Simulation of a New Algorithm to Enhance the Spectral Efficiency of 5G for IoT Applications

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Abstract

The wireless communication systems witness a huge developments in the mobile generations (1G to 5G and recently 6G). These generations is available to satisfy the users need. The basic goal of this paper is to simulate a 5G system in the physical layer for IoT applications. A proposed model in this paper is a sensing system for various signals schemes at different noisy channels. The model depends on new radio (NR) to work at high frequencies in wireless communication applications and IoT applications. The design of the system was based on using a variety types of modulation most commonly used in communication systems: OFDM, 8PSK and MQAM. Matlab simulation tools is used to implement the proposed system, where signals of various lengths and different types of noise were taken. The noise types such as AWGN, phase noise, frequency offset and Dc offset are applied to check the efficiency of the aimed system. The proposed 5G system have been implemented in software by matlab simulation tools to evaluate the results through constellation diagram, frequency spectrum and time scope shows a good response. Obtained results from this work shows a good results in terms the frequency spectrum and. constellation diagram. 5G is the attractive newest technology that must to be studied in details, especially for communication engineers.

Keywords

5G, internet of things, OFDM, new radio, MIMO.

1. Introduction

5G is the next major phase of mobile telecommunications standards, following the present 4G LTE (Long-Term Evolution) standards. Various industries must specify, develop, and deploy the technology. Network equipment makers, network operators, and others are among the participants. Device manufacturers and semiconductor vendors. 5G will have a wide range of applications. Mobile phones to next-generation autos are only a few examples. The race to 5G is being driven by two big trends: the increasing development in the need for wireless broadband that can transport video and other content-rich services, and the IoT, which connects vast numbers of smart devices to the Internet. 5G will achieve these goals by providing ultra-high broadband speeds, ultra-low latency, and ultra-reliable online connectivity. 5G networks and devices will necessitate significantly different designs, radio access technology, and physical layer algorithms than current networks and devices. Macro base stations, which use millimeter wave technologies and enormous MIMO antenna arrays, will be supplemented by dense networks of tiny cells. In addition, the equipment of network and devices processing will be more integrated and adaptive [1].

Hybrid beam forming, for example, is pushing the boundaries of wireless system development. These highly integrated technologies necessitate a corresponding integration of domain skills and tools in the engineering area. Figure 1 represents an examples of 5G Applications and Requirements [2].

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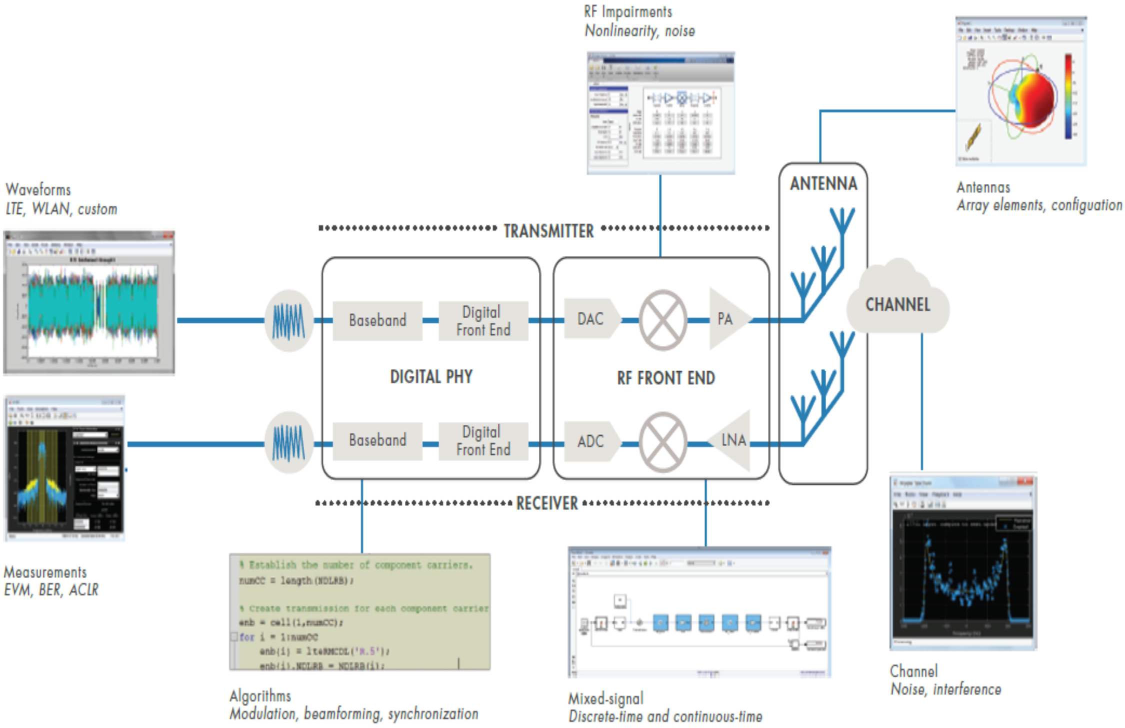

