices. The FCC also allocated a bandwidth of 7.5GHz, i.e. from 3.1GHz to 10.6GHz to UWB applications [1], by far the largest spectrum allocation for unlicensed use the FCC has ever granted. Ultra-wideband (UWB), a radio transmission technology which occupies an extremely wide bandwidth exceeding the minimum of 500MHz or at least 20% of the center frequency [1], is a revolutionary approach for short range high-bandwidth wireless communication. Differing from traditional narrow band radio systems (with a bandwidth usually less than 10% of the center frequency) transmitting signals by modulating the amplitude, frequency or phase of the sinusoidal waveforms, UWB systems transmit information by generating radio energy at specific time instants in the form of very short pulses thus occupying very large bandwidth and enabling time modulation.

Due to the transmission of non-successive and very short pulses, UWB radio propagation will provide very high data rate which may be up to several hundred Megabytes per second, and it is difficult to track the transmitting data, which highly ensures the data security. For the same

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reason, the transmitting power consumption of UWB systems is extremely low in comparison with that of traditional narrow band radio systems. Moreover, the short pulses give rise to avoidance of multipath fading since the reflected signals do not overlap the original ones. Because of these alluring properties, UWB technology is widely employed in many applications such as indoor positioning, radar/medical imaging and target sensor data collection.

In UWB communication systems, one of the key issues is the design of a compact antenna with a ultra-wideband characteristic over the whole operating band. Recently, a variety of slot antennas become very attractive candidates [1-6] due to their low profile, wide bandwidth, compact size, low cost, ease of fabrication, etc. In these designations, number of slot antennas have been experimentally investigated and reported with different geometries such as wide rectangular slot [2], a square-ring slot [3], E-slot [4], quasi-self complementary semicircular structure [5], a rectangular notch [6], and multi-inverted cone slot [7] to realize broadband and ultra-wideband operation characteristics.

Besides the above-mentioned UWB antennas, some open slot antennas with open L- and T-slot [8, 9] are introduced and designed with wide fractional bandwidths about 87% [8] and 94% [9], respectively. There is an apparent contradiction between the reduced antenna size and wider bandwidth in practice. In other words, these inchoate investigations on the ultra-wideband operation and size reduction are not solved well because that the narrow bandwidths in [2,6,8,9] are not enough for ultra-wideband requirement and the sizes in [3-7] are too large for the portable systems.

For a good UWB characteristic, some novel configurations and techniques such as a rectangular aperture [10], multi via holes [11], a fractal-shaped slot [12], a self-similar slot [13], and multiple resonant slots [14] can be used to control and enhance the operation bandwidths for wideband and UWB applications. Unfortunately, these investigations on sizes are large for the portable systems. But how to design UWB antenna with smaller size, is still a significant and challenging subject.

2. SPECIAL DESIGN CONSIDERATIONS FOR UWB ANTENNAS

Interference is a serious problem for UWB application systems. UWB applications are necessary for the rejection of the interference with existing wireless local area network (WLAN) technologies such as IEEE 802.11a in the USA (5.15-5.35GHz, 5.725-5.825GHz) [15]. As a result, UWB transmitters can not cause any electro-magnetic interference on nearby communication systems such as Wireless LAN (WLAN) applications. However, the use of a filter will increase the complexity of the UWB system. Up to date, many UWB antennas have been attempted to overcome interference problem using frequency band rejected function design. In these designations, the filter can be eliminated and the radio frequency systems will be simplified. The most popular antennas design with frequency band rejected function approaches are embedding slots (arc-slot) [16], double U-slots [17], square-slot [18], V-slot [19], and attaching bar [19] as shown in Fig. 1(a)-(d).

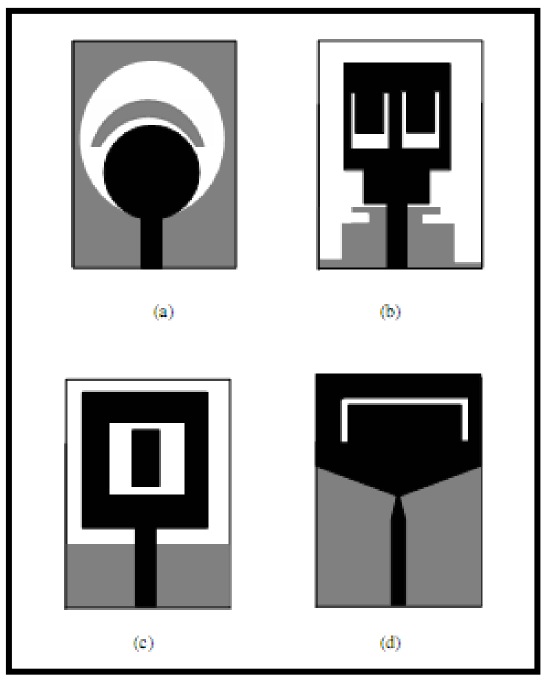

Fig.1 *An example of beveling technique*

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3. BANDWIDTH ENHANCEMENTS TECHNIQUES VARIETY.

