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Planar UWB Antenna with Double Band Rejection Capability Using Double Inclined ESRRs

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Abstract—This paper deals with elliptical split ring resonator (ESRR) loaded CPW-fed ultra wideband (UWB) printed monopole antenna (PMA) with dual band-notching at 5.2 and 6.9 GHz to notch WLAN and C-band wireless applications, respectively. The antenna is fabricated on duroid dielectric substrate with thickness of 1.6 mm and $\varepsilon_r = 2.2$. The antenna uses two ESRR with different dimensions to create dual band-notched characteristics. Details of the proposed antenna are presented along with simulated results. The effect of ESRR dimensions and position is examined. The ESRR is also rotated and the effect of this rotation in the notch frequency is also examined. Radiation patterns are simulated by HFSS and omnidirectional radiation patterns in the *H*-plane could be observed. The group delay is nearly stable in the UWB frequency range, except at the notch frequencies, which is distorted sharply. So, the proposed antenna is a good candidate for the modern UWB systems. Finite element method (FEM) and finite integration technique (FIT) are used to simulate the proposed structures through the usage of HFSS and CST. A very good agreement between both results has been obtained.

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1. INTRODUCTION

A leap in scientific research has occurred since February 2002, when the FCC decree that UWB could be used for data communications as well as for radar and safety applications [1]. The Federal Communications Commission (FCC) first defined UWB as any system having a bandwidth of at least 500 MHz or a fractional bandwidth larger than 0.20.

Higher data rates, low power consumption large band width, etc. are some of the reasons why ultra-wideband has attracted all the attention over the past years [2]. By comparing ultra-wideband (UWB) system with conventional or narrowband systems, a large bandwidth is used to transmit data. The power used over the whole band is much lower than the power used by narrowband systems [3].

In 2002 the FCC allowed the frequency band between 3.1 and 10.6 GHz for unlicensed UWB transmission. The effective isotropic radiated power (EIRP) should be below –41.3 dBm inside the frequency band. UWB provides high secure and high reliable communication solutions due to the low energy density. UWB system has features of low cost and low complexity as it based on baseband signal transmission. UWB does not need modulation and demodulation, so it does not require components such as local oscillators, amplifiers, filters, and mixers.

The antennas are an essential part of any wireless system. Antennas fabricated on planar substrates have been of increased demands it yields very large bandwidth so it can be easily integrated with the microwave integrated circuit (MIC) used in high frequency applications [4–7]. Using this technology, antennas can be of reduced size and easily manufactured.

Sometimes, it is also demanded UWB antenna with frequency notch characteristics need to be designed to suppress radiation to obviate interference of UWB system with the other narrow-band devices and services occupying the same operational band like WLAN, WiMAX, C-, and X-band wireless systems [8, 9]. These bands could be rejected with band stop filters in UWB, but this approach will increase the

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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REFERENCES

1. FCC, First Report and Order 02-48 (Feb. 2002).
2. I. Oppermann, M. Hamalainen, J. Iinatti, *UWB Theory and Applications* (John Wiley & Sons, Ltd, 2004).
3. D. D. Wentzloff, R. Blazquez, F. S. Lee, B. P. Ginsburg, J. Powell, A. P. Chandrakasan, "System design consideration for ultra-wideband communication," *IEEE Commun. Mag.* **43**, No. 8, 114 (Aug. 2005). DOI: 10.1109/MCOM.2005.1497561.

