Simulation Analysis of Cognitive Radio Cooperative Networks for Next Generation Technology

A.Z.Yonis, T. B. Mahmood, E. H. Younis, Y. L, Younis

Communication Engineering Department, College of Electronics Engineering, Ninevah University, Mosul, Iraq.

Email: aws_zuher@yahoo.com

Abstract **- To provide different types of data services within the wireless spectrum, new communication technologies are required. The Cognitive Radio, CR, cooperative network is one such emerging technology to fulfill the new needs. In this paper we used simulation to investigate key enhancement focused on Cognitive Radio technology for fifth generation (5G) mobile communication networks. Cognitive radio is an important candidate for next generation (5G) systems because it gives the unlicensed users the ability to access the spectrum, resulting in increased demand for radio spectrum resources. The effectiveness of spectrum sensing methodologies for cognitive radio is presented to provide a step by step treatment of the topics.**

Keywords - Cognitive radio, 5G, Spectrum bands, SNR.

I. INTRODUCTION

With a growing desire to make life easy, the number of intelligent devices is increasing every day. The obtainable bandwidth allocation in fourth generation (4G) wireless technology cannot handle such a huge number of devices [1]. Further, the services presented by these mobile devices also increase mobile traffic and there is a need to provide quick and efficient services at a low cost. There is an exponential growth in the count of devices that are hungry for bandwidth as well as there is a large shortage in the vacant spectrum. Also, the availability of broadband access to remote areas and the integration of varied networks on a common platform remains elusive. All the above aforesaid factors have led to the advent of next-generation mobile network technology, namely 5G technology [2, 3]. In this technology, methods are deployed to provide faster speeds, greater capacity, and enhanced services. Also expected to meet the increasing demand for data from consumers, and to support new services designed to meet growing demands for data from industrial users. Moreover, it is possible to achieve high data rates with minimum latency and reduced energy [4]. This technology is capable of treating heterogeneous devices. In spite of its many benefits, there are many challenges and implementation issues in 5G. Apart from the humongous increase in mobile traffic, the nature of traffic is not only random but also varied. The diverse variation in traffic in terms of periods poses difficulties in the planning of network infrastructure. The networks are unable to handle huge loads during peak traffic and become underutilized when traffic is less. Further, the services offered are also diverse such as browsing, multimedia and gaming and hence the Quality of Service requirements are different for various services. The existing cellular network is ineffective to handle high volume multimedia downloads. The main challenge is to look into parts to make the futuristic technology of 5G real. Utilization of spectrum, exhaustion of energy and efficiency of cost are three major performance measures that should be majorly looked into in the progress of a 5G system.

II. LITERATURE REVIEW AND WEAKNESSES OF CURRENT TECHNIQUES

In this section, the basic precursor to CR research is essential to work through Mitola and Maguire in 1999 and researched to measure the spectrum early in 1995 to determine the use of the spectrum, both in licensed and non-licensed band. CR research targeted rapidly on Dynamic Spectrum Access (DSA) and secondary utilize spectrum as the major goals of the preliminary research in United States. This was due to the reality that it attracted several early project tasks (such as MILTON, URA and spectrum). For more details find references [5-9].

Another enhancement of the research was provided by many loud researchers, who indicated the existence of flaws applicable in the contemporary organizational field. In the field of standardization, three companies have emerged first of all to job on existing technologies and construction: IEEE 802.22 and most lately the technical committee for reconfigurable radio systems based on commercial register and Software Defined Radio (SDR). likewise, the SDR gathering, even as an industry team, has elaborated several of the CRC- associated problems; commercially, the generality sophisticated standardization endeavor is IEEE 802.22 and associated project aimed at providing dynamic access to the unoccupied television spectrum. Nevertheless, IEEE 802.11 ac needs a somewhat restricted cognition stage [10].

In this paper, CR was being extensively researched as a technology conducive to opportunistic access to white TV Spaces (TVWS): huge parts of the Ultra high frequency / Very high frequency television bands that became obtainable within the geographical backbone next digital conversion. In

US, the Federal Communications Commission (FCC) has previously suggested opportunistic access to television bands at 2004 [11].

The literature shows no consensus on CR, which means that CRs model working in this system was offered to the federal communication commission, MOTOROLA and PHILIPS in 2008 [12]. After considerable testing, the FCC adopted in Nov. 2008 a second statement and arrangement that sets out regulations that permit the process of cognitive tools in TVWS on a secondary basis [13].