In order to fulfill the UWB antenna requirements, various bandwidth enhancement techniques for planar monopole antennas have been developed during last two decades. The recent trends in improving the impedance bandwidth of small antennas can be broadly divided into the following categories the first category is the leading of all categories in numbers and varieties. By varying the physical dimensions of the antenna, the frequency and bandwidth characteristics of the resulting UWB pulse could be adjusted:

A. VARIOUS GEOMETRY AND PERTURBATIONS

Planar monopoles with a huge number of different geometries have been numerical characterized (Z.N. Chen et al, 2006). Many techniques to broaden the impedance bandwidth of planar monopole antennas and to optimize the characteristics of these antennas have been widely investigated. Among all these techniques, the beveling technique was reported to yield maximum bandwidth. Various geometries and perturbations are used to introduce multiple resonances as well as input impedance matching. The input impedance is also extremely dependent on the feeding configuration (M.C.Fabres et al., 2005). An example of beveling technique most current used in literature review is shown in Figure 2.

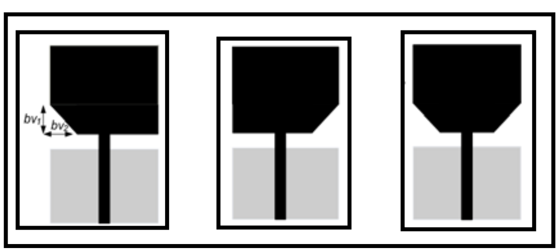

Fig.2 *An example of beveling technique*

Beveling the bottom edge of the radiating element has been demonstrated to shift upward significantly the upper edge frequency when properly designed (Giuseppe R. & Max J. Ammann, 2006), (Z.N. Chen(b) et al.,2006), (M. J. Ammann & Z. N. Chen, 2003), (M. J. Ammann, 2001). The optimization of the shape of the planar antenna especially the shape of the bottom portion of the antenna, improve the impedance bandwidth by achieving smooth impedance transition (Z.N. Chen(a) et al., 2006). In fact, this part of the radiator results to be very critical for governing the capacitive coupling with the ground plane. Any reshaping of this area strongly affects the current path (Giuseppe R. & Max J. Ammann, 2006). The election and beveling angle is critical, as it determines the matching of the mode.

The patch radiator may be slotted to improve the impedance matching, especially at higher frequency. The slots cut from the radiators change the current distribution at the radiators so that the impedance at the input point and current path change (Z.N. Chen(a)et al., 2006). A notch is cut from radiator to reduce the size of the planar antenna (Z.N. Chen(b) et al., 2006). Adding a strip asymmetrically at the top of the radiator can also reduce the height of the antenna and improve impedance matching (A. Chai et al., 2005). An offset feeding point has been used in order to excite more modes and consequently improving the impedance bandwidth (M. J. Ammann & Z. N. Chen, 2004). By optimizing the location of the feed point, the impedance bandwidth of the antenna will be further widened because the input impedance is varied with the location of the feed point.

Moreover, other strategies to improve the impedance bandwidth which do not involve a modification of the geometry of the planar antenna have been investigated. Basically, these strategies consist of adding a shorting post to the structure or using two feeding points to excite the antenna (M.C. Fabres(b) et al., 2005). A shorting pin is also used to reduce the height of the antenna (E. Lee et al., 1999). In (Giuseppe R. & Max J. Ammann, 2006), the shorting pin inserted to the antenna that provides a broad bandwidth has been investigated.