Figure 1: Examples of 5G Requirements and design steps

The software defined radio (SDR) is the concept that is used in communication systems to perform the concept to convert from radio frequency to baseband directly using programmable digital devices such as FPGA and ASIC as seen figure 2.

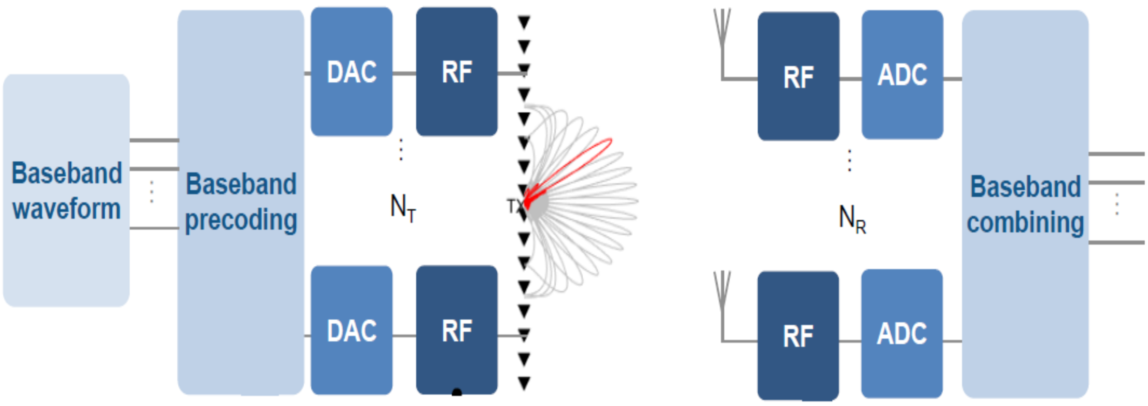

Figure 2: SDR and conversion from RF-baseband and vice versa

Wireless Software Defined Networking is a novel techniques which helps with network management and setup in mobile cloud computing. Rather than boosting network performance or network security, monitoring. More flexibility is required in today's networks and simple debugging; to get to this point, SDN takes a detour. Conventional networks' vertical incorporation and through the ability to control the network from a central location gives you more flexibility network programming SDN has the ability to change the parameters of its network dependent on its operating conditions.
WSDN can be used to implement 5G networks. 5G-IoT systems will be speedier and more scalable thanks to this new paradigm [3, 4].

The evolution of IoT applications is increasingly being guided by 5G networks. 5G has the potential to change the world. By making significant effect on future generation of IoT a network of billions of sentient objects that generates genuine data IoT in the future and on a large scale. At the moment, IoT identification is difficult. Because of the complexity of the gadgets, determining their capability is extremely challenging. The requirements for a heterogeneous domain of applications should be met. The requirements of the application International Data suggests that according to a survey by the International Data Corporation (IDC), global 5G services will 70% of corporations are expected to invest $1.2 billion on the project. Solutions for connectivity management IoT solutions in use today specific application domains, such as healthcare, have a wide range of designs.

BLE, ZigBee, and Wi-Fi are examples. LoraSixgfox networks, as well as cellular communications (3GPP, LTE), and so on. With the introduction of new technologies, the Internet of Things is fast evolving. Technology, particularly in the context of new application domains. IoT boost the life quality. Lifestyles involving the linking of smart devices for the home and smart environments The Many obstacles are emerging in the Industry IoT, as a new solution need changing business models [5, 6 and 7].

