Proceedings of the World Congress on Engineering and Computer Science 2009 Vol I
WCECS 2009, October 20-22, 2009, San Francisco, USA

Software Defined Radio for RFID Application

Muhammad Islam, M A Hannan, S. A. Samad and A. Hussain

***Abstract*—Radio Frequency Identification (RFID) is currently the hottest technology in wireless applications area. Its unique advantages such as data transmission with extreme low power or even without power in tag can be the biggest beneficial for goods management. Software-Defined Radio (SDR) is a wireless communications system where all of the signal processing is implemented in software. By simply downloading a new program, a software radio is able to interoperate with different wireless protocols, incorporate new services, and upgrade to new standards. In this paper, we build an RFID application simulation environment over the SDR. We do the source to sink transmission simulation by using Quadrature Amplitude Modulation, Then, we compare the differences of BER versus SNR performances for input and output signals.**

***Index Terms*— Additive white Gaussian noise, radio frequency identification, software defined radio, quadrature amplitude modulation.**

I. Introduction

Whether we realize it or not, radio frequency identification (RFID) is an integral part of our life. RFID increases productivity and convenience. RFID is used for hundreds, if not thousands, of applications such as preventing theft of automobiles and merchandise; collecting tolls without stopping; managing traffic; gaining entrance to buildings; automating parking; controlling access of vehicles to gated communities, corporate campuses and airports; dispensing goods; providing ski lift access; tracking library books; buying hamburgers; and the growing opportunity to track a wealth of assets in supply chain management. RFID technology is also being pressed into service for use in U.S. Homeland Security with applications such as securing border crossings and intermodal container shipments while expediting low-risk activities.

The world becomes wireless. Radio Frequency Identification (RFID) is the hottest technology in wireless applications area. Its unique advantages such as data transmission with extreme low power or even without power in tag can be the biggest beneficial for goods management. In the coming years, RFID technology can be the perfect replacement option of bar code which is widely used in supermarkets for many decades [1-3].

UHF RFID system can be divided to two parts, readers and tags. Generally, an RFID system contains several readers and a large amount of tags in practical application. The collision problems of both tags and readers are resolved in the arithmetic [4] and MAC protocol [5].

A software-defined radio (SDR) is a wireless communications system where much of the signal processing is implemented in software [6, 7]. By simply downloading a new program, a software radio is able to interoperate with different wireless protocols, incorporate new services, and upgrade to new standards.

In the past 20 years, there has been a big advancement in the wireless communication area [8]. Wireless communications technologies have revolutionized business and personal communications. However, there are many problems raised by using traditional ways to develop wireless products, and also the communication among various standards:

The product was usually developed according to a particular release of a particular standard. When new technology emerges or the standard is upgraded or a new service is required, a new product generation has to use newly developed dedicated chips. Therefore, the application of new technology and new service is restrained, and the investment risk of manufactures and operators will be increased.

People now enjoy the convenience of wireless connectivity by using different devices. Unfortunately, most of them use different standards, so we are forced to carry around a bag full of devices to take advantage of the connectivity options. And to make matters worse, in some emergency cases, like disasters, it's hard for the fireman whose device's radio is digital and in Very High Frequency (VHF) band (30MHz to 300MHz), to communicate with the policeman who can only receive 800 MHz analog signals.

The reason that wireless devices are so inflexible is that they are generally implemented in hardware. There is a chipset in each device that performs the signal processing to allow the device to communicate with its wireless network. This inflexibility led us to consider alternate software-based designs; these fall under the heading of SDR.

DSP plays a prominent role in SDR. It offers development flexibility and is used primarily for number crunching operations in signal processing algorithms. Traditionally, DSP techniques were used for pre-modulation and post-detection functions in radio receivers. In recent times, DSP techniques have been used extensively for advanced digital communications transceiver designs, finding their way into detection, equalization, demodulation, frequency synthesis and channel filtering [9-12].

This work was supported under grant: UKM-GUP-NBT-08-03-123.

