IMPLEMENTATION OF AMPLITUDE MODULATED SOFTWARE DEFINED RADIO

Bima Muhammad Enagi, Aliyu Ahmed

Abstract—The surge in improvement and development of new communication technologies has led to the need for a radio which doesn't get obsolete with technology. The concept of Software Defined Radio (SDR) was suggested as a potential solution. The focus of this paper is to design algorithm for a software defined radio to carry out demodulation of Amplitude Modulated Double Side Band (DSB-WC) signal. The designed system was evaluated for its selectivity. It was discovered that a great deal of flexibility can be derived from the use of SDR and the functionality of the radio is only limited by the capability of the hardware device (sampling speed etc.).

Index Terms: AM SDR, Amplitude modulated SDR, SDR, Software Defined Radio

1 INTRODUCTION

In recent times, the communication industry has seen an out-burst of improvements in technology [1]. Some of the emerging technologies in communications across the globe include 2G (Second Generation), 3G (Third Generation), Worldwide Interoperability for Microwave Access (WiMAX), 3.5G (High-Speed Downlink Packet Access), 3.5GPP LTE, fourth generation (4G), etc. The functionality of the old radio system was limited by the hardware capabilities. This results in to higher costs and reduced flexibility to support new technologies. This has led engineers and scientists thinking of the possibility of having radio devices (mobile phone, base stations, Wi-Fi device etc.) that can easily upgrade itself to new technologies without the need for a replacement of the hardware. Software Defined Radio defines a set of radio systems which has some or all of its radio (i.e. layer 1) functions implemented using modifiable software [2]. This radio has the ability to adapt itself to different technologies both new and legacy; thus making it upgradable [1].

The concept of SDR was introduced in 1991 by Joseph Mitola where he referred to a radio that was reconfigurable [3]. This is a radio where all the hardware components are replaced with a DSP device which has software installed on it to perform the hardware component's functionalities more efficiently. The signal processing and the control of the radio are implemented using software based approaches hence the name SDR. It is common to find many other names used to refer to this concept such as Software radio, reconfigurable radio [1], [4].

In an SDR, the received signal is digitized using an analog to digital converter (ADC) device after being received by the antenna. Subsequently, digital signal processing (DSP) algorithms are used to process the digitized signal. The speed of the ADC device is critical in this regard since it determines the maximum frequency that the radio can operate. In recent times, the development of faster ADC devices and processors has fostered research in the area of software defined radio [1].

Many motivations exist to the utilization of SDR. These are a factor of the many advantages attributed to the characteristics of the technology namely upgradability, efficiency, multi-functionality, size and power efficiency. These lead to some benefits for both the manufacturer and the users such as reduced time to market, reduced cost of production, flexibility, and processing efficiency. These benefits have led to significant interests in SDR especially in the military sector [1], NASA [5], mobile service providers [6] [7] [8].

In this work, an amplitude modulated software defined radio was built using National Instruments (NI) technology. NI My Data Acquisition device (MYDAQ) was used as the radio interface while LabView was used for the signal processing algorithm.

The rest of this paper is organized as follows: Section 2 provides the review of literatures, section 3 covers the design and implementation of the system, section 4 provides the test results and conclusion was made in section 5.

2 LITERATURE REVIEW

- *M.E. Bima is currently a lecturer at Federal University of Technology, Minna, Nigeria. E-mail: bimamuhammad@futminna.edu.ng*
- *Aliyu Ahmed is currently a lecturer at Federal University of Technology, Minna, Nigeria. E-mail: aliyu.ahmed@futminna.edu.ng*

The Wireless Innovation Forum was set up to advocate the innovative use of the spectrum especially in areas of SDR [9]. The architecture for a SDR was proposed by the SDR forum [10]. This architecture ranges from tier 1 to tier 4 (Ultimate SDR) [11] [12]. Research continues to focus towards realizing a tier 4 SDR [13]. This has been done by mainly focusing on improving the viability of implementing SDR in the nearest future in aspects such as processor speed, power efficiency of the signal processing algorithm etc. A Tier3 SDR prototype was built by Jung Ko, et al, using an FPGA of 50 MHz [10]. A number of issues were investigated such as the flexibility of the radio [14], the power consumption, efficiency, security related issues [15] [16], as well as the speed of enabling technology (DSPs and ADCs) [5] [17]. Research in SDR's sister technology, cognitive radio [18], is also on-going and it is one that will benefit greatly from the findings in SDR research.