The object of study is the process of selecting matlab tools to implement 5G system. The subject of study is the methods and the tools for design 5G system for IoT applications via the matlab. The purpose of the work is to simulate and evaluate of 5G physical for IoT based on matlab simulation tools in order to Increased bandwidth, Better spectral efficiency and flexible air interface.

2. Problem Statement

Increased users' needs and requirements for good services at a high degree of quality in last recent years, placed restriction on the technology. Various activities on 5G-IoT have been completed, including wireless research studies on 5G that adapted solutions for 5G problems.
IoT applications benefit from 5G-real-time, IoT's development is online and on-need, and social experiences. The 5G_IoT infrastructure must be fully automated and capable of end-to-end coordinated, intelligent and quick operation at all times.

The 5G-IoT designs will meet the following needs: Engage cloud based radio access network for enormous connections to many standards and implement on-demand deployment of RAN functionalities required by 5G to reconstruct radio access network (RAN). Designing on-demand network functions setup by simplifying core network architecture. This work aims to design and simulate matlab system to serve 5G in IoT applications.

3. Materials and Methods

Architecture with three levels: The three-level architecture is fundamental to the Internet of Things, and it has been created and implemented in a variety of systems. Sensing, transport, and application are the three layers of an IoT architecture. [8] Suggested a self-configuring and scalable architecture for a large-scale Internet of Things network. The Internet of Things is divided into three categories: internet-based, sensors and actuators, and knowledge. In general, IoT technology deployment is close to current civil that practically connected to systems by WSN [9]. The architecture of the Internet of Things is commonly divided into three tiers [10]: perception, network, and application. The sensor layer, also known as the perception layer, is the bottom layer in IoT architecture. Transmission, also known as Network level in IoT design, is implemented as the middle layer [11].

2. Architecture based on SDN. Z. Qin et al. created an SDN-based IoT architecture to deliver high-level QoS to diverse internet of things workloads in heterogeneous wireless sensor network.

3. Architecture based on Quality of Service (QoS). Jin et al. present four distinct IoT architectures in [12], each of which allows different smart city applications to include their QoS needs. The recommended architectures of network are: 1- autonomous, which supports Internet-disconnected networks; 2- ubiquitous, in which STN are a part of the Internet; 3- ubiquitous, in which Smart Things Networks (STN) are a part of the Internet; and 4- ubiquitous, in which Smart Things Networks (STN) are a part of the Internet. 3- application-level overlay, which employs NFV to alleviate node stress and congestion [13]; 4- service-oriented, in which specialized gateways interact with the IoT environment's intrinsic heterogeneity..

4. Mobility-First Design. In [14], it was demonstrated that using name-based future Internet architecture (FIA) termed Mobility First, several issues connected with Smartphones when acting as casual gateways of WSANs in IoT systems could be addressed.

Cloud Things Architecture is number six. J. Zhou et al. [15] provided an IoT-enabled smart home scenario to examine IoT application needs. As a result, a Cloud Things architecture based on a cloud-based IoT platform has been proposed.

A discussion of the Internet of Things, including its definition, prospective applications, obstacles, and enabling technology. Cognitive radio is one of these technologies that has received a lot of attention. The general goal of this article is to provide a global overview of the incentives for integrating cognitive radio into IoT, as well as the obstacles that will be raised, in order to serve as self-reconfigurable solutions for a variety of IoT applications [16].

The three-level architecture is fundamental to the Internet of Things, and it has been created and implemented in a variety of systems. The three tiers of an IoT architecture are sensing, transport, and application. A self-configuring and scalable architecture for a large-scale Internet of Things network was presented in [8]. The Internet of Things is divided into three categories: internet-based, sensors and actuators, and knowledge. In general, IoT technology deployment is close to current civilization, where gadgets and society are practically connected to information systems via wireless sensors [9]. The IoT architecture is commonly divided into three layers [10]: 1- perception level, 2- network. In IoT architecture, the sensor layer, also known as the perception layer, is implemented as the bottom layer. In IoT design, transmission, also known as Network level, is implemented as the middle layer [11]. The application layer is also known as the business layer. Architecture based on Quality of Service (QoS). Jin et al. present four distinct IoT architectures in [12], each of which allows different smart city applications to include their QoS needs. The recommended network architectures are: 1- autonomous, which bolsters Internet disconnected networks; 2- ubiquitous, where Smart Things Networks (STN) are a part of the Internet; 3- application-level overlay, which uses NFV to reduce stress and congestion among nodes[13]; 4- service-oriented, where specific gateways interact with the inherent heterogeneity of the IoT environment.