A dual feed structure greatly enhanced the bandwidth particularly at higher frequencies (E. Antonio-Daviu et al.,2003). By means of electromagnetic coupling (EMC) between the radiator and feeding strip, good impedance matching can be achieved over a broad bandwidth (Z.N. Chen(b) et al., 2003). The use of double feeding configuration to the antenna structure is to enforce the vertical current mode, whereas it prevents other modes such as horizontal and asymmetrical current modes from being excited, which degrade the polarization properties and the impedance bandwidth performance of the antenna (H. Ghannoum et al., 2006), (Christophe Roblin et al., 2004), (E. Antonino-Daviu et al.,

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2003), (Eva Antonino et al., 2004). The double feeding gives a significant improvement of the vertical current distribution resulting in better matching notably over the upper-band part (S. Boris et al., 2005). The matching of this upper frequency band is mainly governed by two parameters: the distance between the two monopole ports and the height between the monopole and the ground plane (H. Ghannoum et al., 2006). In (E. Antonino Daviu et al., 2003), a square monopole antenna with a double feed has been proposed. This feed configuration has shown the improvement on radiation pattern and impedance bandwidth. This is due to a pure and intense vertical current distribution generated in the whole structure. The hidden feed-line technique on printed circular dipole antenna has been investigated in (E. Gueguen et al., 2005). The specific feeding has shown remove any radiation pattern disturbance generally met with this kind of antenna when fed with a coaxial or a microstrip line. It was also shown a wide frequency bandwidth.

Due to the radiation from planar antenna may not be omni-directional at all operating frequencies because they are not structurally rotationally symmetrical. Roll monopoles is a choice to feature broad impedance bandwidth with omni-directional characteristics (Z.N. Chen(a) et al., 2003). With the roll structure, the antenna becomes more compact and rotationally symmetrical in the horizontal plane. However, the roll monopoles are not easy to fabricate with high accuracy (Z.N. Chen(a) et al., 2006). The folded antenna was also presented in (Daniel Valderas et al., 2006) in order to improve radiation pattern maintaining the broadband behavior. In (Daniel Valderas et al., 2006), the antenna was analyzed employing transmission line model (TLM). In (A.A. Eldek,2006), various combinations of bandwidth enhancement techniques was successfully applied in UWB antenna design such as adding slit in one side of the monopole, tapered transition between the monopole and the feed line, and adding notched ground plane.

B. GENETIC ALGORITHM (GA)

Optimization of patch geometry is an ideal technique to have single or more optimized figures of merit like, impedance bandwidth. The GA has been successfully applied by a number of researchers to improve the impedance bandwidth (Z.N. Chen et al., 2004), (A. J. Kerkhoff, 2001), (R. Holtzman et al., 2001), (A. J. Kerkhoff et al., 2004), (S. Xiao et al., 2003), (H. Choo & H. Ling, 2003). The optimized shape however is too much irregular and unconventional and this can only be fabricated using the pattern produced in true scale by the GA code.

Electromagnetic optimization problems generally involve a large number of parameters. The parameters can be either continuous, discrete, or both, and often include constraints in allowable values. The goal of the optimization is to find a solution that represents a global maximum or minimum. For example, the application of GA optimization is used to solve the problem of design a broadband patch antenna (Z.N. Chen et al., 2004). Parameters that are usually included in this type of optimization problem include the location of the feed probe, the width and length of the patch, and the height of the patch above the ground plane. In addition, it may be desirable to include constraints on the available dielectric materials, both in terms of thickness and dielectric constants; tolerance limits on the patch size and probe location; constraints on the weight of the final design; and possibly even cost constraints for the final production model. Given the large number of parameters, and the unavoidable mixture of discrete and continuous parameters involved in this problem, it is virtually impossible to use traditional optimization methods. GA optimizers, on the other hand, can readily handle such a disparate set of optimization parameters (Z.N. Chen et al., 2004).

The use of the GA approach in the design of UWB antennas has been proposed in (A. J. Kerkhoff, 2001), (R. Holtzman et al., 2001). The planar fully-metal monopole (PFMM) of bow tie (BT) and reverse bow tie (RBT) have been demonstrated in (A. J. Kerkhoff, 2001), (A. J. Kerkhoff et al., 2004) have an ultra-wide bandwidth. The element height, the feed height, and the element flare angle were the parameters that used in optimization. The height essentially determines the operating mode and the lower frequency limit of the antenna, while the flare angle and the feed height control the variation of the input impedance over frequency, the high frequency impedance value, as well as the resonance bandwidth (A. J. Kerkhoff, 2001). In this paper, the GA was used to determine the optimal dimensions of the selected element shape in order to fulfill the given bandwidth requirement. As a result, the RBT antenna can achieve a much wider impedance bandwidth than the BT with significantly reduced sizes. In (R. Holtzman et al., 2001), the semi-conical UWB antenna was optimized by using the Green's Function Method (GFM) Absorbing Boundary Condition (ABC) with

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GA. The goal of this optimization is to have significant reduction in the size of the white space, due to the unique capability of the GFM to model arbitrarily shaped boundaries in close proximity to the antenna. The white space is defined as the region between the antenna and the absorbing boundary. The GA optimizer is also used to reconfigure the radiation characteristics of antenna over an extremely wide-band (S. Xiao et al., 2003). The design results indicate that the antenna can obtain the required goals over an ultra-wide band through reconfiguring the states of the switch array installed in shared aperture when it operates with the higher order modes (S. Xiao et al., 2003). Optimization of broadband and dual-band microstrip antennas on a high-dielectric substrate by using GA was also proposed in (H. Choo & H. Ling, 2003).