Amplitude modulation (AM) is a modulation technique that has gained great popularity since Fessenden used it to transmit music over the Atlantic Ocean [19]. This popularity has been mainly due to the simplified demodulation process for AM signals. The envelop method, the quadrature method etc. are methods used for demodulation of AM signals [20]. The quadrature method will be used in this work due to its robust and efficient results after demodulation. The quadrature process can be represented using (1) below.

$$m(t) = x(t)^2 + \hat{x}(t)^2 \quad (1)$$

Where m(t) is the message signal, x(t)2 is the squared AM signal while the $\hat{x}(t)^2$ is the square of the AM signal after it had been passed through a Hilbert transform. *Fig. 1* shows the block diagram for the quadrature method.

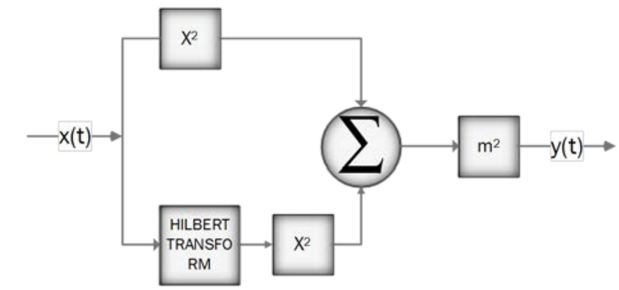

Fig. 1. Demodulation of AM signal using quadrature method

3 DESIGN AND IMPLEMENTATION

The demodulation algorithm used in this system is the Quadrature method. This is represented in *Fig. 2*. The MYDAQ has a resolution of 16 bits and a sampling frequency of 200 kHz. Received signal being fed to MYDAQ is at an intermediate frequency (IF) of 30 kHz. This gets digitized and sent to a signal processing program running on the computer system. The intermediate frequency is chosen because of the sampling frequency of 200 kHz.

For the demodulation of the received signal, quadrature method was employed based on (1). The LabView code for the demodulation is represented in *Fig. 3*. The received AM signal is squared and added to the Hilbert transformed version of the same signal. The square root of the resultant waveform is used to derive the original message.

4 TESTING AND EVALUATION

The testing of the system was done by using AM signals generated by simulation. These signals were received and demodulated using the algorithm developed in this research.

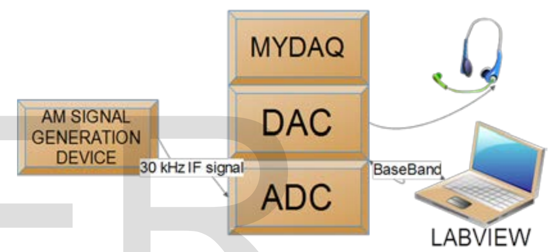

Fig. 3. System Architecture for the SDR implementation

The 3 stations were set to frequencies of 16 kHz, 26 kHz and 51.1 kHz while the message signal had a frequency of 3 kHz. Additive White Gaussian Noise (AWGN) was also injected into generated AM signal.

The generated AM signal and demodulated signal are shown in *Fig. 4*. The radio was tuned to 26 kHz for this test. From the result of the selectivity estimation in *Fig. 5*, the selectivity of the receiver is $\approx 10\ kHz$. This selectivity can be seen as the filtering capacity of the receiver. This result shows how flexible the operation of the SDR can be since some of its layer 1 operations are carried out using software program algorithm.