Muhammad Islam is with the Dept. of Electrical, Electronic and Systems Engineering, National University of Malaysia, 43600 Bangi, Selangor, Malaysia (e-mail: m.islam@nu.edu.pk)

M A Hannan is with the Dept. of Electrical, Electronic and Systems Engineering, National University of Malaysia, 43600 Bangi, Selangor, Malaysia (e-mail:hannan@eng.ukm.my)

S A Samad is with the Dept. of Electrical, Electronic and Systems Engineering, National University of Malaysia, 43600 Bangi, Selangor, Malaysia (e-mail:salina@eng.ukm.my)

A Hussain is with the Dept. of Electrical, Electronic and Systems Engineering, National University of Malaysia, 43600 Bangi, Selangor, Malaysia (e-mail: aini@eng.ukm.my)

Since the SDR itself is an emerging technology, its prospects are related to other important emerging technologies such as smart antennas, networking, software, semiconductors, signal processing and battery technology. Rapid advances in solid-state integrated circuit (IC) technology are fueling the growth in commercial wireless communications systems. These emerging technologies and advances are making SDR technically and commercially realistic.

SDR system can tune to any frequency band and receive any modulation across a large frequency spectrum by means of a programmable hardware which is controlled by software. An SDR perform significant amounts of signal processing in a general purpose computer, or a reconfigurable piece of digital electronics. It can produce a radio that can receive and transmit a new form of radio protocol just by running new software. In this paper we build the Software Defined Radio for RFID application

II. Methodology

As shown in Figure 1, the RFID systems exist in countless variants, produced by many different manufacturers, but RFID system is mainly consists of the following components.

A. *Tag (transponder)*

A device that transmits data to reader which is located on the object to be identifies.

B. *Reader (Transceiver)*

This device is used to read and/or write data to RFID tags. Antenna could be build inside the reader. The antenna is the channel between the tag and the transceiver, which control the systems data access and communication.

These components communicate via radio signals that carry data either uni-directionally or bi-directionally (Figure 1).

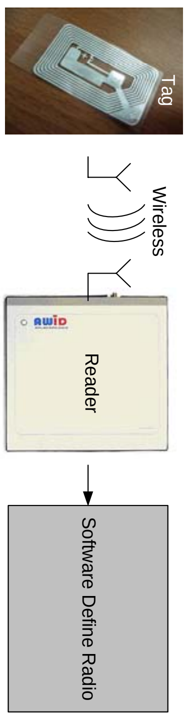

Figure 1: RFID System with SDR

C. *Software Defined Radio*

Software Defined Radio (SDR) is an advanced radio technology in which the modulation and demodulation of radio signals is performed exclusively by software. A communication link consists of three components: the transmitter, the channel, and the receiver. The transmitter element process an information signal in order to produce a signal most likely to pass reliably and efficiently through the channel [13, 14].

As shown in Figure 2, there are five main modules in the Software Defined Radio: SOURCE, TX, CH, RX and SINK. They indicate the signal source, the transmitter, the wireless or wire line channel, the receiver and the signal sink.

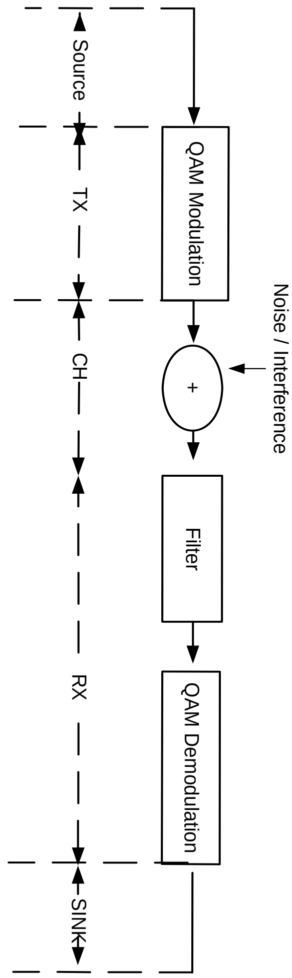

Figure 2: Block diagram of Software Defined Radio

A. *Source*

This module is used to generate data bits to be transmitted. There are two ways. One is read data from given source, like pictures or voice record. The other method is to generate random data bits by itself

B. *TX*

The transmission module, where the data bits are encode and modulate before they are sent to transmit.

C. *CH*

It represents the channel module. It consists of two parts: the channel from TX to RX and the feedback channel from

RX to TX which is used in adaptive system that needs Channel State Information (CSI) on the transmitter side.

D. RX

This module is similar to TX, but the data bits are decoded, filter and demodulated after antennas receive them

E. SINK

Sink, is the place where the simulation results, are computed and presented in both tabular and graphical format.

