Modified UWB Antenna for Cognitive Radio Applications

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Abstract

In this study, an integrated dual port ultra-wide band (UWB) and narrow band (NB) antennas for cognitive radio (CR) application are reviewed. In this paper, a monopole circular antenna is used for UWB sensing antenna fed by coplanar waveguide (CPW) transmission line with rectangular ground plane. The etched "e" shaped micro-strip antenna is basically used for NB as communication purposes, having low surface current density. This integrated antenna is a potential element for CR application, where circular monopole covers the UWB frequency band (3.1GHz to 10.6GHz) for spectrum sensing and NB having two resonant frequencies of 4.8GHz and 5.8GHz for WLAN application in mobile, laptops and wireless adapters operating at C- band. The return loss is less than -10dB in the whole operating band.

Keywords - *Ultra wide band (UWB), narrow band (NB), cognitive radio (CR), coplanar waveguide (CPW).*

I. INTRODUCTION

This document is a template. For the communication system, electromagnetic spectrum plays crucial role. It is kind of natural resource, used as transmitter and receiver efficiently declared by government [1]. As we know electromagnetic spectrum is very vast having the problem of congestion and interference, for this cognitive radio comes under consideration to avoid above problems [2-10]. In such a way, dynamic spectrum management process applied, in which radio signal having the intelligence power to detect the available channel in the spectrum then corresponding changes the features and parameters of transmission and reception in a given band at same location. It is most promising technique for wireless application which makes wireless and radio network fully cognitive. A cognitive radio is "continuously monitoring its own action" in addition to "finding the radio application".

Radio spectrum consists of various numbers of bands, in which ultra wide band having frequency range from 3.1GHz to 10.6GHz (bandwidth=7.5GHz), occupies a very wide bandwidth with the feature of Gigabits/sec data rate. UWB also known as digital wireless pulse used for transmits maximum number of data over the broad spectrum of frequency band, UWB carrying low power consumption as less than 0.5milliwatts for short distance up to 230 feet to achieve high bandwidth connections [11-20]. This bandwidth implies to cause of interference, just because of it will easily cross the boundaries of many present licensed carrier based transmissions, and low power spectral density function. UWB includes several of advantages as robustness for multipath fading, low power transmission and dissipation. It is also having some similar characteristics like wireless technology that might allow it to coexist with various networking standard LAN, MAN & WAN.

Narrow band implies to data and telecommunication services and tools that having narrow set of frequencies in communication channels. It is generally used to carry out the voice data audio spectrum that accepts the restricted frequency range. The federal communication commission (FCC) has approved the use of UWB technology for commercial purposes and FCC also allocated specific range of frequency as 50cps to 64kbps for mobile communication on 14th February, 2002 [21-22].

II. STATE OF ART

It is kind of integrated antenna for cognitive radio having UWB for sensing and monitoring the spectrum and narrow band NB for communication purposes. For the non fading environment the capacity of communication channel can be derived as:-

$$C = B * log2\ [1 + \frac{S}{N} \qquad (1)$$

C= channel capacity. (Bit/sec)
B= channel bandwidth (Hz)
S= signal power (watts)
N= noise power (watts)

From the above equations, refer that capacity C is directly proportional to B and S, and inversely proportional to N. As the UWB system having the issue of interference from other wireless technology but this complication can be diminish by adaptive selection of frequency band in assorted band UWB system. The wide band antenna used for feeding the receiver for spectrum sensing [23].

III. ANTENNA DESIGN

This is kind of integrated antenna system combines with UWB for sensing the spectrum and NB for transmission and reception purpose. Here the new integration technique takes place where one antenna having large metallization space which is efficiently shared by additional antenna. The present design is two port antenna system where port 1 consist of coplanar waveguide (CPW) fed circularly monopole radiating patch [24] as the first antenna performing UWB operations and port 2 consist of coaxial fed "e" shape micro-strip slot antenna achieve narrow band NB applications as second antenna providing dual purpose operations. Both antennas are working simultaneously aiming to space of low current concentration. Here port 1 circular monopole behaves as coplanar ground for second "e" shape antenna for narrow band at port 2. In this way, such kind of approach provides dual band communication for CR application. The proposed dual antenna geometry is designed and simulated by using Ansys High Frequency Structural Simulator (HFSS.14) [25].