C. RESONANCE OVERLAPPING

Normally, the bandwidth of a resonant antenna is not very broad because it has only one resonance. But if there are two or more resonant parts available with each one operating at its own resonance, the overlapping of these multiple resonances may lead to multi-band or broadband performance. Theoretically, an ultra-wide bandwidth can be obtained if there are a sufficient number of resonant parts and their resonances can overlap each other well. However, in practice, it is more difficult to achieve impedance matching over the entire frequency range when there are more resonant parts. Also, it will make the antenna structure more complicated and more expensive to fabricate. Besides, it is more difficult to achieve constant radiation properties since there are more different radiating elements.

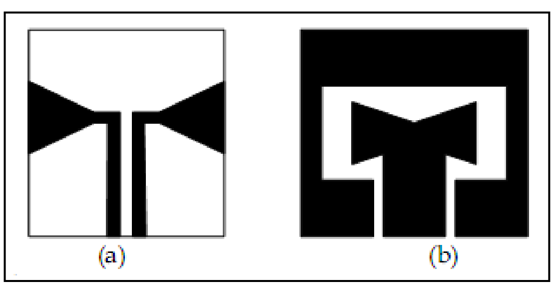

Fig.3 *The microstrip fed the UWB bowtie antennas*

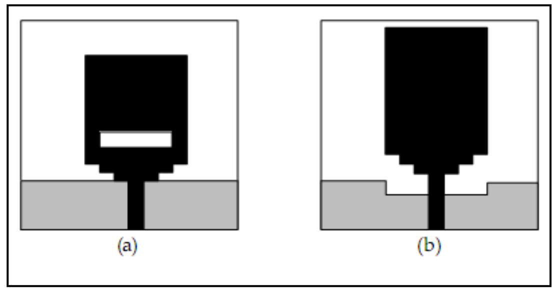

Fig.4 *The microstrip fed monopole antennas with rectangular patch*

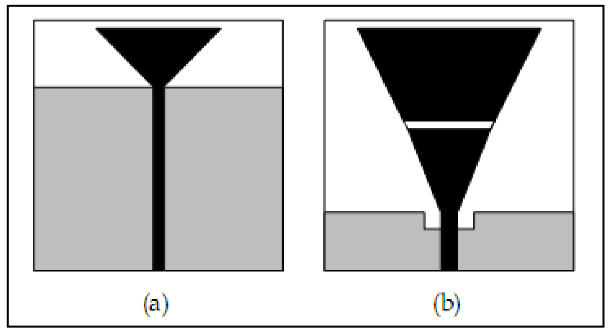

Fig.5 *The microstrip fed monopole antennas with triangular patch*

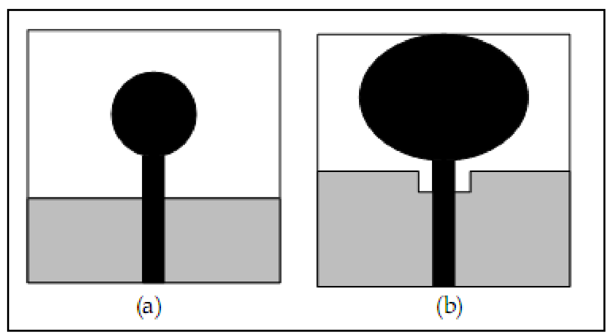

Fig.6 *The microstrip fed monopole antennas with circular and elliptical patch*

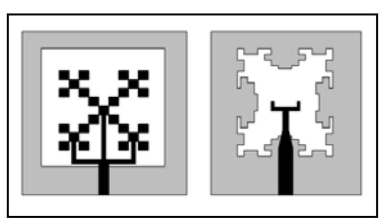

Fig.7 *The frequency notched UWB fractal slot antennas*

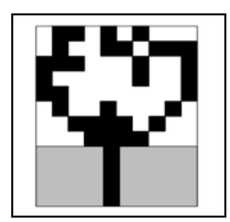

Fig.8 *The frequency notched UWB antenna using genetic algorithm*

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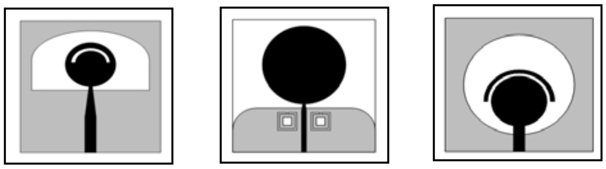

