Survey of MIMO Application for Compact and Planer UWB Antenna

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Abstract: ***The communication industry field is mainly focused by high data transfer and more channel capacity in mobile communication. The monopole resonator antenna which is used to radiate in the omni - directional pattern is used for multi broadcasting. Ultra wide band antenna technology is used for transmitting the information through large bandwidth. Recently, ultra-wideband (UWB) technology has attracted much attention both in the industry and academia due to its low cost, potential to handle high data rate and relatively low power requirement. A UWB antenna is one of the key components for realizing the UWB systems. We note, however, that designing a UWB antenna to deliver high performance is much more challenging than it is when dealing with the conventional narrowband antennas. Typically, it is desirable for a UWB antenna to cover a wide bandwidth spanning the entire range of 3.1-10.6GHz, to produce an omnidirectional radiation pattern, and to have a compact size as well as a simple configuration. This paper focuses on the planar printed UWB antennas.***

1. Introduction

Antennas are a very important component of communication systems. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain way. A graphical representation of the relative distribution of the radiated power in space is called a radiation pattern. Various MIMO antenna for UWB applications were proposed earlier. A multiple input multiple output (MIMO) band notched antenna for portable Ultra Wide Band applications consisting of two square monopole antenna elements, a vertical Tshaped ground stub to reduce the mutual coupling and two strips on the ground plane to create a notched frequency. The antenna can operate at the frequency range of 3.1GHz to 11GHz with notched frequency of 5.15 - 5.85 GHz. A MIMO antenna for portable UWB applications consists of two planar monopole antenna elements with micro strip-fed printed on one side of the substrate and placed perpendicular to each other to achieve good isolation. To achieve better isolation and to increase impedance matching, two long protruding ground stubs are added to the ground plane on the other side. A short ground strip is used to connect the ground planes of the two PMs together to form a common ground. The use of ultra-wideband (UWB) technology can be traced back to the 1950s for military communications, and high-resolution radar [1-3]. UWB antennas are one of the key components needed to realize a UWB system, and a large number of UWB antennas have been designed and investigated in the past, both numerically and experimentally [4-11]. UWB technique is a radio transmission technology which occupies a relatively wide bandwidth, which exceed 500MHz as a minimum or it has at least 20% of the center frequency [18]. This technology has gained attention because of its potential as a novel approach for short-range and wide bandwidth wireless communication. In contrast to the traditional narrowband communication systems, UWB systems transmit information by generating radio energy at specific time instants in the form of very short pulses. Thus, these systems occupy a relatively large bandwidth and enable us to use time modulation. In addition, UWB systems can provide a high data rate which can reach up to hundreds of Mbits per second, and which make them useful for secure communication in military applications. Moreover, the UWB systems demand a relatively low transmitting power in comparison with the traditional narrowband communications systems; hence their use can prolong the battery life. In addition, use of short pulses helps reduce multipath channel fading since the reflected signals do not overlap with the original ones. In view of these aforementioned advantages, and following the approval of the FCC in 2002, a number of related topics pertaining to UWB systems have been proposed and studied for more than a decade. The Ultra wide band MIMO antenna which covers WCDMA (1.92 - 2.17 GHz), Wi-Max (2.3, 2.5 GHz), WLAN (2.4 GHz), UWB (3.1 -10.6 GHz) bands for wireless device applications consists of printed folded monopole antenna coupled with a parasitic inverted-L element with an open stub inserted in the antenna to reject the WLAN band which interfere with the UWB band. The two antennas are arranged symmetrically on the mobile device substrate. Here, the antenna structure was little complicated and required high fabrication accuracy. Dual –slot element antenna with parasitic monopoles for mobile terminals was used. Double coupling path was introduced which create a reverse coupling to reduce mutual coupling. Parasitic elements are used to reduce the mutual coupling. A compact planar ultra wide band (UWB) antenna with band notched characteristics has the shape of radiation element and ground plane modified with two symmetrical bevel slots on the lower edge of the radiation element and on the upper edge of the ground plane to make the antenna different from the rectangular printed monopole. These slots improve the input impedance bandwidth and the high frequency radiation characteristics. An additional small radiation patch was introduced to develop a frequency-notched antenna. A compact printed UWB MIMO antenna system was proposed which was operating at a frequency of 3.1 to 10.6 GHz. The wide band isolation was achieved through a tree-like structure on the ground plane. It is suitable for portable UWB applications. This paper, which focuses on printed UWB antenna, begins by presenting a review of the development of UWB antennas from past to present. First, we illustrate the UWB antenna designs based on microstrip-fed and CPW-fed techniques. Next, we describe the band-notched UWB antennas based on the previously proposed UWB antennas. Also introduce the concept of MIMO-UWB antennas. Finally, we turn to some special designs for configurable UWB antennas that have a wide bandwidth and notch-band reconfigurablity, useful for multi-band as well as CR communication, which can meet the system requirements not only for UWB applications but for multi-band and CR communication applications as well.