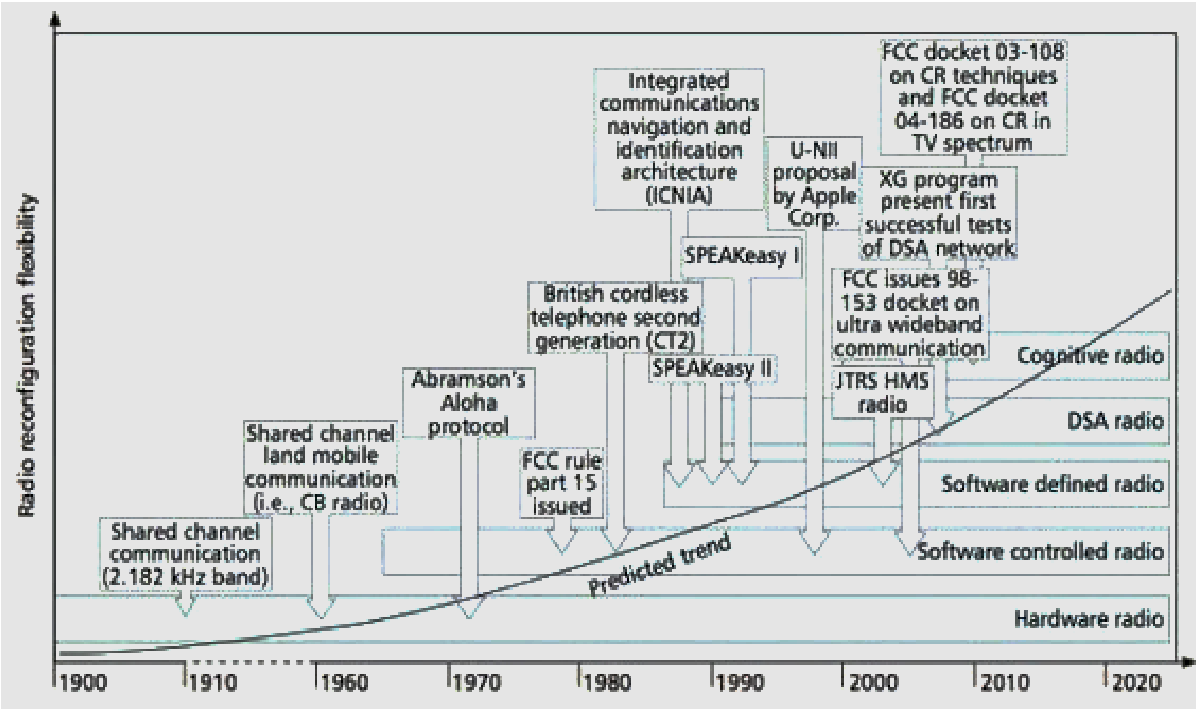


Fig. 1. Evolution of cognitive radio [14].

Fig. 1 shows the evolution of cognitive radio from 1900 to 2020. Moreover, in what is undoubtedly revolutionary policy shift, in the lately freed digital earnings rehearsal notification, the UK organizer, The office of communications, commonly known as Office of Communications, Commonly (OFCOM).

OFCOM, proposes to “allow the use of a license that is exempt from the cognitive spectrum of cognitive devices”. Moreover, OFCOM cases that “we see a tremendous scope for cognitive equipment to use overlapping spectrum and to emerge and benefit from international economies of scale” [15]. More lately, Auerbach published a new session offering in addition to specifics of the suggested cognitive radio networks [16].

Each the United States and the United Kingdom conform the cognitive access paradigm and a high level of cognitive access to the 802.22 television bands [17] [18] in the last stage, researchers expect CR to evolve into a major global technology in the future.

III. DEFINITION OF COGNITIVE RADIO

Cognitive radio is a mobile communications radio in which the network or the wireless node adjusts the transmission or adjusts the reception parameters based on contact with the environment to communicate effectively without interfering with the licensed users [19]. There are two major characteristics [20] of CR:

- Cognitive Power: Cognitive power knows the might to sense data from its radio circumference for radio technology.
- Reconfiguration: The cognitive function provides spectrum consciousness. Reconfiguration indicates to the radio's ability to alternate tasks, and permits CR software to be dynamically adapted to the radio environment (modulation scheme, frequency, communication protocol, and transmission power).