In this defined integrated antenna design, reported in [26], is examine as a reference design and then further refinements are carried out to enhance the performance. The UWB and NB antennas are printed on a very compact FR-4 epoxy substrate of the dimensions of 30mm*30mm*1.6mm as shown in fig.1. The FR-4 epoxy substrate having relative permittivity $\varepsilon_r = 4.4$, relative permeability $\mu_r=1$ and dielectric loss tangent tan Ө= 0.025.The width of micro-strip is optimized for impedance matching of 50Ω. The radius of circular patch can be defined by formula considering lower frequency as 3.1 GHz.

$$L.F. = \frac{7.2}{2.25 * R + g} \qquad (2)$$

Where L.F. = lower resonant frequency in GHz, R= radius of circular patch in centimeters, g= gap in centimeters between patch and ground plane.

The radius of patch determine the variation in return loss as increase in the radius, resonance gets shifted towards lower frequency [27]. The design analysis and optimization of antenna were performed using finite element method (FEM) based up on HFSS simulator.

The design approach includes two antenna systems. The first antenna is CPW fed circular monopole provide high impedance matching over wider bandwidth. The second antenna placed on the same substrate etched "e" shape micro-strip fed by coaxial feeding technique incorporated very good isolation and mutual coupling between the ports [28,29].

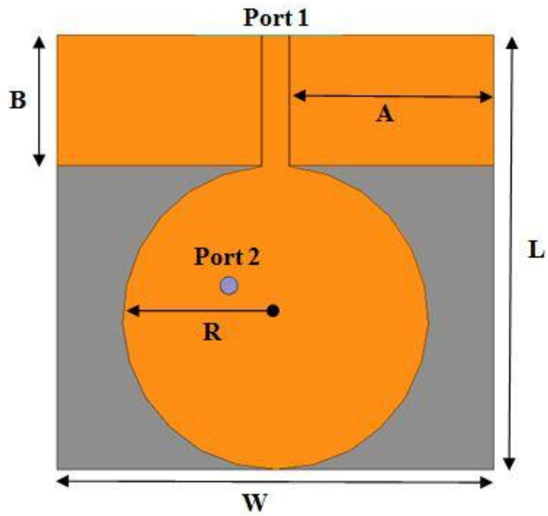

Fig.1. Proposed dual port integrated UWB and NB antenna system top view

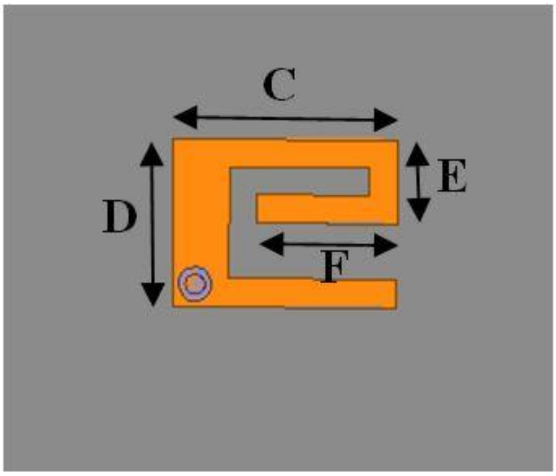

Fig.2. Proposed dual port "e" shape etched integrated antenna system bottom view

TABLE I
Antenna Parameters

Parameters	Values (mm)
W	30
L	30
R	10.5
A	14
B	9
C	8
D	6
E	3
F	5

IV. RESULT ANALYSIS

The simulation of prototype antenna done by HFSS to activates the communication in bandwidth from 3.1GHz to 10.6 GHz. The simulated reflection coefficient for UWB and NB antenna describe by S_{11} and S_{22} parameter respectively in fig [3].The NB resonates at two frequency 4.8GHz and 5.8GHz used for WLAN mobile, laptop and wireless adapters also. Additionally, the reflection coefficient $S_{11}$and S_{22}value below -10dB indicates the frequency region where antenna can radiate electromagnetic energy efficiently [30].

