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Comparative Analysis of 5G Multicarrier techniques with index Modulation

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ABSTRACT:

In the last two decades, the wireless communications field has seen many radical disruptions in improving technologies. It is to provide the highest quality of service to the end-user. Fourth-generation wireless communications technology is one of this kind. Currently, Fifth-generation (5G) wireless communications network is the muchanticipated technology to serve massive bandwidth efficiency. This technology gives a stable platform to many state-of-the-art technologies regarding their need for reduced latency communication purposes. The applications of this technology are used in the fields of critical healthcare services, autonomous driving and smart homes etc. The existing technology has shown some intriguing trade-off among the requirements for 5G. Generalised Frequency Division Multiplexing (GFDM) and Filter Bank Multicarrier (FBMC) are the potential schemes that satisfy the needs of the 5G networks. On the other hand, Index Modulation (IM) provides the modular architecture and the BER efficiency for the multicarrier systems. The aforementioned potential schemes, when combined with IM, open for new possibilities. The proposed research work is mainly focused on the applications of the GFDM-IM and FBMC-IM. Under the Rayleigh multipath fading channel and Additive White Gaussian Noise channel (AWGN), this research work presents the GFDM-IM and FBMC-IM device models. These models are then compared with GFDM-QAM, FBMC-OQAM, and OFDM-IM in terms of error performance without compromising the requirements of 5G.

Index Terms—5G Wireless Communications Networks, GFDM, FBMC, OFDM, Index Modulation, relaxed synchronisation, error performance.

I. INTRODUCTION

The Next Generation Mobile Networks (NGMN) Alliance highlights the necessity to make more spectrum available in the existing sub-6 GHz radio bands and introduce new agile waveforms that exploit the existing underutilized fragmented spectrum, in order to satisfy specific fifth-generation (5G) operating scenarios. The goal of the waveform symbiosis will be to flexibly optimize the use of existing underutilized spectrum resources, guarantee interference-free coexistence with legacy transmissions and provide an improved spectral containment compared to the orthogonal frequency division multiplexing (OFDM) modulation that is widely used in broadband wireless systems operating below 6 GHz. The massive number of devices and the support of multi-point transmissions in 5G use cases will imply the use of relaxed synchronization, potentially leading to strong inter-user interference. OFDM is a multicarrier communication scheme that has been widely adopted in a number of different wired and wireless communication systems. Among others, 3GPP adopted it as the underlying physical layer (PHY) technology in mobile broadband systems denoted as 4G long-term evolution (LTE). It exhibits some intrinsic drawbacks including frequency leakage caused by its rectangular pulse shape, spectral efficiency loss due to the use of a cyclic prefix (CP) and need for fine time and frequency synchronization in order to preserve the carrier orthogonality,which guarantees a low level of intra and inter-cell interferences. To overcome these limitations, several alternative candidates have been intensively studied in the literature over the past few years, such as universal filtered multi carrier (UFMC) and filter bank multicarrier (FBMC). The popular candidate 5G waveforms and compares them in terms of specific performance features such as spectral efficiency, peak-to-average power ratio (PAPR) and Bit Error Rate (BER) are presented in this work. Finally, presentation of practical implementations of FBMC-based waveforms demonstrating the feasibility of adopting such PHYlayer schemes and verifying their superior performance when compared to 2 CP- OFDM, under shared licensed spectrum use cases (i.e. a driving technology of several 5G usecases). Depending on the end use and specific operation band (i.e. sub 6 GHz and millimeter wave frequencies), it is expected that two versions of 5G radio access waveforms will be standardized. Details related to real-time implementation of 5G waveforms and laboratory-based experimental validation are very scarce in the literature and typically provide benchmarking of a particular use case.

II. LITERATURE SURVEY:

• S. M. Alamouti, presented diversity plan utilizing two transmitting and single receiving antenna. This plan provided identical order of diversity as a maximal ratio combining at the destination, with single and double antenna at input in this new scheme, there is no need of any bandwidth expansion.