Moreover, there are also two kinds of cognitive radio are:

- Full Cognitive Radio: complete CR examination of each parameters. The node or wireless network can be familiar with each observable parameter [21].
- Cognitive radio spectrum sensor: Discovers channels in the radio frequency spectrum. The basic request

DOI 10.5013/IJSSST.a.21.02.18

ISSN: 1473-804x online, 1473-8031 print

in the cognitive radio network is the spectrum sensor. To consolidate the probability of detection [22], many signal revelation methods are utilized in the spectrum sensor.

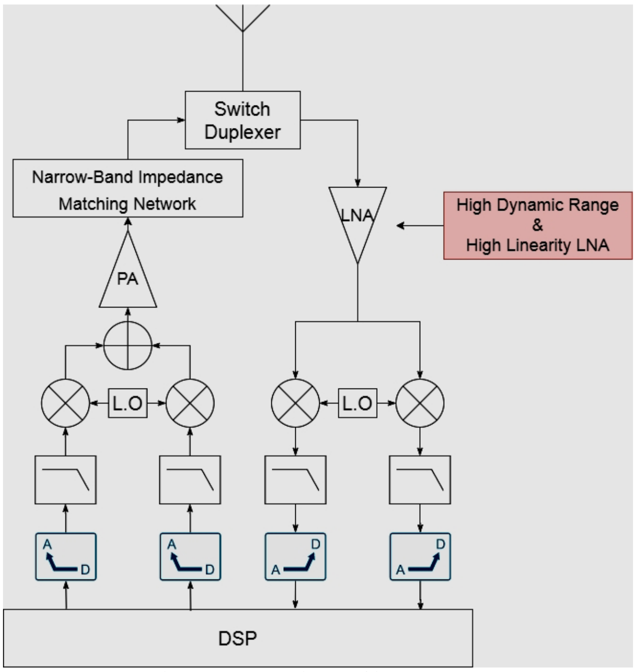


Fig. 2. CR transceiver architectures [22]

As shown in Fig. 2, wideband radio or tunable radio can be a transceiver architecture with cognitive radios. Taking wideband radio into account, the problems are not only the (analog-to-digital converter / digital to analog converter) posed in the next paragraph, but also the high dynamic range and high linearity Low Noise Amplifier (LNA), and matching network narrowband impedance [23].

IV. EXPERIMENTAL METHODOLOGY AND SOFTWARE TO OBTAIN RESULTS

Figure 3 shows a block diagram of the simulation for cognitive radio. Where the system can be analyzed through simulation in the MATLAB program.

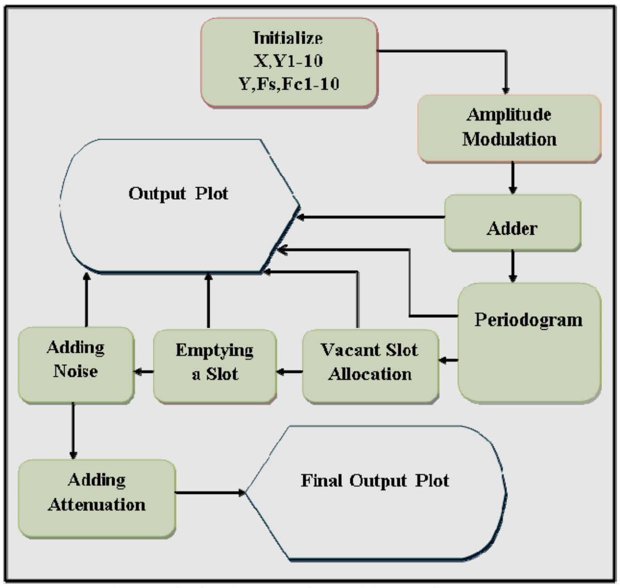


Fig. 3. Block Diagram of Cognitive Radio System

Ten primary users were assumed in this system, carrier frequencies used for a system are 10 signals, 10, 20, 30, 40, 50 and 100 MHz, respectively, for each user. The sampling frequency is 200MHz used to simulate the system. The Power Spectrum Density (PSD) is determined, in contrast to the predefined threshold value and calculates the existence of a Primary User (PU) signal.