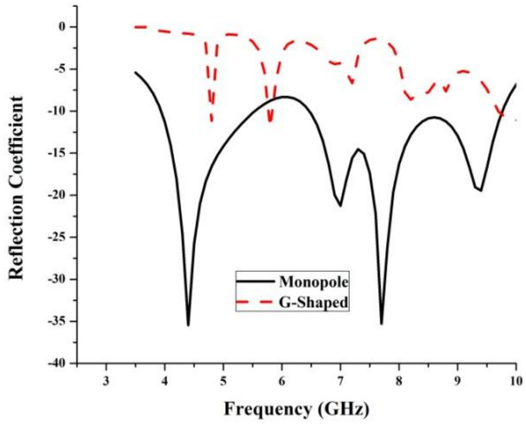

Fig.3. Reflection coefficient of integrated antenna system

V. CONCLUSION

From the above discussion and result analysis, it can be concluded that integrated antenna for cognitive radio application provides better performance in terms of high data rates and bandwidth compared to other. In sequence to get rid of interference between UWB and communication NB such as WLAN and C- band communication system, a simple integrated antenna with two notch band for UWB application is designed in this paper and simulated result shoes the better agreement for cognitive radio application.

REFERENCES

[1] J.Mitola and G.Q. Maguire, Cognitive radio: Making softwareradios more personal, IEEE Pers Communication 6 (1999), 13–18.

[2] P.S. Hall, P. Gardner, and A. Faraone, Antenna requirements forsoftware defined and cognitive radios, Proc IEEE 99 (2012), 1–9.

[3] J.R. Kelly, P. Song, P.S. Hall, and A.L. Borja, Reconfigurable 460MHz to 12GHz antenna with integrated narrowband slot, Propagation Electromagnetic Res C 24 (2011), 137–145.

[4] E. Ebrahimi, J.R. Kelly, and P. S. Hall, Integrated wide-narrowband antenna for multi-standard radio, IEEE Trans Antennas Propagation 59 (2011), 2628–2635.

[5] F. Ghanem, P.S. Hall, and J.R. Kelly, Two port frequency reconfigurableantenna for cognitive radios, IET Electron Letter 45 (2009),534–535.

[6] E. Ebrahimi, J. Kelly, and P.S. Hall, A reconfigurable narrowbandantenna integrated with wideband monopole for cognitive radio applications,In: IEEE Int. APS/URSI/AMEREM, Charleston, SC, 2009.

[7] Y. Tawk, J. Costantine, and C. Christodoulou, Reconfigurable filtennasand MIMO in cognitive radio applications, IEEE Trans AntennasPropagation 62 (2014), 1074–1084.

[8] Y. Tawk, J. Costantine, K. Avery, and C. Christodoulou, Implementation of a cognitive radio front-end using rotatable controlled reconfigurableantennas, IEEE Trans Antennas Propagation 59 (2011), 1773–1778.

[9] C.T.P. Song, P.S. Hall, H. Ghafouri-Shiraz, and D. Wake, Tripleband planar inverted F antennas for handheld devices, IET ElectronLetter 36 (2000), 112–114.

[10] S. Yoon, C. Jung, Y. Kim, and F. De Flaviis, Multi-port multi-bandsmall antenna design, In: Asia-Pacific Microwave Conference, Bangkok,
Thailand, Dec. 2007.

[11] Hamza Nachouane, AbdellahNajid, AbdelwahedTribak, and Fatima Riouch, “Dual Port Antenna Combining Sensing and Communication Tasks for Cognitive Radio”, Int. Journal of Electronics and Telecommunications, Vol. 62, no. 2, PP. 121–127, 2016.

[12] F. Ghanem, P. S. Hall and J. R. Kelly, “Two port frequency reconfigurable antenna for cognitive radios”, Electronics Letters, Vol. 45, no. 11, May 2009.

[13] ArjunaMuduli, Rabindra K. Mishra, “Modified UWB Microstrip Monopole Antenna for Cognitive Radio Application”, in Proceedings of the IEEE Applied Electromagnetics Conference (AEMC), pp. 1-2, Guwahati, Assam, Dec. 2015.

[14] Yongfeng Wang, Tayeb A. Denidni, Qingsheng Zeng, Gao Wei, “A Design of Integrated Ultra-wideband/Narrow Band Rectangular Dielectric Resonator Antenna”, in Proceedings of the IEEE International Wireless Symposium (IWS), pp. 1-4, Xi’an, China, March 2014.