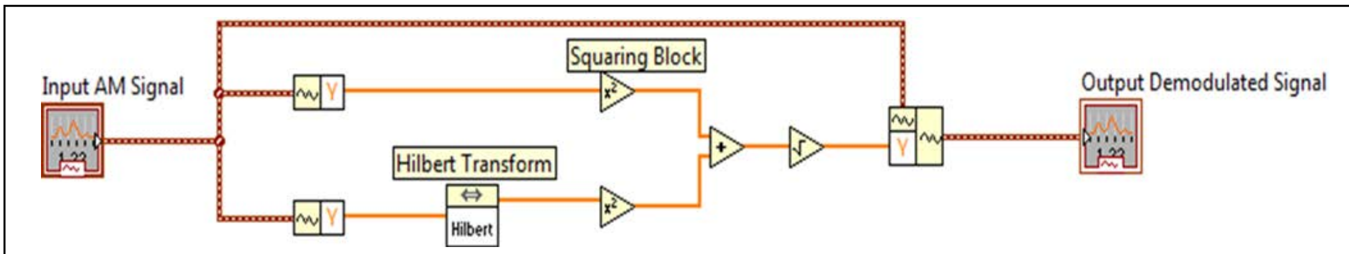

Fig. 2. Code for Quadrature method implementation

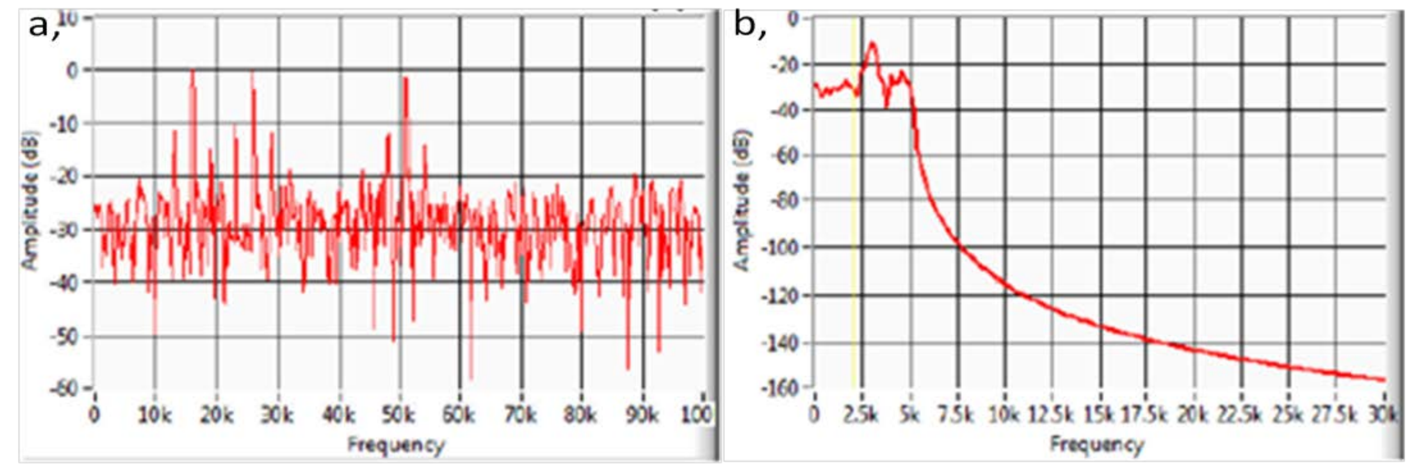

Fig. 4. AM signal (a) and Demodulated Signal (b)

5 CONCLUSION

This paper describes the work that was undertaken in the implementation of a Software Defined Amplitude Modulated Radio. The algorithm was designed to demodulate a double side band (DSB-WC) with carrier amplitude modulated signal. LabView programming language was used to carry out the design while MYDAQ device was used to acquire the signal. The selectivity property of the receiver was considered for the performance evaluation. This work demonstrates how much flexibility can be achieved by the use of SDR. It was observed however that the functionality of the radio is also limited to the system hardware (computer system and MYDAQ in this work) limitations in terms of sampling frequency, band of received frequency etc.

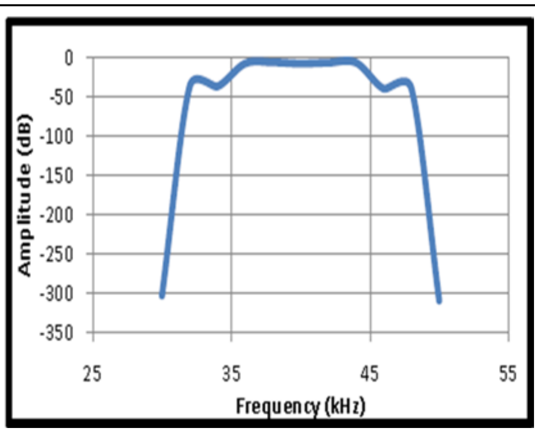

Fig. 5. Measured Selectivity of the radio receiver

Acknowledgment

M.E. Bima wishes to thank Mr. Peter R. Green of University of Manchester.