2. Conventional UWB Antennas

As mentioned above, UWB technology is characterized by a large bandwidth that can be defined as absolute bandwidth and the fractional bandwidth. The Federal Communications Commission (FCC) defines UWB operation as any transmission scheme that has a fractional bandwidth greater than or equal to 20% or an absolute bandwidth greater than or equal to 500 MHz. Here, the fractional bandwidth (FBW) is then given by the following equation:

$$\text{FBW}= 2\frac{f_H - f_L}{f_H + f_L}$$

where H f is the upper boundary of the frequency bandwidth and L f is the lower boundary of the frequency bandwidth. Many of the conventional wideband antennas, shown in Fig. 1, which satisfy the definition of UWB bandwidth, can be used for UWB applications. These conventional antennas include horn antennas, and monopole as well as dipole antennas, which have wide bandwidth and have been widely studied and investigated for UWB communication applications. However, these antennas are large in size, hence are difficult to integrate into hand-sets and indoor wireless communication terminals..In addition, their size cannot be significantly miniaturized in comparison with fully planar structures, such as microstrip antennas.

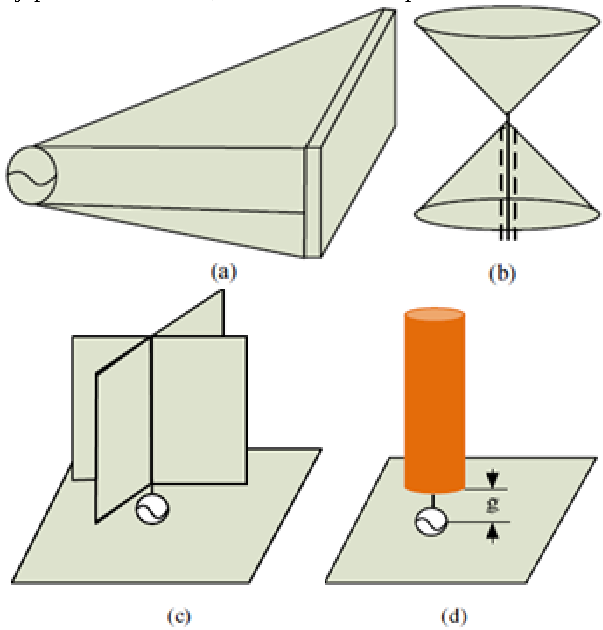

Figure 1: Conventional wideband antennas

A. UWB antennas

To meet the requirements for hand-held devices and indoor wireless applications, the monopole antenna shown in Fig. 1(d) has been modified to develop printed antennas by using the equivalent area method proposed in [29, 94-96], which is described below. For a monopole antenna, the lower frequency Lf, with the voltage standing wave ratio (VSWR) less than 2, can be obtained by means of the approximation method of equivalent area from a cylindrical monopole antenna, shown in Fig. 2.

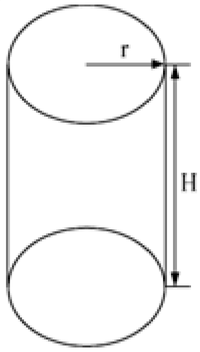

Figure 2: Parameters of cylindrical antenna

A number of CPW-fed UWB antennas with compact size have been developed and investigated to meet the requirements of impedance bandwidth and the omnidirectional radiation pattern characteristics. CPW-fed UWB antennas are printed only on one side of the substrate, which may reduce the cost of fabrication. Moreover, the CPW-fed structure is easy to integrate with the front-ends of wireless communication systems, which not only simplifies the design of the front-end but also gives rise to low complexity of the device. From the previous investigations on the design of CPW-fed UWB monopole antennas, we know that these antennas are compact in size, and they offer a wide bandwidth, as well as good omnidirectional radiation patterns that are suitable for practical UWB communication applications.

