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Software Defined Radio in Radio Frequency Identification Applications

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Abstract: RFID is an important aspect of today's age because it boosts efficiency and convenience. It is used for a lot of applications that prevent thefts of automobiles and merchandise. In current times there have been continuous transitions from analog to digital systems where software is being used to define the waveforms and analog signal processing is being replaced with digital signal processing. In this paper, we have done a thorough literature survey and understood the working of how software-defined radio is implemented in radio frequency identification for a better BER performance.
Keywords: Software defined radio, Radio frequency identification, QAM, Digital Modulation, AWGN channel, BER performance

I. INTRODUCTION

Software-defined radio technology was at first planned as a way to expedite higher communications between the various forces of the United States military. This technology was seen as one thing that would lubricate the operating of these different radios and radio systems used inside the forces. Thus a software system radio is in a position to upgrade to new standards and additionally incorporate new services simply by downloading a program. Within the past few years, there are advancements within the field of wireless communication. This technology has reworked communication and businesses. Since SDR is a rising technology, its chances are associated with alternatives necessary to rising technologies thanks to that these rising technologies create SDR to advance technically and commercially.

Radio Frequency Identification is a phrase that could be applied to wireless radio technologies that are used for identification. RFID is a fundamental part of our lives that will boost productivity and convenience, whether we realise it or not. It has a wide range of applications, including preventing automotive and merchandise theft, among others. Its distinctive benefits like information transmission with extremely low power or even without power in the tag are often most importantly useful for product management. RFID system incorporates four different elements; a tag (or transponder), a reader (or interrogator), an antenna, and a bunch system that acts as each controller and database. It's an auto-ID system that could include bar codes, optical character scanners, or even retinal scans. They're employed in parturient prices to enhance accuracy and save time and money when data was previously recorded manually. RFID identifies and tracks tags attached to objects using electromagnetic waves. The tag transmits digital information, often a unique inventory number, back to the reader when triggered by an electromagnetic interrogation pulse from a close-by RFID reader device. This figure is frequently used to keep track of inventory. RFID tags are divided into two categories: passive and active. Active tags are powered by a battery, but passive tags are fueled by energy from the RFID reader's interrogating radio waves. As a result, passive tags may be read at a greater distance from the RFID reader, up to many metres. The tag, unlike a barcode, does not need to be inside the reader's line of sight, therefore it will be embedded into the monitored object. RFID is a method of automatic data capture and identification (AIDC). RFID tags are information storage devices that can be updated or modified as needed. This technology makes tracking products much easier. Software-defined radio relies heavily on digital signal processing since it allows for greater development flexibility. Several emerging technologies, such as NMT, GSM, and UMTS, are entering the scene. Multimode devices, such as 4G devices, legacy devices, and so on, are becoming more popular, and the same devices are being used on many networks. As a result, software-defined radio is becoming a more prominent and favoured technology as the capabilities of digital signal processing advance.

II. LITERATURE REVIEW

A structural scheme of software-defined transmitter and receiver of a proportionately wide class of known and synthesised multi-position radio signals and signal-code constructions was developed in this paper that provided effective adaptation to encroaching action under various environmental ambiences. The authors developed two generalised approaches for adjusting SDR systems to interference circumstances [1].

The writers conducted study on the blockchain digital platform's creative business classification. Three models were utilised in this paper: OIPB, OARB, and OAPB, which used multiparty process analysis to examine the main roles in the supply chain. The digital platform would also help to boost the ability to link with external systems and improved the effectiveness of online forensics, according to this report [2].

This research developed a new RFID anti-collision algorithm that took path loss into account while identifying tags. Collision, empty, and success probabilities in a mobile RFID environment were calculated using a probabilistic identification model, and were utilised to determine the cardinality estimation approach and the ideal frame length. The proposed solution's simulation and experimental findings revealed a significant performance improvement over commercial systems [3].

The authors compared RFID Tag performance and got results from an SDR-based measuring platform in this research. The collected results, according to the author, could be utilised to create custom-based performance indicators and evaluated RFID tags in a specific scenario. The overall SNR characteristics of both the RFID Tags were provided in this article at various frequencies and gains. The reader's ability to detect EPC was measured using the number of successful EPC detections made by both RFIDS. The ALN- 9740 RFID Tag values in the CDF plots were lower in all of them [4].

