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Software Defined Radio for RFID Applications

Promila Singh[1] and Gaurav Kumar[2]

[1]*M. Tech Student, Department of Electronics and Communication Engineering, Krishna Engineering College, Ghaziabad, U.P*
[2]*Department of Electronics and Communication Engineering, Rajasthan Institute of Engineering & Technology, Bhankrota, Jaipur*
E-mail: [1]promisingh22@gmail.com, [2]gauraveceriet@gmail.com

Abstract—*Initially RFID tags were developed to eventually replace barcodes in supply chain management. Their advantages are that they can be read wirelessly and without line of sight, contain more information than barcodes, and are more robust than other. 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. With recent advances in semiconductor processing technology and the development of reconfigurable devices, high bit-rate software-defined radio (SDR) has become practical for commercial applications. As certain convergence occurs when multiple technologies align in time to make possible those things that once were only dreamed. 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 technique. Then, we compare the differences of BER versus SNR performances for input and output signals. A software-defined radio is characterized by its flexibility. Simply modifying or replacing software programs can completely change its functionality. This allows easy upgrade to new modes and improved performance without the need of replacing hardware. An SDR can also be easily modified to accommodate the operating needs of individual applications.*

Keywords*: RFID, SDR, QAM, BER, SNR*

1. 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

Ham burgers; 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. 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 and MAC protocol.

2. SOFTWARE DEFINED RADIO (SDR)

A software-defined radio (SDR) is a wireless communications system where much 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 the past 20 years, there has been a big advancement in the wireless communication area. 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.

3. RFID

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

Tag (transponder)

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

Reader (Transceiver)

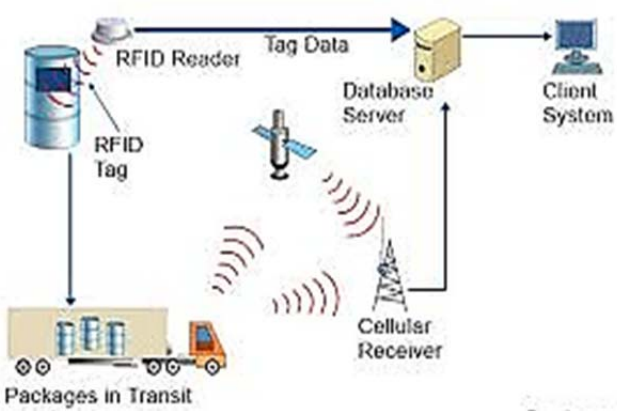
This device is used to read and/or write data to RFID tags. Antenna could be build inside the reader.

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.

3.1 RFID – As an integral part of our life

It prevents theft of automobiles & merchandise, Collecting tolls without stopping, Managing traffic, automatic parking, Controlling access of vehicles to gated communities, dispensing goods, tacking library books etc. RFID also used in U.S. homeland security with application such as securing border crossing etc.

3.2 RFID in industry



3.3 Types of RFID tags

- Active RFID tags

  - having their own power source.

  - advantage is if radar is much farther away, it still get the signal.

- Passive RFID tags

  - limited time span of upto 10 years.

  - do not require battery & having much smaller size.

4. MODULES OF SDR

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. QAM Modulation QAM Demodulation Filter +CH Noise / Interference Source TX RX SINK

4.1 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

4.2 TX

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

4.3 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.

4.4 RX

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

4.5 Sink

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

5. TECHNIQUE USED

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 band pass 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.

5.1 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 Fig. 5.1.

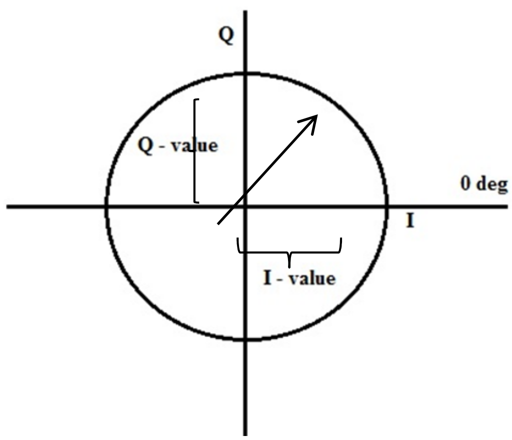


Fig. 5.1: IQ Constellation Diagram

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 Fig. 5.2.