Here, suppose all primary users are present. The power spectral density curve of the signal as shown in Fig. 4 where all frequency bands used efficiently after adding another user.

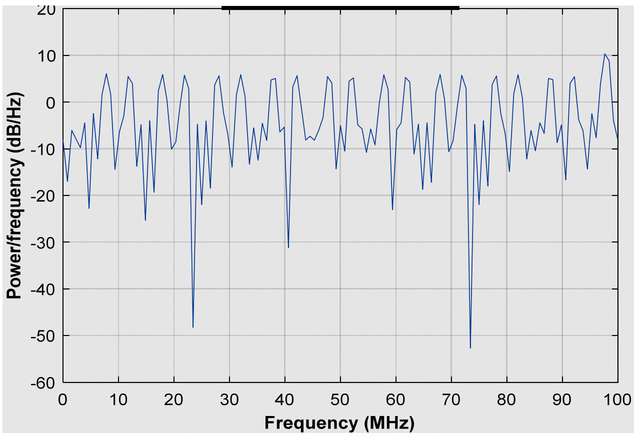


Fig. 4. Spectrum Bands Utilization

The power spectral density for the signal is determined through its predefined value to the determined presence of Primary Users (PU). Figure 5 assumed the first two and fifth and eight primary users, that’s present (Used Bands). 3rd, 4th, 6th, 7th, 9th, and 10th is not present (Unused Bands) in the spectrum.

DOI 10.5013/IJSSST.a.21.02.18 ISSN: 1473-804x online, 1473-8031 print

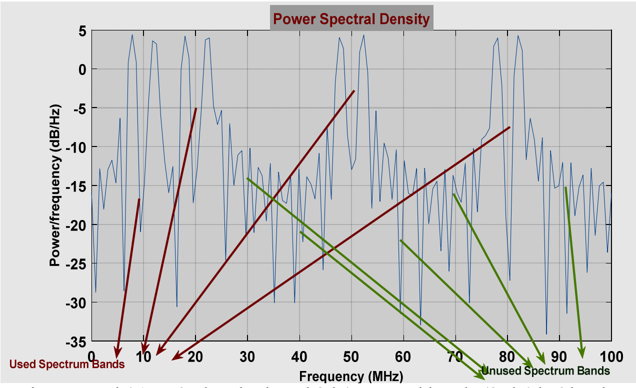
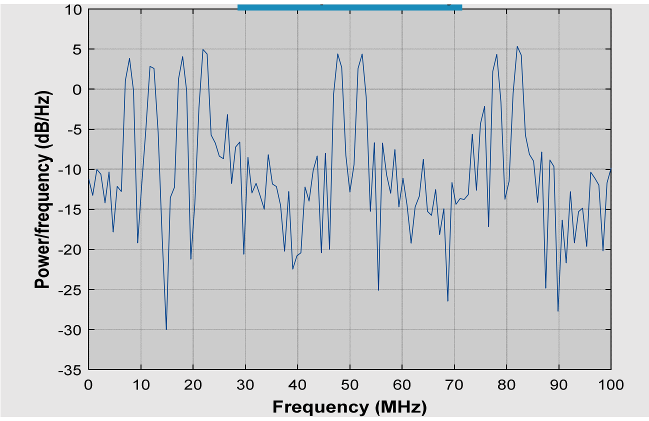


Fig. 5. Used (1st , 2nd and 5th and 8th), unused bands (3rd,4th,6th,7th ,9th and 10th)

After that add a 12dB Signal-to-Noise Ratio (SNR) to the system, the result is shown as Figure 6.



–Fig. 6. Power Spectral Density at SNR= 12dB

After that add a 20 dB Signal-to-Noise Ratio (SNR) to the system, the result is shown as Fig. 7. It is clear that disturbance in spectrum can be spotted to minimize with the increase in SNR.