The proposed system consist of the transmitter and the receiver that maintain uplink and downlink respectively. Different channel types are used to test the quality of the system because of the RF imperfections that cannot be neglected, especially in 5G with higher frequency, there will be a need for greater integration between RF and baseband. For compliance testing, the 3GPP 5G NR standard offers sets of link and waveform configurations. NR test models (NR-TM) for base station (BS) RF testing and downlink fixed reference channels (FRC) for user equipment (UE) input testing are two types of downlink conformance waveforms. OFDM-based transmission for both uplink and downlink was developed for outdoor cellular deployments up to ~3GHz carrier frequency 15 KHz subcarrier spacing 4.7microsecond CP for the Uplink transmission according to the following table that represents the specification of 5G NR waveform. For the U link-Downlink Configuration, It is provided as part of the system information. To avoid severe interference between different cells, neighboring cells typically have the same uplink downlink configuration. It is possibility to dynamically change the uplink-downlink configurations per frame. The Dynamic reconfiguration is useful in small and relatively isolated cells where the traffic variations can be large and inter-cell interference is less of an issue.

Table 1.
Specification of 5G NR waveform

Subcarrier spacing (KHz)	Useful symbol time $\mu sec.$	Cyclic prefix Tcp
15	66.7	4.7
30	33.3	2.3
60	16.7	1.2
120	8.33	0.59
240	4.17	0.29

24-bit CRC is calculated & appended to each transport block, triggers H-ARQ/reTx. Turbo Coding with QPP (Quadratic Polynomial Permutation) inter leaver, decoding can be parallelized, different parallel processes can access the inter leaver memory. Outputs of Turbo encoder are separately interleaved. Interleaved bits are inserted into circular buffer (order). Bit selection extracts consecutive bits that matches the number of available resource blocks. A Redundancy. Version (RV) specifies a starting point to start reading out bits. Input bit sequence undergoes a bit-wise XOR operation with a cell specified pseudo-random sequence generated by length-31 Gold sequence generator. Reduces interference from adjacent cells, full utilization of channel coding as seen in Fig. 3.