F. Digital Modulation

In digital modulation, the information signals, whether audio, video, or data are all digital. As a result, the digital information modulates an analog sinusoidal waveform carrier. The sinusoid has just three features that can be modified to carry the information: amplitude, frequency, and phase. Thus bandpass modulation can be defined as the process whereby the amplitude, frequency, or phase of the carrier, or a combination of them, is varied in accordance with the digital information to be transmitted. If the amplitude, frequency, or phase of the carrier is altered by the digital information, then the modulation is called amplitude shift keying (ASK), frequency shift keying (FSK), or phase shift keying (PSK), respectively.

G. Quadrature Amplitude Modulation (QAM)

Quadrature amplitude modulation (QAM) can be viewed as a combination of ASK and PSK. That means that digital information is carried in both the phase and the amplitude of the carrier signal.

QAM is a method for sending two separate (and uniquely different) channels of information. The carrier is shifted to create two carriers namely the sine and cosine versions. The outputs of both modulators are algebraically summed, the results of which is a single signal to be transmitted, containing the In-phase (I) and Quadrature (Q) information. The set of possible combinations of amplitudes, as shown on an x-y plot, is a pattern of dots known as a QAM constellation as shown in Figure 3.

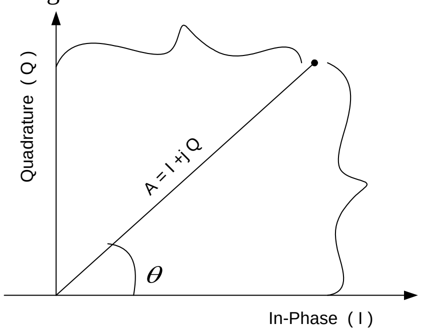

Figure 3: IQ Constellation Diagram

Consider the 64 QAM modulation schemes, in which 6 bits are processed to produce a single vector. The resultant constellation consist four different amplitude distributed in 12 different phases as shown in Figure 4.

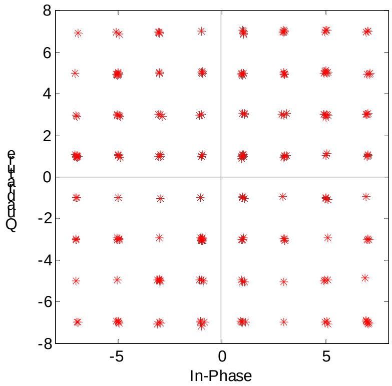

Figure 4: 64 QAM Constellation

III. RESULTS

By taking advantage of the SDR simulation, we add the RFID application in this paper in order to study its transmission performances. The simulation is done in Matlab. The modulation used in transmission from source to sink is QAM. Just like in other applications, the input data are generated by SOURCE, and then fed into modulator. The data is then fed into Additive White Gaussian Noise (AWGN) for RFID application. In communications, the AWGN channel model is one in which the only impairment is the linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for the phenomena of fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple, tractable mathematical. Models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered. Based on the normal positions between reader and tag in RFID application, we choose simulate in AWGN channel. Before demodulating the data from TX, the filter is used to filter the data coming and process data back to the original. Then the data is send to the output of RX.

We initially assume ideal conditions including no feedback delay or error, perfect channel estimation, and perfect channel quality estimation. We will then relax the first two restrictions to examine their impact. Finally, we collect all the data in SINK.

In our initial simulation work we have assumed ideal conditions. Specifically, we have simulated the performance of QAM modulation in AGWN channel for different BER performance of carrier frequency of 32 KHz, 64 KHz and 128 KHz. They gave us error of 1.34%, 0.60% and 0.105% respectively. Figures 5, 6 and 7 show the simulated and theoretical BER performance of the QAM under ideal conditions. As the error is lowest, thus, the preferable carrier frequency is 128 KHz for QAM modulation.