B. Bandwidth Enhancement Techniques

We point out that some of the proposed UWB antennas cannot cover the entire impedance bandwidth designated by the FCC, which ranges from 3.1 GHz to 10.6 GHz. In order to enhance the impedance bandwidth of these antennas, several bandwidth enhancement techniques have been proposed. These include introducing stair-case tapers on the radiating patch, or inserting slots either on the radiating patch or in the ground plane of these UWB antennas. By using these bandwidth enhancement techniques, the impedance bandwidth of the related antennas can be significantly improved.

C. Band-notched UWB antennas

Based on the above discussion of microstrip- and CPW-fed UWB antennas, we observe that these UWB antennas not only cover the entire bandwidth designated by the FCC, but can also provide good radiation patterns over the operational frequency band. However, there exist a large number of narrowband wireless communication systems that have around for a long time, and they may present potential interference with the UWB system and vice versa. Examples are IEEE 802.11a WLAN systems operating at 5.15–5.825 GHz, super high frequency (SHF) and satellite services operating in the 4.5-5 GHz band, IEEE 802.16 WiMAX systems operating in 3.3–3.7 GHz range and ITU 8 GHz band operating in the 7.725-8.275 GHz band. To suppress these types of unwanted potential interference to the UWB system, the traditional method is to insert narrowband bandstop filters in the antenna or in the feed line, which increases the complexity as well as cost of the devices.

D. Reconfigurable UWB antennas

It is worthwhile to mention that these band-notched UWB antennas cannot be used to cover the entire UWB band we desire. Thus, designing a UWB antenna which can switch between a notch-band and a conventional UWB antenna is necessary. For this reason, a number of reconfigurable UWB antennas have been proposed for operation either as a notch-band or a full UWB antenna, an example being the reconfigurable wide slot UWB antenna shown in Fig.3. In this figure, switch-1 (SW1), switch-2 (SW2) and switch-3 (SW3) are used for controlling the operational state of the UWB antenna. When all the switches are turned ON, this antenna operates as a band-notched UWB antenna, which can be used to reduce potential interference from signals emanating from narrowband systems. When all the switches are OFF, this antenna functions as a UWB antenna, which covers the entire the FCC-designated UWB band ranging from 3.1 GHz to 10.6 GHz. However, when the SW1 switch is ON while SW2 and SW3 are OFF, it functions as a UWB antenna with only a single notch band. In this design, the SW2 and SW3 are turned ON or OFF at the same time to retain the symmetry of the antenna, which can also achieve a good omnidirectional radiation pattern. In addition, such reconfigurable UWB antennas can also be used for UWB-CR communication applications. Thus, the reconfigurable UWB antenna is one of the desirable candidates for such applications.

3. Special Design of Reconfigurable UWB Antennas

We now turn to an example of a reconfigurable UWB antenna design, which is a modification of the reconfigurable UWB antenna. The geometry of the proposed reconfigurable dual-band-notched UWB antenna is presented in Fig. 4. A substrate with a dielectric constant of 2.65, a loss tangent of 0.002, and a thickness of 1.6mm is employed to design the antenna by using a commercial electromagnetic solver HFSS (High Frequency Structure Simulator) based on the Finite Element Method (FEM). The antenna consists of a circular wide-slot in the CPW ground plane, a circular ring radiating patch, a pair of open-ended T-shaped stubs (OET-S) inserted into the inside of the circular ring radiating patch, an inverted-F stub loaded rectangular resonator (IFSLRR) etched in the CPW-fed transmission line, two ideal switches denoted as switch-1 (SW1) and switch-2 (SW2), and a CPW ground plane together with a 50 Ohm CPW feed structure. The 50 Ohm CPW feed structure is comprised of two parts, namely, CWP-fed transmission line having a width of W5=3.6mm and a gap between the CPW ground plane, and the CWP-fed transmission line with a width of 0.2mm.