The authors of this research developed a method for updating UAV networking that combined software-defined radio and software-defined networking. While the findings were analysed, it was shown that reinforcement learning could meet the need for network updates when certain UAVs were out of power [5].

A four-channel coherent receiver, GNU Radio software for signal processing, and a four-dipole antenna element array were used in this paper to create a classic radio signal direction finder. The signals were received by a four-channel software-defined radio (SDR) using a four antenna dipole antenna array and processed by GNU Radio software, according to the author [6].

This study proposed multi-static networks of commodity, low-cost software-defined radios (SDR) connected over Ethernet to disperse Gen2 operation. The experimental results presented in this paper showed that Gen2 RFID tags could be reliably detected without rate-limiting preamble pilot bits using real-time carrier frequency offset estimation with phased-lock loop (PLL), and that more than one distributed SDR transmitter could boost the area coverage [7].

A framework for smart real-time performance monitoring and control of next-generation supply chains was given in this study. Dynamic Supply Chain Performance Management (DSCPM), that was a computerised event-driven system that ran in real-time, monitored a set of selected supply chain performance indicators, and effectively enabled real-time decision-making, was the proposed method employed in this work [8].

The authors of this work described a Bluetooth-based mobile application for supporting and improving internal and external interfaces to software-defined radio platforms. With examples of various control flows, a control message protocol was devised and implemented between the software-defined radio platform and smart devices [9].

This study suggested a framework for a Supply Chain based on RFID that incorporated the SCOR model into the Enterprise resource planning (ERP) system (Radio Frequency Identification). A case study on the new distribution of Italian postal stamps on the Italian market was used to demonstrate the methodology [10].

This paper presented a novel method for teaching electrical engineering students about wireless communications hardware impairments. The laboratory session's gear, software, and methods were given in the article, allowing for easy replication in other classes. The authors used modern and accessible SDR technology to explain well-established RF concepts based on research on the practical implications of heterogeneous RF characteristics of radios that shared spectrum [11].

A monostatic UHF RFID reader for personal applications is presented in this work, which is based on recently available COTS software-defined radio (SDR) application-specific integrated circuits (ASICs) and field-programmable gate arrays (FPGAs). When attached to a channel model and connectorized tag, the author achieved a sensitivity of -73dBm at the antenna port, and an open area tag read range of 2.6m with a 1.2dBi dipole antenna and 15.2m with a 12.5dBi patch antenna [12].

This research described a unique wireless tag that operates entirely on ambient backscatter signals and can modulate at high orders of magnitude. In this paper, a proof-of-concept prototype was exemplified indoors with a low bit rate of 328 bps with power dissipation under 20 A over a 2 m tag-reader distance [13].

The authors of this research employed face detection as a mechanism to support RFID operations in order to confirm that the person utilising RFID was the authorised user. The canny detection technique was used in this paper's proposed model to recognise the face user and check if the user was accepted or rejected [14].

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The electromagnetic challenge of chip impedance matching was linked in this research to variations in tag SNR at the reader. According to the author, the simulation results showed the difference in tag backscattering for various chip impedance states. The performance of the actual system and characterised variation of SNR at the reader were recovered using fully customizable Software Defined Radio (SDR) [15].

A theoretical examination of the sinkhole attack mitigation technique in SD-WSCRNs was reported in this research. The two key performance metrics chosen in this work were the false alarm rate and the detection rate. According to the author, the suggested scheme's performance appeared to be optimal when compared to the other schemes, and it was able to identify the sinkhole attack effectively when just the sinkhole node transmitted a single-hop count to the BS [16].

The solution to phase synchronisation for IEEE 802.15.4 coherent receivers on software-defined radio was described in this paper. The approach for software-based carrier synchronisation for software-defined radio was presented in this study. When compared to the phase unwrapping technique, the author claimed that the given solution enabled substantially improved synchronisation under low SNR settings [17].