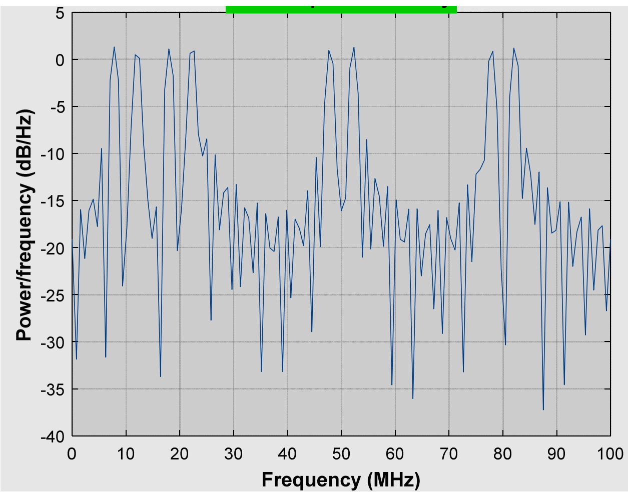


Fig. 7. Power Spectral Density at SNR= 20dB

Finally, the received signal was attenuated by 30% and the result is shown in figure 8 while attenuate the received signal by 15% and the result is shown in figure 9.

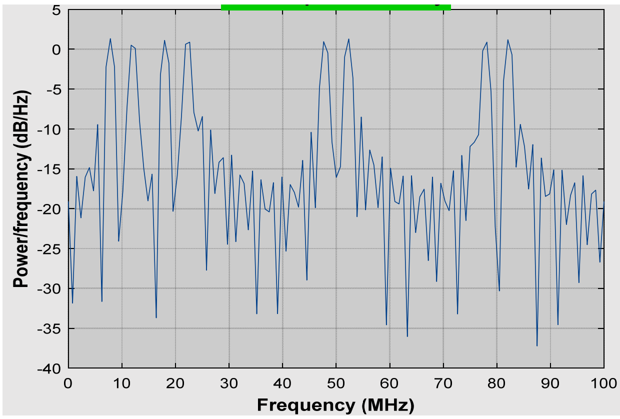


Fig. 8. Power Spectral Density at attenuation of received signal by 30%

The peaks of the signals are proportionally decreasing as the attenuation increases, so the attenuation in the channel will decrease the signal strength, essentially hindering the reception of appropriate signals.

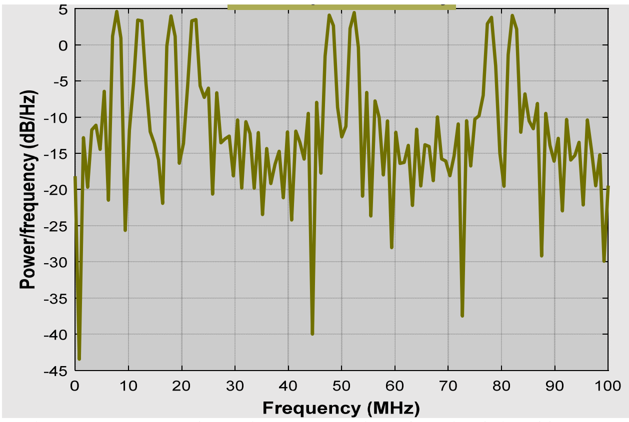


Fig. 9 Power Spectral Density at attenuation of received signal by 15%

V. CONCLUSIONS

Cognitive radio plays a vital role in the efficient utilization of radio frequency spectrum. In this paper we explored the use of dynamic spectrum access at run time and, by using sensing spectrum cognitive radio, to discover the spectrum gaps and to permit primary users to utilize these gaps at will in order not to interfere with the main (licensed) users. Using simulation, we explored: i) how a CR system can be effectively used to recycle the unutilized spectrum to increase the whole design capability, and ii) the design and simulation of cognitive radio system by using MATLAB, to ensure maximum utilization by decreasing spectrum holes.

DOI 10.5013/IJSSST.a.21.02.18

ISSN: 1473-804x online, 1473-8031 print

ACKNOWLEDGMENT

This research paper analysis is carried out in the Communication Engineering Department / College of Electronics Engineering at Ninevah University in Mosul, Iraq.

REFERENCES

[1] M.F. Ghanim, M.F.L. Abdullah, A.Z.Yonis, "Software implementation and comprehensive performance of uplink channel on mobile 4th generation technology", International Journal of Smart Home, Vol. 7, No. 3, pp. 185-196, 2013.

[2] A. Gupta, R. K. Jha, "Survey of 5G Network: Architecture and Emerging Technologies", IEEE Access, Volume 3, 2015.

[3] A.Z.Yonis "Effect of increasing the network capacity using device-to-device technology for next generation networks", Indonesian Journal of Electrical Engineering and Computer Science, vol (17), no (1), pp.303-309, 2020.