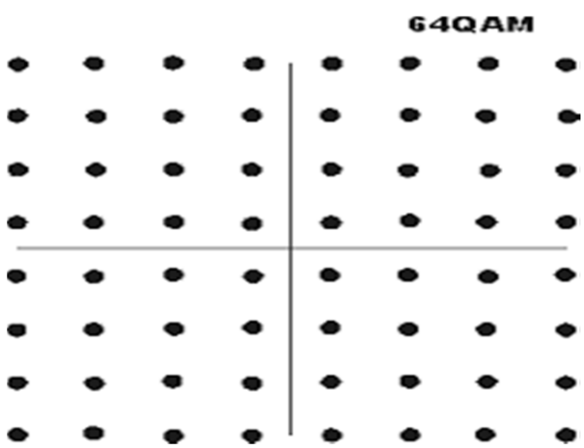


Fig. 5.2: 64 QAM Constellation

6. PERFORMANCE OF BER, SNR, POR IN QAM

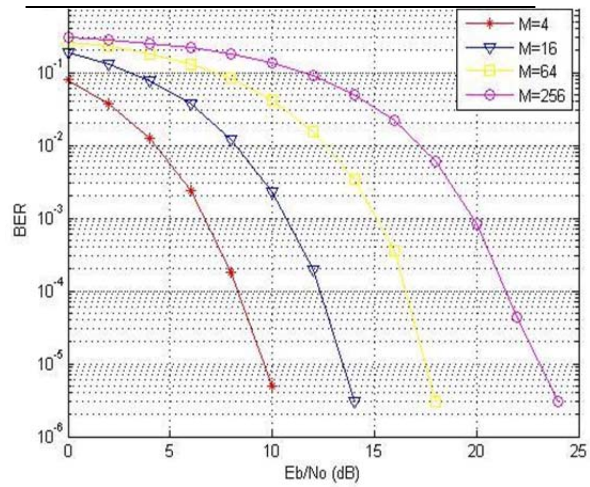


Fig. 6.1: BER vs probability of error of QAM

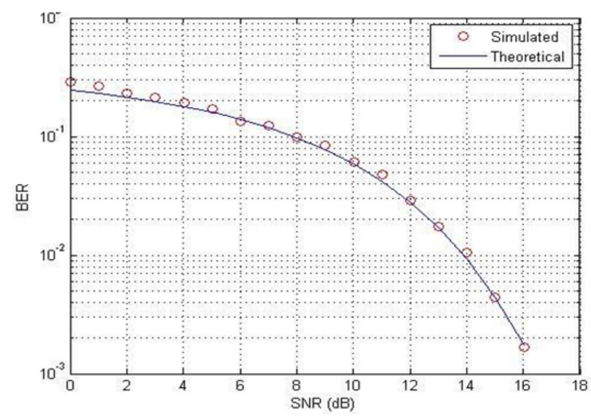


Fig. 6.2: BER vs SNR curve for QAM-16 modulation scheme in AWGN

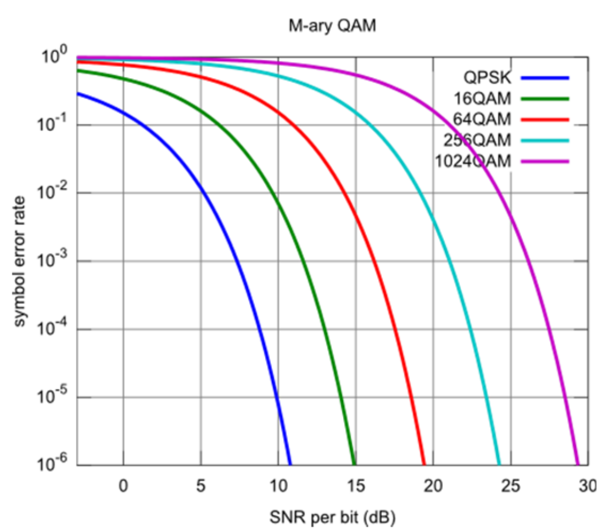


Fig. 6.3: Curve b/w symbol error rate vs SNR

7. COMPARISON OF RFID WITH BARCODE

Capability/ Technology	Bar code	RFID	RFID benefit example
Line of sight requirement	Required	Not required	No need
No. of items that can be scanned	One	Multiple	Very fast item inventory scan
Automation & Accuracy	Manual read error & miss scanning	Fully automated & highly accurate	Error free inventory count
Identification	Only series or type	Unique item level	Targeted recall
Data Storage	Limited codes	Up to several kb data	Real time data access in any location

8. APPLICATION SCENARIOS

8.1 Airport Logistics Asset Tracking

One of the motivating applications is asset tracking at airports. The location of objects and persons shall be tracked to improve logistic processes. Examples of assets are containers, baggage, vehicles, tools, personnel (crew, service personal, maintenance) on both the airfield and onboard of an aircraft, and also spare parts and maintenance tools. Interesting applications areas are in particular logistical processes as cleaning, catering, and maintenance. RFID tags can also be used to authenticate an airport's maintenance and service personal, and possibly even used tools when getting on-board of the aircraft. Another application scenario is to ensure that all tools are off the airplane when maintenance is complete.

8.2 Manufacturing

At a certain point during the manufacturing process, the future aircraft will include RFID reader devices that may be integrated with a fixed RFID infrastructure. However, a different view is to use special mobile, wirelessly connected RFID readers for the manufacturing process; In contrast to existing RFID systems, not only RFID tags are attached to movable objects, but some of them such as the aircraft body, a wing, or crawlers would contain also mobile, wirelessly connected RFID readers. The mobile readers provide the advantage of extending the possibility of inventory tracking and supervising logistic processes into areas, inside the aircraft, that could not be covered by a fixed RFID reader infrastructure located in the manufacturing hall. During the manufacturing process many different scenarios are of interest. Examples are the matching of parts to their real world positions on the aircraft, access control and time management of employees, self organising crawlers for efficient manufacturing, automating process control, facilitating the generation of status reports, or simply locating personal and equipment.

9. RESULTS

By taking advantage of the SDR simulation, we add the RFID application 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. 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. 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. As the error is lowest, thus, the preferable carrier frequency is 128 KHz for QAM modulation. Proposed system improves BER upto 10% and data rate upto 100%.

10. CONCLUSION

From the simulation results, 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. This results in a framework that allowed the RFID signal to be modulated with a constellation that was most appropriate for the channel conditions b/w the source & sink. The result is an intelligent reader that reads any tag to upgrade the system at different frequency's. When bit transmission rate requirement is high, QAM is used as a modulation scheme for better transmission performance. The QAM has the best performance in terms of BER vs SNR in the AWGN channel.

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