(a) (b) (c)

Fig.9 *The UWB antennas using the slots on the*
(a) *Radiating element* (b) *Ground plane* (c) *Near the radiating element*

4. CASE STUDY

As mentioned above, UWB technology has gained great popularity in research and industrial areas due to its high data rate wireless communication capability for various applications. As a crucial part of the UWB system, UWB antennas have been investigated a lot by researchers and quite a few proposals for UWB antenna design have been reported [2-14, 16-19]. However, the design of those proposed papers are quite complex and tolerance of those special features/variables on the antenna design will be a big issue when it goes to mass production. Hence, this has motivated us to design up a very low complexity, low cost and compact antenna to cover a very wide frequency band including Satellite Digital Multimedia Broadcasting (S-DMB), Wireless Broadband (WiBro), Wireless Local Area Network (WLAN), China Multimedia Mobile Broadcasting (CMMB) and the entire UWB.

In this case study, we present a very simple rectangular (no perturbation) planar antenna having the operating bandwidth ranging from 2GHz-8GHz, by integrating various technologies into one compact antenna. We start with a simple rectangular planar antenna fed by a 50Ω microstrip line with a truncated ground plane. Next, based on the study of the feeding position and current distribution, the antenna is designed to have the operating bandwidth covering the entire UWB, i.e. 3.1GHz-10.6GHz. Then, studies upon the size of the partial ground plane are done to increase the bandwidth towards the lower side of the frequency spectrum, covering the bands for WLAN (2.4GHz - 2.484GHz) and CMMB (2.635GHz–2.66GHz). With an extra patch printed on the back side of the substrate, underneath the rectangular radiator, the bandwidth can be further increased to cover Wibro (2.3GHz-2.4GHz) and S-DBM (2.17GHz-2.2GHz) without significantly influencing other frequency bands. Thus the proposed antenna can be applied in various applications: S-DBM, Wibro, WLAN, CMMB and the entire UWB. The operating bands are evaluated by CST Microwave Studio TM 2009 [20] with the criterion of return loss S1,1 less than -10dB. Simulated radiation patterns over the whole frequency bands are acceptable.

Fig. 10 show the top, bottom and side views of the proposed antenna as well as its dimensions. As has been stated before, the antenna structure comes from a conventional design: a simple pure rectangular planar monopole antenna. Lr and Wr are critical parameters associated with the operating frequencies and input impedance of the antenna. Accordingly, Lr is selected to have a reasonable return loss at middle f= 7 GHz, which is approximate center of the UWB band. A good starting point for the dimension is as follows:

$$L_R \cong \frac{\lambda_{eff} \cdot f_{middle}}{2}$$

Where $\lambda eff = \lambda 0 \sqrt{\varepsilon eff}$ is the effective wavelength for the radiation mode in the substrate with the effective dielectric constant. Wr is chosen to obtain reasonable return loss for the whole frequency band. After performing the optimization of Lr and Wr, the radiator is having a small size of (12.6mm x 15.4mm) (L_r x W_r) and printed on the top side of the (60mm x50mm) (L_{Sub}xW_{Sub}) RT/Duriod5870 substrate with dielectric constant (ε_r=2.33) and height (h=0.79 mm)

5. RESULTS AND DISCUSSION

A. RETURN LOSS

Numerical simulation return loss results of our design performed using Ansoft HFSS, return loss for the UWB antenna is shown in Fig. 11. The bandwidth from the simulation result is achieved around 98% for UWB antenna, and they show more than (-15 to -30) dB return loss at the bandwidth ranging from 3GHz-8GHz.

B. RADIATION PATTERN

The simulation result of the radiation pattern for the UWB antenna at various frequencies is checked. The radiation pattern is in the broadside direction. At lower frequency 3.5 GHz the cross-polar isolation for E plane is 8.5 dB. The HPBW at this frequency is 20^o for E plane. At frequency 4 GHz the cross-polar isolation for E plane is 15.29 dB and the HPBW is 25^{o}The measurement at the middle frequency 5 GHz shows that the cross-polar isolation for E plane is 19.19 dB. The HPBW at this

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frequency is 15° for E planes. For the higher frequency at 6 and 7 GHz the cross-polar isolation is 1.9 dB and 14.54 dB respectively. The HPBW for both frequencies are 40° for E plane as shown in Fig. 11.