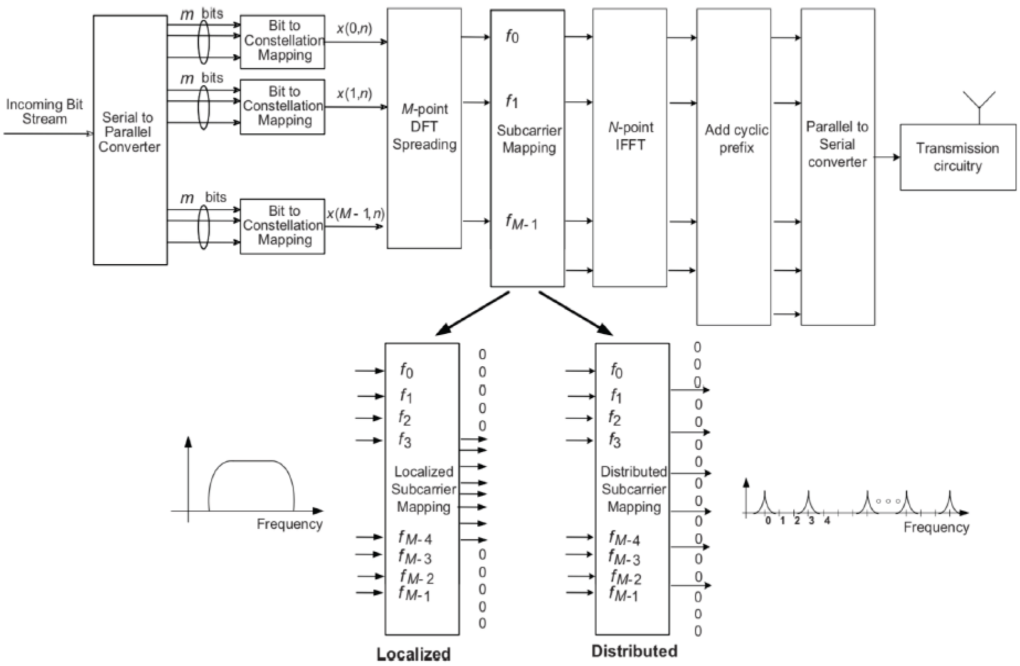

Figure 3: Processing of the Uplink Physical Layer

The Processing of the downlink Physical Layer can be seen in Fig. 4

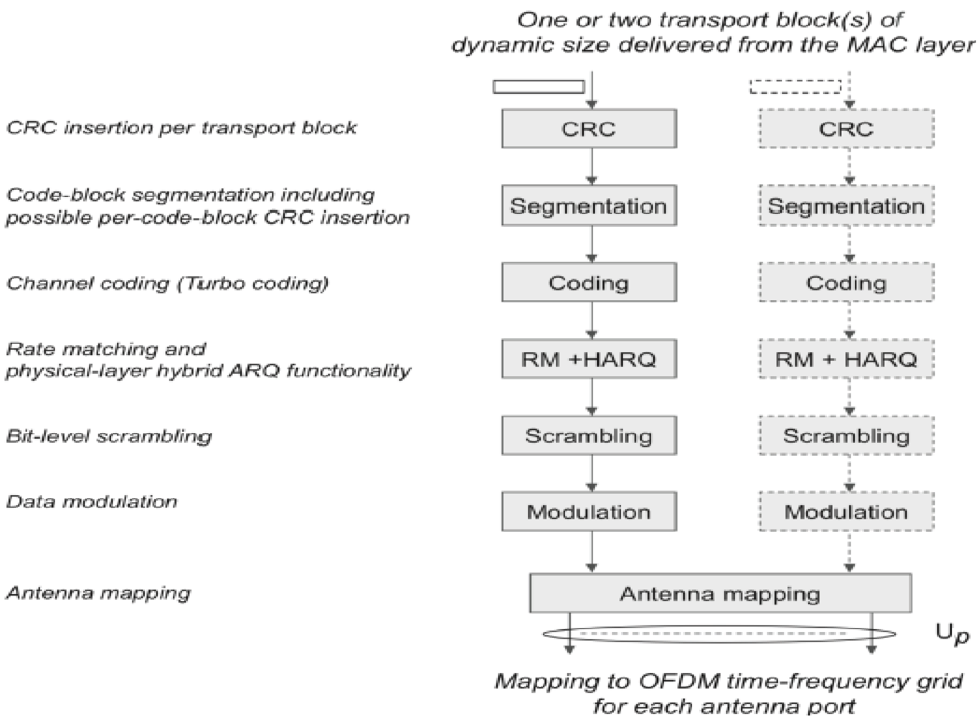

Figure 4: Processing of downlink Physical Layer

4. Results and Discussion

The proposed system uses the Matlab 2021 simulation tool in the design and simulation. The basic purpose of this work is to get a good synchronization between the transmitter and the receiver even when the impairments are founded. The details of the uplink is clear in table 2 that stand for the required parameters of the system in the uplink case. It seen from the table that the frequency range is from 410 MHz to 7125MHz and the modulation types are PSK, QAM and OFDM.

Table 2- Design parameters and their values

Parameter	The value	description
Frequency range	410-7125 MHz	Subcarrier spacing 15 KHz
Modulation type	PSK, QAM, OFDM	Target code rate is 2/3, 4/5
Fixed ref. channel	G-FRI-A2	Layers :1
BW	40 MHz	Payload: 9224 bit/slot
sub frames	10	Allocated symbols 0:13
Noise types	AWGN, Phase noise, DC offsets, IQ imbalance	Different noisy environments
Input data	Random	Different values

Matlab simulation results shows the ability of the system to get the goal. Fig. 5 represents the time scope for the signal (real and imaginary) for the uplink stage. Fig. 6 is the frequency spectrum of the uplink stage.