The use of big data-driven clustering for the orderly discovery of real-time eccentricities in the process, as well as their route-cause audit, was discussed in this work. Whirlpool used the proposed approach to improve process control, and the most significant findings from the assessment research were provided [18].

The authors demonstrated methods for systematically refining domain analysis to account for all business rules in this study. The use of a state machine to express all aspects of domain selection was proposed. The state machines were chosen for their ease of use and formality. The major goal of the approach used in this paper was to show how to generate a DSL from a Domain Analysis that could be used by a coding system while respecting all business rules without the need for elaborate definitions or papers [19].

RFID, according to the authors, was the hottest technology in the domain of wireless applications. A software radio consolidated with different wireless protocols, provided new services, and ameliorates to new standards by simply downloading a new programme. The authors of this paper used the SDR to create an RFID application simulation environment. The authors used Quadrature Amplitude Modulation to simulate source-to-sink transmission and then scrutinized the differences in BER against SNR performance for input and output signals [20].

III. THEORY AND CONCEPTS

An RFID system that existed in countless variants or produced by many different manufactures consists of a tag (transponder), a reader (transceiver), and software-defined radio as shown in Fig. 1.

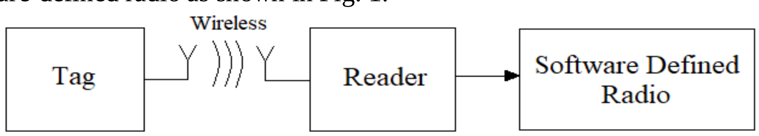

Fig. 1 Radio frequency identification system with SDR

When the information was queried electromagnetically, the tag replied to the presence of a reader by communicating its information, as shown in Fig. 1. Everything from the information conveyed to the power source of the electromagnetic wave to the lengths this information travelled vary greatly from chip to chip depending on the chip's application, but the concept stayed the same. Hence the tag provided the information to the reader. In between tag and reader was an antenna that received the information from the tag and sent it to the reader. This RFID antenna was created to send and receive EM radio waves at the desired frequency, polarity, and directionality. The antenna then used RF energy to send and receive power and/or data between readers and tags. All the information transmitted from the antenna to the reader was then processed inside the reader for further communication with a computer that hosted the RFID middleware. This data or information was then sent to the software-defined radio for modulation and demodulation of these radio signals. As shown in Fig. 2, software-defined radio has three primary components: a transmitter, a channel, and a receiver.

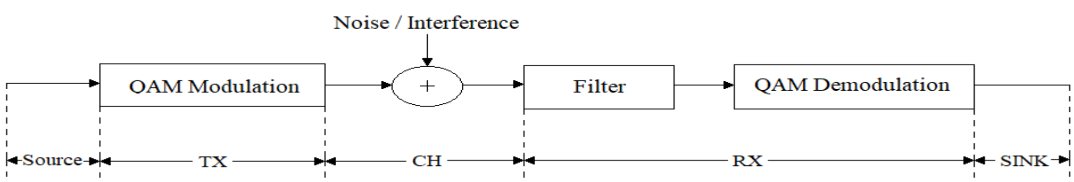

Fig. 2 Block diagram of software-defined radio

As shown in Fig. 2 the data from the reader was first given to the source to generate data bits that were to be transmitted. This information or data was then encoded and modulated in QAM modulation before they were sent to transmit. A channel module was placed between the transmitter and filter. This channel was divided into two sections: the transmitter-to-receiver channel and the receiver-to-transmitter feedback channel. After generating I and Q baseband signals, they were modulated with two quadrature carriers using an I-Q modulator, allowing these two signals to be sent and received over a single channel with the same bandwidth. The AWGN channel generated noise on the receiver side if the transmitter was expected to be perfect and noiseless.This Gaussian noise proved crucial in the performance analysis of communication systems. This signal was then sent to the SRRC filter, which demodulated the channel's received signal. All of the receiver's parameters were set to the same values as the transmitter's. Because the matching filter's output signal had a significantly higher sample rate than the input signal, a downsampler was required to restore the signals to the same symbol rate as the input signal. The input symbol rate was downsampled at a rate of 16 times the input symbol rate. The data bits were decoded, filtered, and demodulated after antennas received them in the RX module, which was comparable to the TX module. Then the signal was transmitted to Sink where all the simulation results were computed and presented [1], [3], [4], [20].