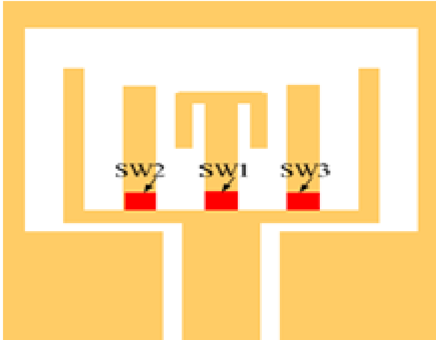

Figure 3: Reconfigurable band-notched UWB antenna

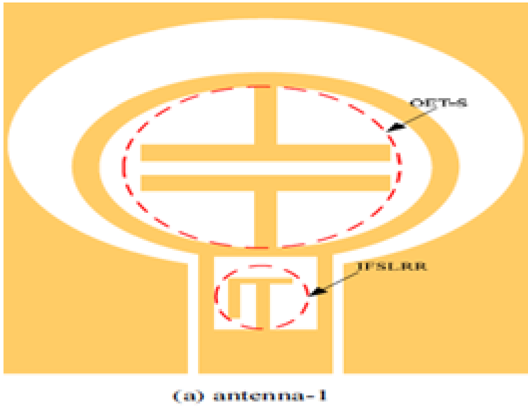

Figure 4: Example of a reconfigurable UWB antenna

4. Future Work and Development

For commercial applications 3.1-10.6 GHz bandwidth has now been released. Some topics are still being investigated for future UWB antenna designs such as Multiple notch band UWB antennas, Reconfigurable UWB antennas and MIMO UWB antennas.

5. Conclusions

In this paper, we have studied and reviewed a wide variety of UWB antennas. We found that there are number of interesting aspects that need to be taken into account when designing high performance UWB antennas, as opposed to conventional narrowband antennas. We also highlighted number of potential applications that could be further considered for designing UWB antennas. We concluding that UWB antenna measurements and characterization of UWB antennas for practical applications should be carried out in the time domain. In future, we believe that UWB antennas show considerable promise and that they will witness further developments alongside the rapid and explosive growth of wireless communication technology that we are witnessing today.

References

[1] V. H. Rumsey, "Frequency Independent Antennas", IRE national convention record, Part I, pp. 114-118, 1957.
[2] V. H. Rumsey, "A Solution to the Equiangular Spiral Antenna Problem," IRE National Convention, 1959.
[3] John D. Dyson, 'The Equiangular Spiral Antenna,' IRE National Convention, 1959.