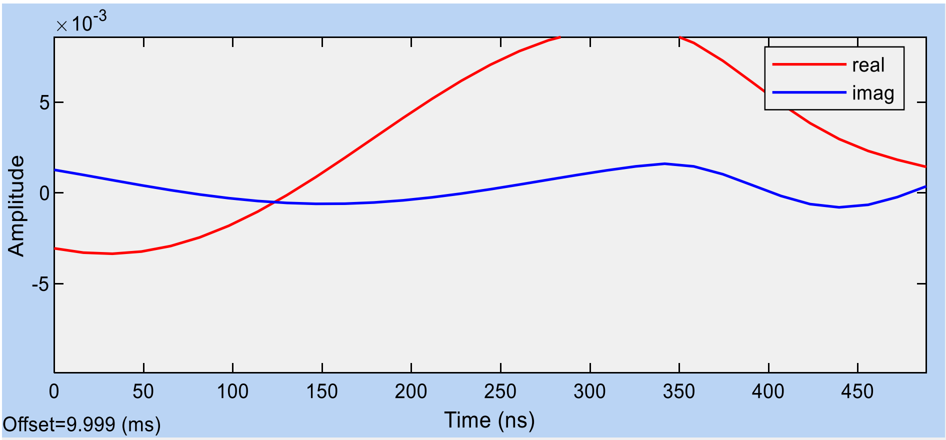

Figure 5: Time scope

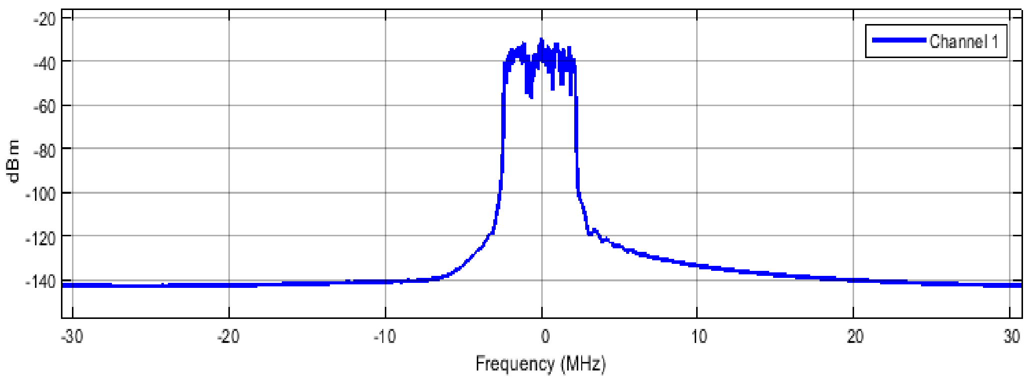

Figure 6: Frequency spectrum

For QAM signal, the real and imaginary is represented on Fig. 7. The used filter is the root raised cosine with roll off is 0.3 with input bit is 60000.

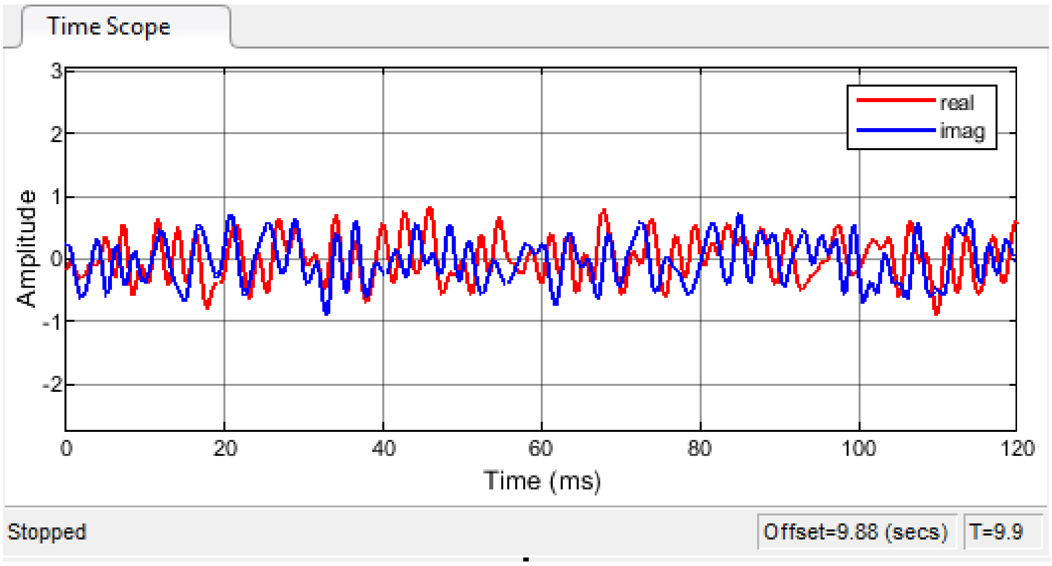

Figure 7: 64QAM time scope

When quadrature amplitude modulation is used, the spectrum will be as seen in Fig. 8 that dedicated for the frequency spectrum in the case of 64QAM.