[4] A.Z.Yonis, M.F. Abdullah, "A novel LTE-advanced carrier aggregation with higher throughput", International Journal of Smart Home, 2013.

[5] A. Bagwari and G. S. Tomar,"Cooperative Spectrum Sensing in Multiple Energy detectors Based Cognitive Radio Networks Using Adaptive Double-Threshold scheme", "International Journal of Electronics" (IJE) - Taylor & Francis Group, Vol. 101, pp 1-13, 07 February 2014,

[6] A. Bagwari, J, Kanti and G. S, Tomar, "Novel Spectrum detector for IEEE 802.22 Wireless Regional Area Network", "International Journal of Smart Device and Appliance" (IJSDA), Publisher: IACS (International Academic Consulting and Service), Vol. 3, number 2, pp 9-25, 2015,

[7] A. Bagwari and G. S. Tomar, "Enriched the Spectrum Sensing Performance of Estimated SNR Based Detector in Cognitive Radio Networks", "International Journal of Hybrid Information Technology" (IJHIT), Publisher: SERSC (Science & Engineering Research Support society), Vol. 8, number 9, pp 143-156, 2015.

[8] A. Bagwari and G. S. Tomar, "Comparison between Adaptive Double-Threshold Based Energy Detection and Cyclostationary detection technique for Cognitive Radio Networks", CICN-2013: \"5th IEEE International Conference on Computational Intelligence and Communication Networks\", pp 182-185, 27-29 September 2013

[9] A. Bagwari and G. S. Tomar, "Cooperative Spectrum Sensing with Multiple Antennas using Adaptive Double-Threshold Based Energy Detector in Cognitive Radio Networks", "Journal of the Institution of Engineers (India): Series B" – Electrical, Electronics & Telecommunication and Computer Engineering, Springer, Vol. 95, number 2, pp 107-112, 11 June 2014, 4.

[10] A.Z.Yonis, "Performance analysis of IEEE 802.11ac based WLAN in wireless communication systems", International Journal of Electrical and Computer Engineering, vol (9), no (2), pp.1131-1136, 2019.

[11] Federal Communications Commission, "First report and order and further notice of proposed rulemaking in the matter of unlicesed operation in TV broadcast bands." ET Docket No. 04-186, Oct. 2006.

[12] Federal Communications Commission, "The FCC's Office of Engineering and Technology release report on tests of prototype white space devices." ET Docket No. 04-186, Oct. 2008.

[13] Federal Communications Commission, "FCC adopts rules for unlicenesd use of television white space." Official FCC announcement, Nov. 2009.

[14] R. V. Prasad, P. Pawelczak, J. A., Hoffmeyer and H. S. Berger, "Cognitive functionality in next generation wireless networks: standardization efforts", IEEE Communications Magazine, 46(4), 72–78, 2008.

[15] Office of Communications, "Digital dividend review, a statement on our approach to awarding the digital dividend", Dec.2007.

[16] Y. Xiao, F. Hu, "Cognitive Radio Networks", Auerbach Publications published, Sept., 2019.

[17] IEEE 802.22 Working Group on Wireless Regional Area Networks. [Online]: www.IEE802.org/22, Feb. 2009.

[18] C. Cordeiro, K. Challapali, D. Birru, and S. Shankar, "IEEE 802.22: An introduction to thefirst wireless standard based on cognitive radios,"Journal of Communications,vol.1,no. 1, pp. 38–47, 2006.

[19] FCC, "Spectrum Policy Task Force Report," vol.ET Docket No. 02-155, November 2002.

[20] I. F. Akyildiz, W.Y. Lee, Mehmet C. Vuran, Shantidev Mohanty, "Next generation/dynamic spectrum access/cognitive radio wireless networks: A survey" Broadband and Wireless Networking Laboratory, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332, United States.

[21] Ž. Tabaković, "A Survey of Cognitive Radio Systems", Post and Electronic Communications Agency, Jurišićeva, vol.13, 2011.

[22] S. Haykin, "Cognitive radio: brain-empowered wireless communications," IEEE Journal Select. Areas Commun. vol. 23, no. 2, 2005, pp. 201-220.

[23] V. T. Nguyen, F.Villain, and Y Le Guillou, "Cognitive Radio RF: Overview and Challenges", Hindawi Publishing Corporation VLSI Design, Vol. 2012, 13 pages.

.