4. K. P. Ray, G. Kumar, P. Anob, "Wideband circular wire mesh and annular ring monopole antennas," *Microwave Opt. Technol. Lett.* **48**, No. 12, 2459 (2006). DOI: 10.1002/mop.21977.
5. H. G. Schantz, "Planar elliptical element ultra-wideband dipole antennas," *IEEE Antennas and Propagation Society Int. Symp.*, 16-21 Jun. 2002, San Antonio, USA (IEEE, 2002), Vol. 3, pp. 44. DOI: 10.1109/APS.2002.1018152.
6. K. P. Ray, "Design aspects of printed monopole antennas for ultra-wide band applications," *Int. J. Antennas Propag.* **2008**, ID 713858 (2008). DOI: 10.1155/2008/713858.
7. X.-B. Sun, M.-Y. Cao, Y.-J. Guo, J.-J. Hao, "A planar circular disc monopole with improved bandwidth," *Microwave Opt. Technol. Lett.* **54**, No. 3, 593 (2012). DOI: 10.1002/mop.26595.
8. D. Thiripurasundari, D. S. Emmanuel, "CPW fed slot antenna with reconfigurable rejection bands for UWB application," *Radioelectron. Commun. Syst.* **56**, No. 6, 278 (2013). DOI: 10.3103/S0735272713060022.
9. E. K. I. Hamad, N. Mahmoud, "Compact tri-band notched characteristics UWB antenna for WiMAX, WLAN and X-band applications," *Advanced Electromagnetics* **6**, No. 2 (May 2017). DOI: 10.7716/aem.v6i2.465.
10. M. Awida, A. Boutejdar, A. Safwat, H. El-Hennawy, A. Omar, "Multi-bandpass filters using multi-armed open loop resonators with direct feed," *IEEE/MTT-S Int. Microwave Symp.*, 3-8 Jun. 2007, Honolulu, USA (IEEE, 2007), pp. 913-916. DOI: 10.1109/MWSYM.2007.380129.
11. A. Kumar, M. K. Singh, "Band-notched planar UWB microstrip antenna with T-shaped slot," *Radioelectron. Commun. Syst*. **61**, No. 8, 371 (2018). DOI: 10.3103/S0735272718080058.
12. Y. Zhang, W. Hong, C. Yu, Z.-Q. Kuai, Y.-D. Don, J.-Y. Zhou, "Planar ultrawideband antennas with multiple notched bands based on etched slots on the patch and/or split ring resonators on the feed line," *IEEE Trans. Antennas Propag*. **56**, No. 9, 3063 (2008). DOI: 10.1109/TAP.2008.928815.
13. A. A. L. Neyestanak, A. A. Kalteh, "Band-notched elliptical slot UWB microstrip antenna with elliptical stub filled by the H-shaped slot," *J. Electromagn. Waves Appl.* **22**, No. 14-15, 1993 (2008). DOI: 10.1163/156939308787537973.
14. M. Yazdi, N. Komjani, "A compact band-notched UWB planar monopole antenna with parasitic elements," *PIER Lett.* **24**, 129 (2011). DOI: 10.2528/PIERL11043002.
15. X.-J. Liao, H.-C. Yang, N. Han, Y. Li, "UWB antenna with dual narrow band notches for lower and upper WLAN bands," *Electronics Lett.* **46**, No. 24, 1593 (2010). DOI: 10.1049/el.2010.1943.
16. L. Li, Z.-L. Zhou, J.-S. Hong, B.-Z. Wang, "Compact dual-band-notched UWB planar monopole antenna with modified SRR," *Electronics Lett.* **47**, No. 17, 950 (2011). DOI: 10.1049/el.2011.1874.
17. D. Jiang, Y. Xu, R. Xu, W. Lin, "Compact dual-band-notched UWB planar monopole antenna with modified CSRR," *Electron. Lett.* **48**, No. 20, 1250 (Sep. 2012). DOI: 10.1049/el.2012.2489.
18. W. Jiang, W. Che, "A novel UWB antenna with dual notched bands for WiMAX and WLAN applications," *IEEE Antennas Wireless Propag. Lett.* **11**, 293 (2012). DOI: 10.1109/LAWP.2012.2190490.
19. M.-C. Tang, S. Xiao, T. Deng, D. Wang, J. Guan, B. Wang, G.-D. Ge, "Compact UWB antenna with multiple band-notches for WiMAX and WLAN," *IEEE Trans. Antennas Propag.* **59**, No. 4, 1372 (Apr. 2011). DOI: 10.1109/TAP.2011.2109684.
20. Lin Peng, Cheng-Li Ruan, "UWB band-notched monopole antenna design using electromagnetic-bandgap structures," *IEEE Trans. Microwave Theory Tech.* **59**, No. 4, 1074 (2011). DOI: 10.1109/TMTT.2011.2114090.
21. J. Y. Siddiqui, C. Saha, Y. M. M. Antar, "Compact SRR loaded UWB circular monopole antenna with frequency notch characteristics," *IEEE Trans. Antennas Propag.* **62**, No. 8, 4015 (2014). DOI: 10.1109/TAP.2014.2327124.
22. J. Y. Siddiqui, C. Saha, Y. M. M. Antar, "Compact dual-SRR-loaded UWB monopole antenna with dual frequency and wideband notch characteristics," *IEEE Antennas Wireless Propag. Lett.* **14**, 100 (2015). DOI: 10.1109/LAWP.2014.2356135.
23. Chinmoy Saha, Jawad Y. Siddiqui, Y. M. M. Antar, "Multilayered stacked square SRR coupled UWB monopole antenna with dual notch function," *Proc. of IEEE Antennas and Propagation Society Int. Symp.*, 6-11 Jul 2014, Memphis, USA (IEEE, 2014), pp. 787-788. DOI: 10.1109/APS.2014.6904723.
24. M. Nitas, M.-T. Passia, T. V. Yioultsis, "Analysis and design of a CSRR-based fully planar substrate-integrated waveguide for millimeter-wave circuits and antennas," *Proc. of 11th European Conf. on Antennas and Propagation*, EUCAP, 19-24 Mar 2017, Paris, France (IEEE, 2017), pp. 3501-3505. DOI: 10.23919/EuCAP.2017.7928832.
25. M. A. W. Nordin, M. T. Islam, N. Misran, "Design of a compact ultra wideband metamaterial antenna based on the modified split-ring resonator and capacitively loaded strips unit cell," *PIER* **136**, 157 (2013). DOI: 10.2528/PIER12100708.
26. A. S. Elkorany, Ghidaa T. Ahmed, Said M. Elhalafawy, Demyana A. Saleeb, "New dual band notched UWB monopole antenna using two HSRRs," *Wireless Commun.* **9**, No. 6, 129 (2017). URI: http://www.ciitresearch.org/dl/index.php/wc/article/view/WC072017005.
27. A. S. Elkorany, Ghidaa T. Ahmed, Demyana A. Saleeb, Hesham A. Mohamed, "Tunable elliptical split ring resonator using single varactor diode," *Advanced Electromagnetics* **7**, No. 1, 7 (2018). DOI: 10.7716/aem.v7i1.580.
28. http://www.ansys.com/Products/Electronics/ANSYS-HFSS.
29. https://www.cst.com/products/cstmws.