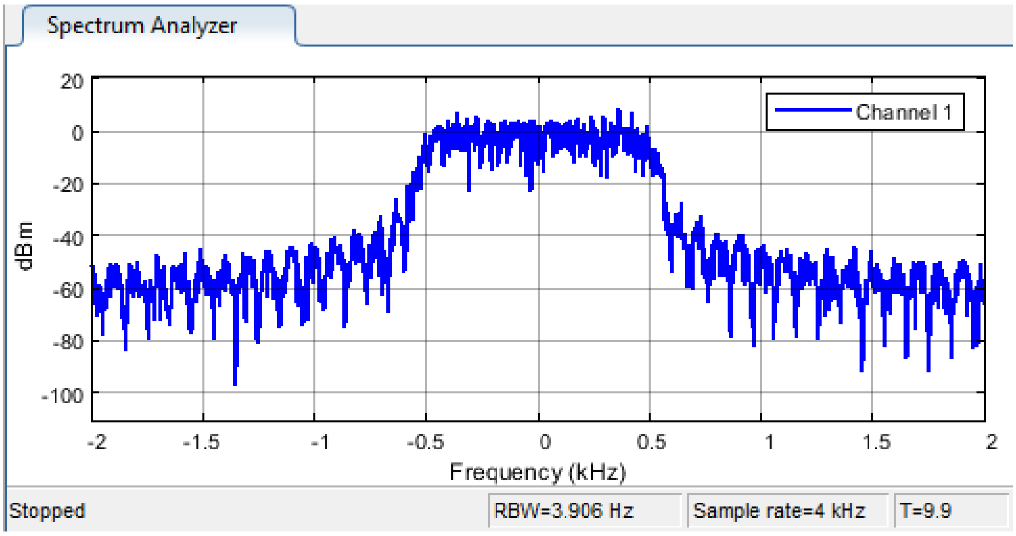

Figure 8: the frequency spectrum of 64QAM

The constellation diagram is measured to show the allocation for each one of the samples as shown in Fig. 9 that represents the constellation diagram for the 8PSK at noiseless case.

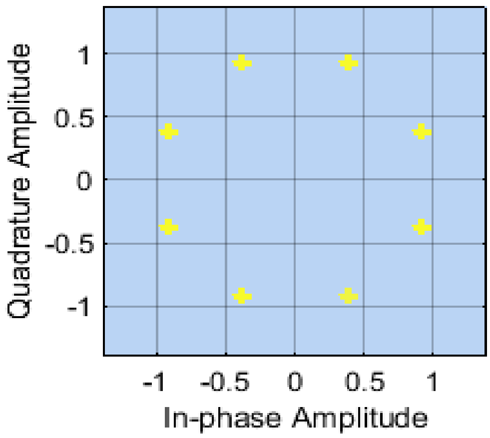

Figure 9: The constellation diagram of 8psk noiseless case

When the AWGN is applied on the system as the case as seen in Fig. 10, the phase angles are moved and changed from the standard location.

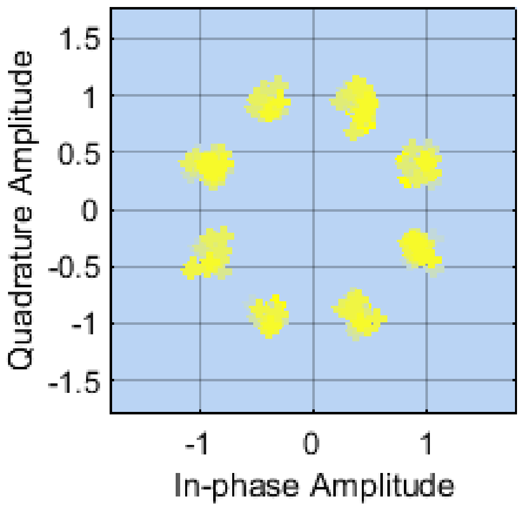

Figure 10: The constellation diagram of 8psk at AWGN case

For the case of noiseless 64QAM, the constellation diagram is seen in Fig. 11.