TABLE I represents the design specifications that were used and obtained for the system working [1], [3], [4], [9], [10], [11], [12], [17], [20].

TABLE I
DESIGN SPECIFICATIONS

Sl. No.	Design Specifications	
	Parameters	Value
1.	Bit rate	10Gbps
2.	Length	25cm, 100cm
3.	Power	20dBm
4.	UHF band	870MHz
5.	Total bandwidth	30kHz – 8MHz
6.	Frequency	70MHz – 6GHz
7.	Carrier Frequency	32kHz, 64kHz, and 128kHz
8.	BER	1.34%, 0.60%, and 0.105%
9.	SNR	6dB
10.	TX power	30dBm
11.	QAM	6 bits

IV. ANALYSIS OF THE RESULTS

The RFID application was introduced to study the transmission performances using the SDR simulation. In the transmission from source to sink, QAM was employed as the modulation. The source generated the input data, which was then passed into the modulator before being supplied to the AWGN channel for radio frequency identification. The filter was used to filter the data coming in before demodulating it from the transmitter and processing it back to the original before sending it to the receiver's output. Ideal conditions were initially anticipated, including no feedback delay or error, flawless channel estimation, and exemplary channel quality estimation.

The first two limits were then eased in order to assess their impact. Finally, all of SINK's data was acquired. Ideal conditions were considered in the initial work, and a simulation of 16-QAM, 64-QAM, and 256-QAM modulation in the AGWN channel for BER performance of varied carrier frequencies of 32 kHz, 64 kHz, and 128 kHz was successfully completed. An inaccuracy of 0.8 percent, 0.26 percent, and 0.12 percent was found for 16-QAM modulation carrier frequencies of 32 kHz, 64 kHz, and 128 kHz, respectively.

The error for 64-QAM modulation with carrier frequencies of 32 kHz, 64 kHz, and 128 kHz was 0.56 percent, 0.0505 percent, and 0.065 percent, respectively. The error for 256-QAM modulation with carrier frequencies of 32 kHz, 64 kHz, and 128 kHz was 1.1150 percent, 0.715 percent, and 0.5750 percent, respectively. It was discovered that as the carrier frequency increased, the error decreased; hence, the preferred carrier frequency for M-QAM modulation was 128 kHz that produced a superior result [20].

V. THE NEED FOR SDR AND RFID IN OUR LIFE

Computers can use radio frequency identification to automatically record information about what is happening in the real world and to warn managers when something isn't going as planned. It prevents car and merchandise theft, collects tolls without stopping, manages traffic, automates parking, controls vehicle entrance to gated communities, dispenses commodities, and tracks library books, among other things. RFID is also used in homeland security with an application such as securing border crossing etc. RFID systems offer perks for businesses of different sizes, allowing them to promptly improve efficiency and diminish cost by automating processes and enhancing utilisation of assets and quality. SDR technology provides the flexibility, cost effectiveness, and power to pitch communications forward, with far-reaching benefits realised by service providers and goods producers all the way to end-users.

VI. APPLICATIONS

A. Airport Logistics Asset Tracking
B. Wildlife/Livestock monitoring and tracking.
C. Production and Processing
D. Inventory and manufacturing process control.
E. Order fulfilment in the warehouse.
F. Managing the Supply Chain
G. Inventory management software.
H. Management of logistics.
I. Retail
J. Inventory management and customer knowledge.
K. Reverse logistics with auto checkout.
L. Security
M. Control of access.
N. Anti-counterfeiting and anti-theft measures.

VII. CONCLUSIONS

After analyzing the results it was observed that in the AWGN channel the QAM had the supreme performance of BER versus SNR. In this case, as a denouement when there was a high requirement of bit transmission rate, then for better transmission performance a modulation scheme known as QAM was used. We observed that the results that were obtained allowed the signal to be modulated with a constellation for the channel conditions between source and sink and the reader was able to read any tag for upgrading the system at different frequencies and parameters. Since software-defined radio eliminated different kinds of radio hardware for different RF bands and could communicate with each other irrespective of the band limitations it was implemented in radio frequency identification for better performance, security, flexibility, cost efficiency and better results.