6.0 REFERENCES

[1] T. Ulversoy, “Software Defined Radio: Challenges and Opportunities,” IEEE Communications Surveys & Tutorials, Vol. 12 no.4, pp. 531-550, May 2010 (IEEE Surveys and Tutorials).

[2] "What is Software Defined Radio?" Wireless Innovation Forum www.wirelessinnovation.org/introduction_to_SDR, 2014. (URL link 2014)

[3] M.E. Bima, “Feasibility studies for the project titled software defined radio”. University of Manchester, Manchester, 2011 (Technical Report).

[4] R. J. Graessle and Chi-Hao Cheng, “A SOFTWARE-DEFINED RADIO BASED ON THE UNIFIED SMSE FRAMEWORK”, Wireless Telecommunication Symposium (WTS), Newyork City, vol, no, pp 1-6, 13-15, 2010. (Symposium)

[5] A.W. Mast, “Reconfigurable Software Defined Payload architectu- re that reduces cost and risk for various missions”, IEEE Aerospace Conference, Big Sky, MT, vol, no, pp. 1-5, 5-12, 2011. (Conference Proceedings)

[6] “Anywave Base station", Vanu, http://www.vanu.com/solutions/anywave, 2011 (URL link 2011)

[7] “ZTE to Build SDR Network for Portugal’s Optimus", ZTE, http://www.en.zte.com.cn/en/press_center/news/201002/t20100224_180750.html, 2010. (URL link 2010).

[8] Luna Lynnette, “SOFTWARE-DEFINED RADIO MOVES TOWARD MILESTONE, Urgent Communications. http://urgentcomm.com/networks_and_systems/news/software-definedwhite-space-20110105/, 2011. (URL link 2011).

[9] "About the Wireless Innovation Forum", Wireless Innovation Forum, www.wirelessinnovation.org/about_the_forum, 2014 (URL link 2014.).

[10] Lee Pucker. “SDR Architecture. SDR FORUM”, http://data.memberclicks.com/site/sdf/tut-SDR_Architectures.pdf, 2014. (URl link 2014)

[11] "Sofware Defined Radio. Broadband Engineering”, http://telecomnormalized.tech.officelive.com/SoftwareDefinedRadio.aspx, 2011. (URL link 2011).

ISSN 2229-5518
[12] Ko Jung, V.C. Gaudet and H.A. Robert, "A tier 3 Software Defined AM Radio.", IEEE 9th International Database Engineering and Application Symposium (IDEAS'05), Canada ,vol, no, 2005. (IEEE Symposium)

[13] Glossner John et al., "Trends in Low Power Handset Software Defined Radio.", Heidelberg : Springer-Verlag , Berlin, 2007.

[14] G.J. Minden, J. B. Evans, L. Searl, D. DePardo, V.R. Petty, “KUAR: A Flexible Software-Defined Radio Development Platform”, New Frontiers in Dynamic Spectrum Access Networks 2nd IEEE International Symposium, Dublin, vol, no, pp 428-439, 17-20, 2007. (IEEE Symposium)

[15] C. R. A. Gonzalez, and J. H. Reed, “Power fingerprinting in SDR & CR integrity assessment” Military Communications Conference, vol, no, 18-21 Oct 2009. (Conference Proceedings)

[16] C. F. Lam, et al, “Radio security module that enables global roaming of SDR terminal while complying with local radio regulation”, IEEE 58th Vehicular Technology Conference (VTC), vol, no, pp. 2132- 2136, 6-9th Oct 2003. (IEEE Conference Proceedings)

[17] T. A. Nesimoglu, “A review of Software Defined Radio enabling technologies”, Microwave Symposium (MMS), Guzelyurt, vol, no, pp. 87-90. 2010. (Microwave Symposium)

[18] J. Mitola, and G.Q. Maguire, “Cognitive radio: making software radios more personal”, IEEE Personal Communication, Stockholm, vol 6, no 4, 1999. (Personal Communication)

[19] J.S. Belrose, "Reginald Aubrey Fessenden and the Birth of Wireless Telephony”. IEEE Antenna's Propagation Magazine, Canada, Vol 44, no 2, pp 38-47, April 2002. (IEEE magazine)

[20] M.E., Bima. “Software Defined Radio”. The University of Manchester, Manchester Final Rep Sept 2011. (Thesis or dissertation)