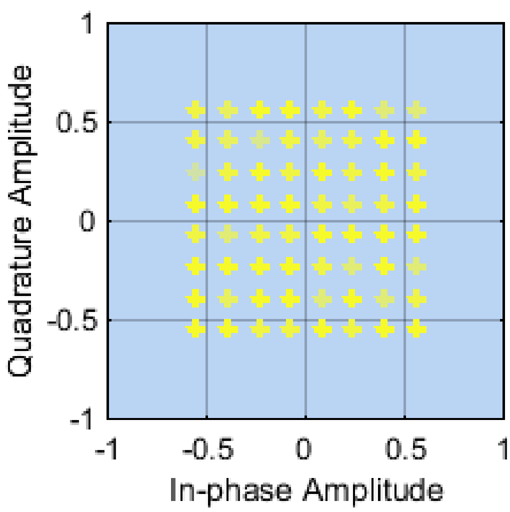

Figure 11: The constellation diagram of 64QAM noiseless case

The system is effected when phase offset is applied as shown on Fig. 12 that represents the constellation diagram for 64QAM for pi/4 phase offset.

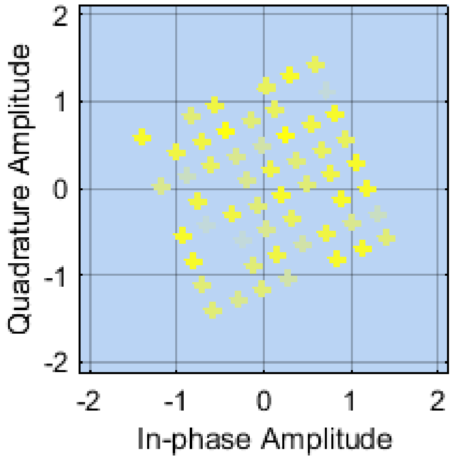

Figure 12: The constellation diagram of 64QAM at phase offset of pi/4 case

For the case of OFDM, the OFDM subcarrier of all transmitters antennas is shown in Fig. 13.

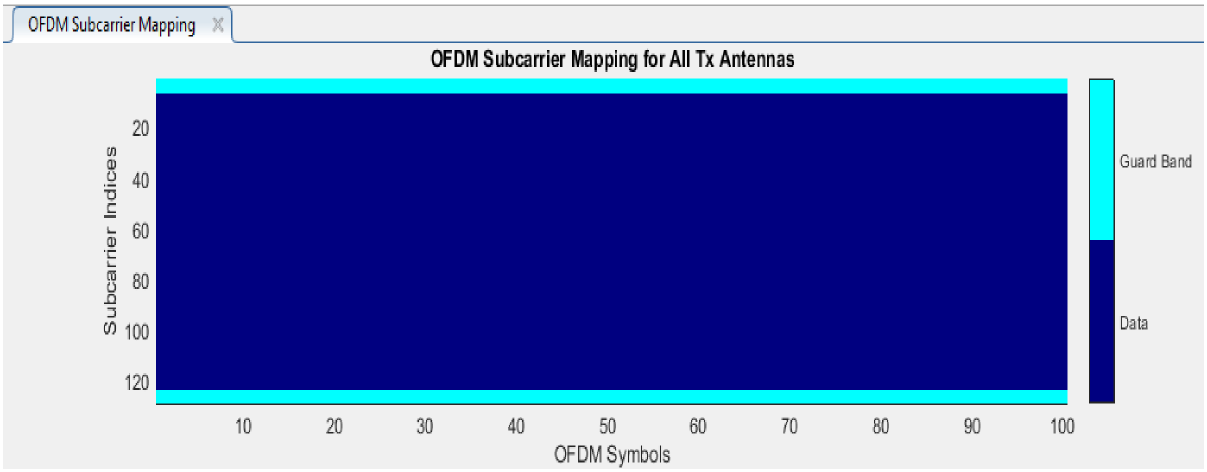

Figure 13: OFDM subcarrier of all transmitters antennas

5. Conclusions

5G is the more attractive technology in our daily life in terms of the services and devices that users need to use. As a result from the proposed system we see that the system deals with most power modulation techniques (PSK, QAM and ODFM). The frequency spectrum and the constellation diagram reflects the capability of the system at high frequency bands and the ability to overcome the noise.

6. Acknowledgements

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7. References

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