ISBN:978-988-17012-6-8

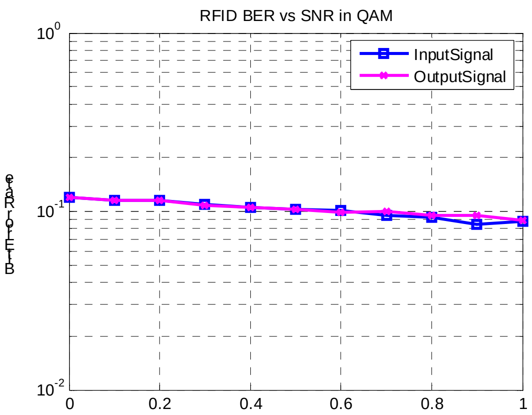

Figure 5: BER performance of QAM with 32 KHz with carrier frequency

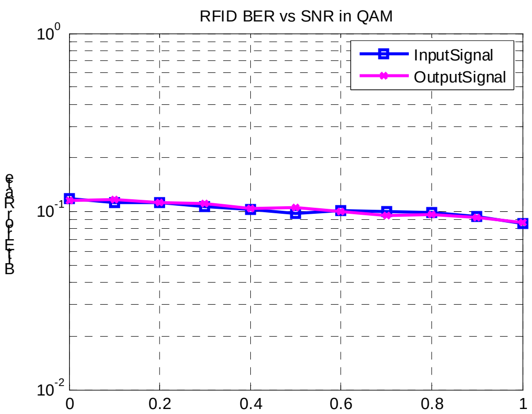

Figure 6: BER performance of QAM with 64 KHz with carrier frequency

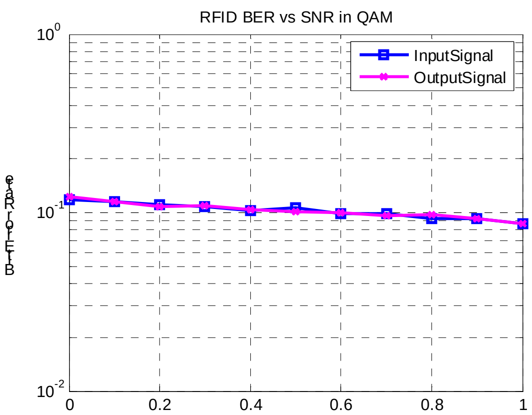

Figure 7: BER performance of QAM with 128 KHz with carrier frequency

IV. CONCLUSION

From the simulation results is shown in Figure 5, we can see that in simulation Matlab, QAM has the best performance of BER versus SNR in AWGN channel. As a conclusion, in the case when bit transmission rate is high requirement, we can use the QAM as modulation scheme for better transmission performance.

REFERENCES

[1] Kin Seong Leong, "Synchronization of RFID Reader Environments", IEEE from Proceedings of 2006 Symposium on Applications and Internet, Jan. 2006
[2] Monarch "RFID Basics", "RFID Basics Updated", May 2006, www.paxar.com
[3] Tiko Computer Corporation, "Inc Understanding RFID, White paper"
[4] BITKOM, "RFID White Paper Technology, Systems, and Applications", www.bitkom.org
[5] MIT Auto-ID Center Publications: http://www.autoidcenter.org
[6] Daniel W. Engels, "The Reader Collision Problem", MIT-AUTOID-WH-007
[7] Xinyu Xu, Renato G. Bosisio, "Analysis and implementation of six-port software-defined radio receiver platform", IEEE, July 2006 Edition", ISBN: 0130617938, Pearson Education, 2002.
[8] Afshin Haghighat, "A review on essentials and technical challenges of software defined radio", *IEEE British Crown*, 2002
[9] B. Sklar, Digital Communications: Fundamentals and Applications, Prentice Hall Inc., Englewood Cliffs, NJ, 1998.
[10] Theodore S. Rappaport, "Wireless Communication: Principle and Practice", Pearson Educational International, 2nd edition. 2002
[11] Bernard Sklar, "Digital Communications: Fundamentals and Applications", Prentice-Hall, 2nd Edition, pp. 30-33
[12] Jihoon Myung, "An adaptive memoryless tag anti-collision protocol for RFID networks", *The 23rd conference of the IEEE communications society*, 2005
[13] M A. Hannan, Muhammad Islam, S. A. Samad, A. Hussain. Intelligent Vehicle Crash Data Analysis using Software Defined Radio. *European Journal of Scientific Research*. ISSN 1450-216X Vol.30 No.3 (2009), pp.417-426.
[14] Muhammad Islam, M. A. Hannan, S. A. Samad, A. Hussain. Modulation Technique for Software Defined Radio Application. *3rd WSEAS Int. Conf. on Circuits, Systems, Signal and Telecommunications (CISST'09)*. ISSN: 1790-5117.