6. CONCLUSION

Since the release by the Federal Communications Commission (FCC) of a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra wideband (UWB) wireless communications, UWB is rapidly advancing as a high data rate wireless communication technology. As is the case in conventional wireless communication systems, an antenna also plays a very crucial role in UWB systems. Therefore, UWB planar printed circuit board (PCB) antenna design and analysis have been discussed in this paper. Studies have been undertaken covering the areas of UWB fundamentals and antenna theory. Extensive investigations were also carried out on the development of UWB antennas from the past to present. First, the planar PCB antenna designs for UWB system is introduced and described. Next, the specia design considerations for UWB antennas were discussed and summarized. A new concept (case studies) for the design of a UWB antenna with a bandwidth ranging from 3GHz-8GHz is introduced, which satisfies the system requirements for S-DMB, WiBro, WLAN, CMMB and the entire UWB .

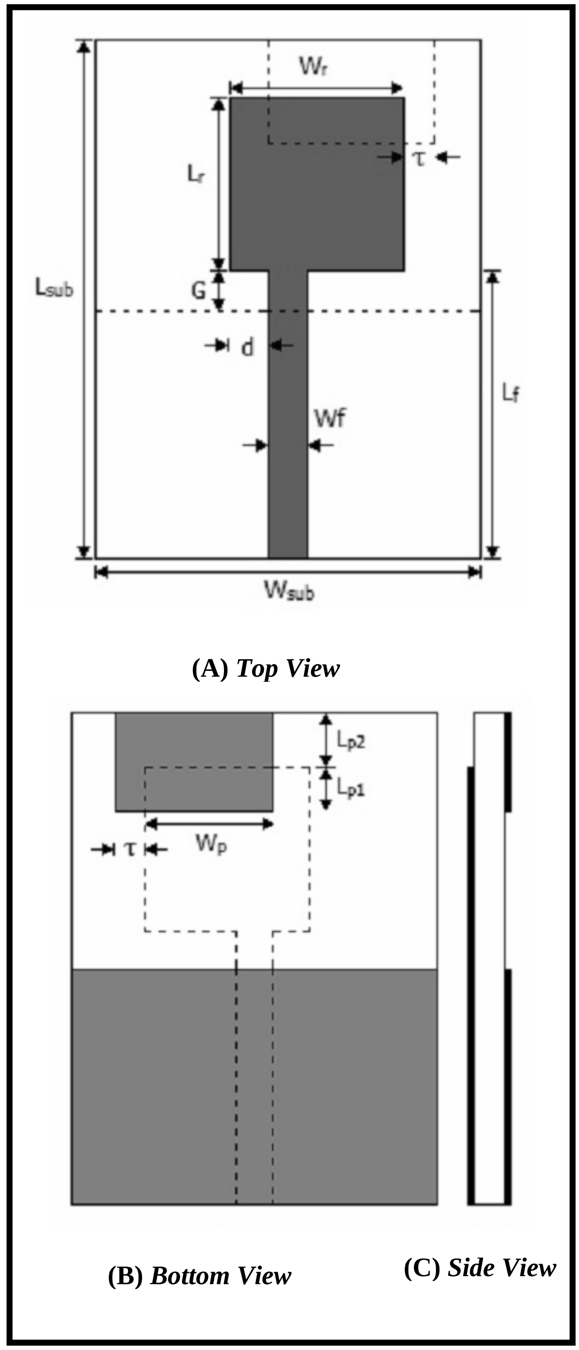

Fig.10 *Configuration of the proposed antenna*

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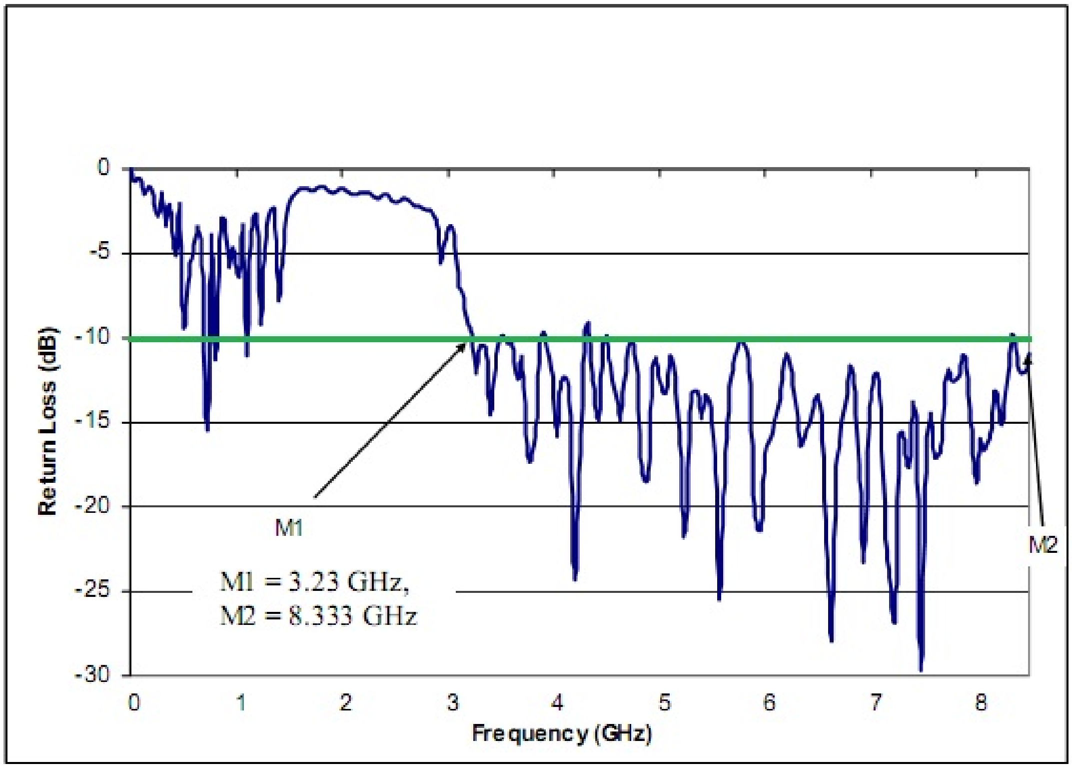

Fig.11 *Simulated Result of the Return Loss for the Proposed Antenna.*

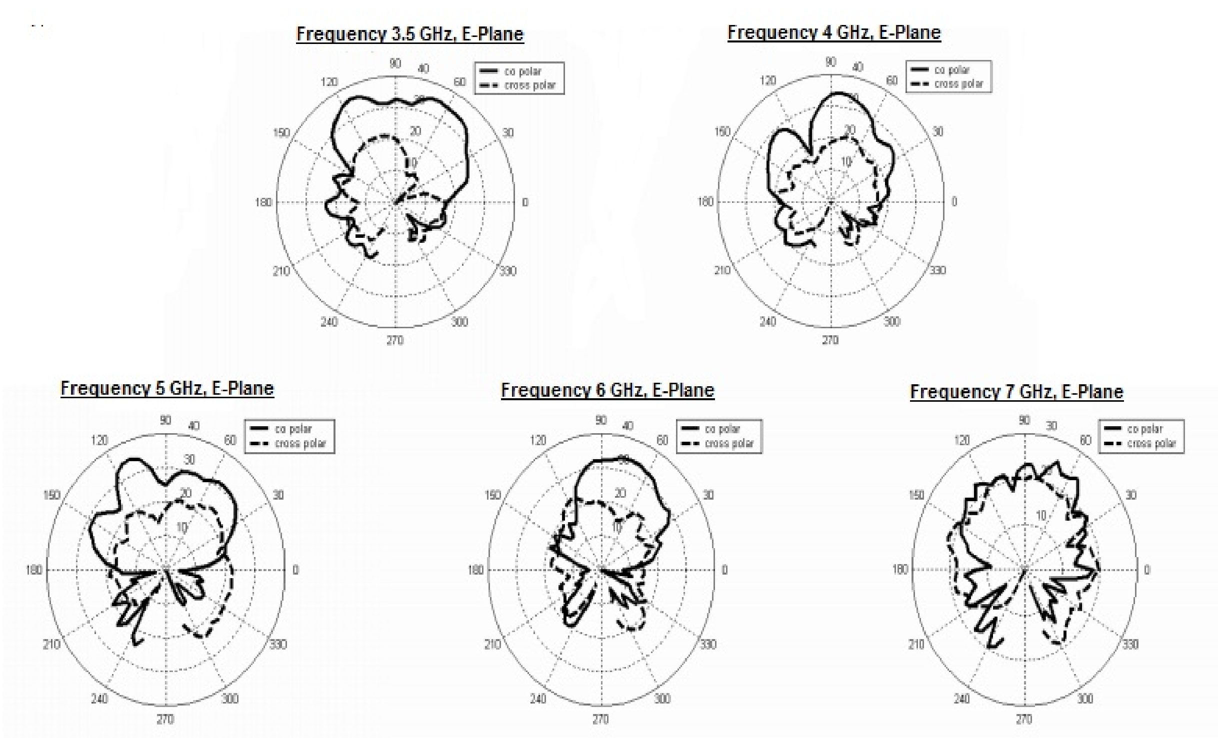

Fig.12 *Radiation Patterns for the Proposed Antenna.*

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REFRENCES:

[1] Federal Communications Commission, Washington, DC, “FCC report and order on ultra wideband technology”, 2002.