[4] D. G. Berry and F. R. Ore, "Log Periodic Monopole Array ", IRE Int. Conv. Rec., Vol. 9, pp. 76-85, 1961
[5] R. H. DuHamel and D. E. IsBell, "Broadband Logarithmically Periodic Antenna Structures", IRE national convention record, Part I, pp. 119-128, 1957.
[6] B. Rojarayanont and T. Sekiguchi, "A Study on Log-Periodic Loop Antennas", The Trans. of IECE of Japan, Vol. J60-B, pp. 583-589, August 1977.
[7] A. Moallemizadeh, H.R. Hassani, and S. Mohammad ali nezhad , "Wide bandwidth and small size LPDA antenna," 2012 6th European Conference on Antennas and Propagation (EUCAP), pp.1-3, 2012.
[8] R. Dehdasht-Heydari, H. R. Hassani, and A. R. Mallahzadeh, "Quad ridged horn antenna for UWB applications," Progress In Electromagnetics Research,Vol. 79, 23-38, 2008.
[9] J. D. Kraus and R. J. Marhrfka, Antennas, McGraw-Hill, 3rd Edition, Nov. 2001.
[10] L. T. Chang and W. D. Burnside, "An ultrawide-bandwidth tapered resistive TEM horn antenna," IEEE Transactions on Antennas and Propagation, vol.48, pp.1848–1857, 2000.
[11] R. T. Lee and G. S. Smith, "On the characteristic impedance of the TEM horn antenna," IEEE Transactions on Antennas and Propagation, vol.52, pp.315–318, 2004.
[12] Federal communications commission, First report and order, Revision of Part 15 of commission's rule regarding UWB transmission system FCC 02-48, Washington, DC, USA, 2002.
[13] J. Liang, C. C. Chiau, X. Chen, and C. G. Parini, "Study of a printed circular disc monopole antenna for UWB systems", IEEE Transactions on Antennas and Propagation, vol. 53, no. 11, pp. 3500-3504, 2005.
[14] S. H. Choi, J. K. Park, S. K. Kim, and J. Y. Park, "A new ultra-wideband antenna for UWB applications," Microwave and Optical Technology Letters, vol.40, no.5, pp.399-401, 2004.
[15] A. Alipour and H. R. Hassani, "A novel omni-directional UWB monopole antenna," IEEE Transactions on Antennas and Propagation, vol. 56, no. 12, pp. 3854– 3857, 2008.
[16] C.-L. Hsu, F.-C. Hsu, and J.-T. Kuo," Microstrip bandpass filters for ultra-wideband (UWB) wireless communications", in IEEE MTT-S International, Long Beach, CA, pp.679–682, 2005.
[17] T. Jiang, C. Y. Liu, Y. S. Li, M. Y. Zhu , "Research on a Novel Microstrip UWB Notch-Band BPF", in Proc.APMC, pp.261-264,2009.
[18] E. G. Lim, Z. Wang, C. U. Lei, Y. Wang, and K. L. Man, "Ultra wideband antennas----Past and present," IAENG International Journal of Computer Science, vol.37, no.3, 2010.
[19] Z. Yang, J. Qiu, W. guo, and C. Yang, "Novel ultra-wide band omni-directional dipole antenna," 2012 International Conference on Microwave and Millimeter Wave Technology (ICMMT), vol.3, pp.1-4, 2012.
[20] L. Lizzi, F. Viani, R. Azaro, A. Massa, "Design of a miniaturized planar antenna for FCC-UWB communication systems," Microwave and Optical Technology Letters, vol.50, no.7, pp.1975-1978, 2008.
[21] Q. Ye, Z. N. Chen, and T. S. P. See, "A novel butterfly-shaped monopole UWB antenna," Microwave and Optical Technology Letters, vol.51, no.3, pp.590-593, 2009.
[22] Y. Li, X. D. Yang, C. Y. Liu, and Q. T. Li, "A non-planar monopole antenna for ultra-wideband bandwidth applications," The 6th International conference on wireless communications, Networking and Mobile Computing, Chengdu, China, September, 2010.
[23] Yingsong Li, Wenxing Li, Qiubo Ye and Raj Mittra," A Survey of Planar Ultra-Wideband Antenna Designs and Their Applications" Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)
[24] *S D Priya Sankari," A Compact MIMO Antenna For UWBApplications"* International Conference on Emerging Engineering Trends and Science (ICEETS – 2016)
[25] Z. N. Chen, "Novel bi-arm rolled monopole for UWB applications," IEEE Transactions on Antennas and Propagation, vol. 53, no. 2, pp. 672–677, Feb. 2005.
[26] M. J. Ammann and Z. N. Chen, "A Wide-Band Shorted Planar Monopole With Bevel," IEEE Transactions on Antennas and Propagation, vol. 51, no. 4, pp. 901-903, April 2003.
[27] G. Kumar, K. P. Ray, Broadband microstrip antennas, Artech House, 2003.
[28] Z. N. Chen, M. J. Ammann, X. Qing, X. H. Wu, and T. S. P. See, "Planar antennas," IEEE Microwave Magazine, vol.7, no.6, pp.63-73, Dec. 2006.
[29] H. Wang, Y. Li, "Bandwidth enhancement of a wide slot UWB antenna with a notch band characteristic," IEEE 3rd International Conference on Communication Software and Networks (ICCSN), pp.365-368, Xi'an, 2011.
[30] N. Ojaroudi and M. Ojaroudi, "Bandwidth enhancement of an ultra wideband printed slot antenna with WLAN band - notched function," Microwave and Optical Technology Letters, vol.55, no.7, pp.1448-1451, 2013.