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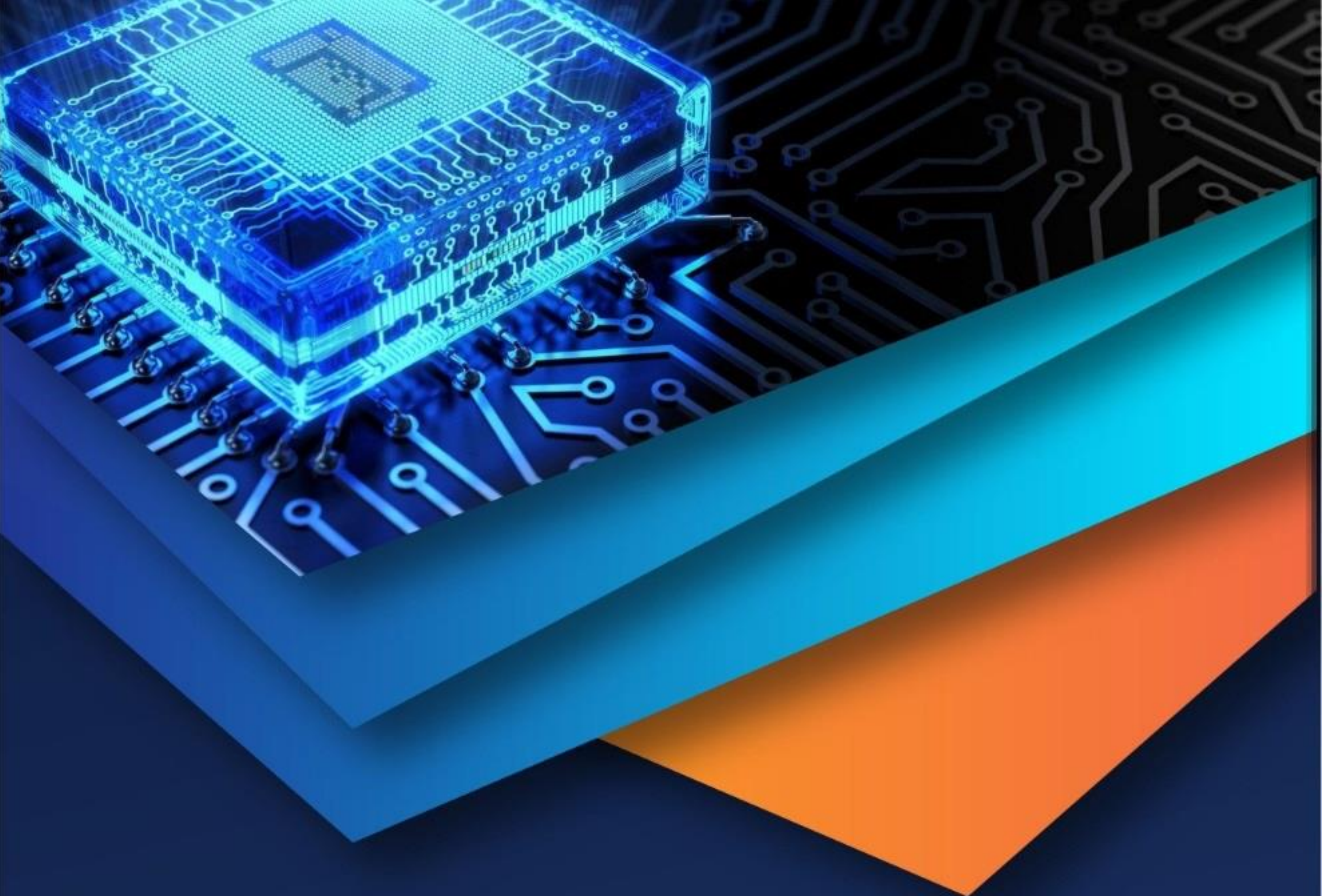

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