[2] Chair, R., A. A. Kishk, K. F. Lee, C. E. Smith, and D. Kajfez, “Microstrip line and CPW fed ultra wideband slot antennas with U-shaped tuning stub and reflector” Progress In Electromagnetics Research, Vol. 56, 163{182, 2006.Progress In Electromagnetics Research Letters, Vol. 22, 2011 45

[3] Sadat, S., M. Fardis, F. Geran, and G. Dadashzadeh, “A compact microstrip square-ring slot antenna for UWB applications” Progress In Electromagnetics Research, Vol. 67, 173{179, 2007

[4] Dastranj, A., A. Imani, and M. Naser-Moghaddasi, “Printed wide-slot antenna for wideband applications” IEEE Transactions on Antennas and Propagation, Vol. 56, No. 10, 3097{3102, 2008.

[5] Guo, L., S. Wang, Y. Gao, Z. Wang, X. Chen, and C. G. Parini, “Study of printed quasi-self-complementary antenna for ultra- wideband systems” Electronics Letters, Vol. 44, No. 8, 511{512,2008}.

[6] Lin, S.-Y. and B.-J. Ke, “Ultrawideband printed patch antenna in notch” Microwave and Optical Technology Letters, Vol. 51, No. 9, 2080{2084, 2009}.

[7] Wang, H., H. Zhang, X. Liu, and K. Huang, “A CPW- fed ultra-wideband planar inverted cone antenna” Progress In Electromagnetics Research C, Vol. 12, 101{112, 2010}.

[8] Latif, S. I., L. Shafai, and S. K. Sharma, “Bandwidth enhancement and size reduction of microstrip slot antennas” IEEE Transactions on Antennas and Propagation, Vol. 53, No. 3, 994{1003, 2005.

[9] Chen, W. S. and K. Y. Ku, “Broadband design of non-symmetric ground ¸λ/4 open slot antenna with small size” Microwave Journal, Vol. 50, 110{121, 2007.

[10] Lin, Y.-C. and K.-J. Hung, “Compact ultra-wideband rectangular aperture antenna and band-notched designs” IEEE Transactions on Antennas Propagation, Vol. 54, No. 11, 3075{3081, 2006.

[11] Chen, D. and C. H. Cheng, “A novel compact ultra-wideband (UWB) wide slot antenna with via holes” Progress In Electromagnetics Research, Vol. 94, 343{349, 2009.

[12] Chen, W. L., G. M. Wang, and C. X. Zhang, “Bandwidth enhancement of a microstrip-line-fed printed wide-slot antenna with a fractal-shaped slot” IEEE Transactions on Antennas Propagation, Vol. 57, No. 7, 2176{2179, 2009.

[13] Song, K., Y.-Z. Yin, and L. Zhang, “A novel monopole antenna with a self-similar slot for wideband applications” Microwave and Optical Technology Letters, Vol. 52, No. 1, 95{97, 2010.

[14] Kim, H. and C.-W. Jung, “Bandwidth enhancement of CPW fed tapered slot antenna with multi-transformation characteristics” Electronics Letters, Vol. 46, No. 15, 1050{1051, 2010.

[15] Federal Communications Commission FCC Website, www.fcc.gov/pshs/techtopics/techtopics10.html.

[16] A.A.Kalteh, R.Fallahi, and M.G.Roozbahani, “A novel Microstrip-fed UWB Circular slot antenna with 5-Ghz Band-notch characteristics” IEEE International Conference on Ultral-wideband (ICUWB2008), vol.1, 2008, pp.117-120.

[17] M.Ojaroudi, G.Ghanbari, N.Ojaroudi, C.Ghobadi, “Small square monopole antenna for UWB applications with Variable frequency band-notch function”, IEEE Antennas and Wireless Propagation Letters, vol.8, 2009.

[18] H.w.Liu, C.H.Ku, T.S.Wang, C.F.Yang, “Compact monopole antenna with band-notched characteristic for UWB applications”, IEEE Antennas and Wireless Propagation Letters, vol. 9, 2010.

[19] B.Ahamadi, R.F.Dana, “A miniaturized monopole antenna for ultra-wideband applications with band-notch filter”, IET Microwave antennas Propagations, vol.3, 2009, pp.1224-1231.

[20] CST Microwave Studio, version 2009,00.

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