[15] P. Tummas, P. Krachodnok and R. Wongsan, “A Frequency Reconfigurable Antenna Design for UWB Applications”, in Proceedings of the 11th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), pp. 1-4, NakhonRatchasima, Thailand, May 2014.

[16] Gijo Augustin and Tayeb. A. Denidni, “An Integrated Ultra Wideband/Narrow Band Antenna in Uniplanar Configuration for Cognitive Radio Systems”, IEEE Transactions on Antennas and Propagation, Vol. 60, no. 11, Nov. 2012.

[17] Divya Soundharya, Nivethitha, Lekha priyadharshini, Vanaja "Design of Ultra Wide Band Antenna", SSRG International Journal of Electronics and Communication Engineering (SSRG - IJECE), V5(6), 7-10 June 2018.

[18] Gijo Augustin, Bybi P Chacko and Tayeb A Denidni, “Diversity Antenna with Electronically Switchable Wide/Narrow band for Cognitive Radio Systems”, in Proceedings of the 8th European Conference on Antennas and Propagation (EuCAP 2014), pp. 3243-3245, Hague, Netherlands, April 2014.

[19] ElhamEbrahimi, James R. Kelly and Peter S. Hall, “Integrated Wide-Narrowband Antenna for Multi-Standard Radio”, IEEE Transactions on Antennas and Propagation, Vol. 59, no. 7, July 2011.

[20] NadjetSahnoun, Idris Messaoudene, Tayeb A. Denidni, and AbdelmadjidBenghalia, “Integrated Flexible UWB/NB Antenna Conformed on a Cylindrical Surface”, Progress In Electromagnetic Research Letters, Vol. 55, pp. 121–128, 2015.

[21] FCC 1st Report and Order on Ultra-Wideband Technology, Feb. 2002. Patel, K. R. and R. Kulkarni, “Ultra-wideband wireless system,” International Journal ofApplication or Innovation in Engineering &Management, 2014, ISSN 2319-4847.

[22] Khan, R., et al., “Reconfigurable UWB monopole antenna for cognitive radio applications,” 2016 International Conference on Computing, Electronic and Electrical Engineering (ICE Cube), 59–62,Quetta, 2016.

[23] NellaAnveshkumar, and Abhay Suresh Gandhi, “A Survey on Planar Antenna Designs for Cognitive Radio Applications”, Wireless Personal Communications, Vol. 98, no. 1, pp. 541-569, Jan. 2018.

[24] R.N. Simons, Coplanar waveguide circuits, components, and systems,Wiley Inter science, New York, 2001.

[25] Ansys High Frequency Structure Simulator (HFSS), Version 14.0., Ansoft, Pittsburgh, PA.

[26] N. Anvesh Kumar and A. S. Gandhi, “A Compact Novel Three-Port Integrated Wide and Narrow Band Antennas System for Cognitive Radio Applications”, International

Journal of Antennas and Propagation, Volume 2016, Article ID: 2829357, 14 pages, 2016.

[27] Amitkumar F sonar, Nitesh S Mishra, Rahul P Mishra, JayeshMhaskar&ShilpaKharche, " UWB monopole antenna", ITSI Transactions on Electrical and Electronics Engineering (ITSI-TEEE), ISSN (PRINT) : 2320 – 8945, Volume -1, Issue -1, 2013.

[28] Hua-Ming Chen, Yi-Fang Lin, Chin-Chun Kuo and Kuang-Chih Huang, "A Compact Dual-Band Microstrip-Fed Monopole Antenna", in proceedings of the IEEE Antennas and Propagation Society International Symposium, pp. 124-127, Boston, MA, USA, 2001.

[29] Y.-C. Liang, A. T. Hoang, and H.-H. Chen, "Cognitive radio on TV bands—A new approach to provide wireless connectivity for rural areas,"IEEE Wireless Commun., vol. 15, no. 3, pp. 16–22, Jun. 2008.

[30] A. Abbagnale, F. Cuomo, and E. Cipollone, "Measuring the connectivityof a cognitive radio ad hoc network," IEEE Commun. Lett., vol. 14, no. 5,pp. 417–419, May 2010.