• K. Kalliola, 2002 has proposed another framework for radio connections estimations together with radiation and space for investigating wireless transmission in broadband framework. The author described various benefits of the created estimation framework with accomplishing of channel estimation with rate of 2 GHz. Ye (Geoffrey)

• Li et.al. 2002 have focused upon an innovative approach in which multi antenna technique is combined with MCM in broadband to alleviate inter symbol interference and improve framework capacity this framework utilizes different space codes for different antennas combination. At the destination, different decoders have used.

• V. D. Nguyen et.al. 2003 have focused upon an approach by considering time variant channel on interference in MCM. The author has presented the comparison Analysis of simulated with hypothetical results.

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• Gesbert et al. 2003 have proposed the enhancement in the field of MIMO space time coded systems. They also show the different advantages of MIMO as well as spatial multiplexing and pace-time coding schemes. At long last, the paper addresses current queries relating to the mixing of MIMO links in sensible remote framework and standards.

• H. Al-Hassan, 2004 has presented model of radio receiver and its simulated results. The author additionally tried several systems to enhance the transmission of data in form of diversity and equalization .The author has utilized SSC type of diversity approach.

• S. H. Krishnamurthy, 2005 focused upon the electromagnetic field pattern of transmitter and spreading of energy in surroundings on which the capacity of system depends. The author has also presented the constraints on which execution of designed algorithm depends. The author utilized the hypothetical systems for multiple antenna to execute propagation in fading environment.

III. EXISTING METHODOLOGY:

3.1: 5G air interface design based on universal filtered (UF-)OFDM

5G air interface design with respect to waveforms, multiple access and frame structure are discussed. 5G will be driven by supporting very heterogeneous service and device classes. A unified frame structure for handling those heterogeneous traffic types is presented. POFDMhasitslimitationsinspectralproperti esand in conjunction with relaxed time-frequency alignment. The most discussedcontenderso far is Filter-Bank based Multi-Carrier (FBMC), with better spectral properties but new drawbacks introduced by offset-QAM and long filter lengths. Hence, a new alternative is required: Universal-Filtered OFDM (UF-OFDM), also known as Universal Filtered Multi-Carrier (UFMC), is a recent technology close to OFDM. UF-OFDM, according to encouraging results so far, summarized in this paper, fits best to the 5G system requirements. A further feature of the Unified Frame Structure is the usage of multiple signal layers. Here, users can be separated e.g. based on their interleavers. This will introduce an additional degree of freedom for the system, improve robustness against crosstalk and help to exploit the capacity of the multiple access channel (MAC). Altogether, the proposed new concepts offer an emboldening approach for dealing with the new challenges, faced by 5G wireless system designers.

3.2: FBMC - generalized frequency division multiplexing

A generalized digital multi carrier transceiver concept where FBMC is based on traditional filter bank multi-branch multi-carrier concepts which are now implemented digitally. The FBMC approach exhibits some attractive features which are of particular importance for scenarios exhibiting high degrees of spectrum fragmentation. Spectrum fragmentation is a typical technical challenge of digital dividend use cases, exploiting spectrum white spaces in the TV UHF bands which are located in close proximity to allocated spectrum. Specifically, the FBMC features are a lower PAPR compared to OFDM, a ultra-

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low out-of-band radiation due adjustable Tx- 40 filtering and last but not least a block-based transmission using cyclic prefix insertion and efficient FFT-based equalization. FBMC enables frequency and time domain multi-user scheduling comparable to OFDM and provides an efficient alternative for white space aggregation even in heavily fragmented spectrum regions.

3.3: Performance Analysis of UFMC and its Comparison with CP-OFDM

Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) is used in 4G communication systems. There are problems in 4G Waveform such as out of band emission and lower spectral efficiency which forces to explore new waveforms for Fifth Generation (5G). Universal Filtered Multi-Carrier (UFMC) is one such air interface which is analyzed in this work and compared with CP-OFDM highlighting the merits of the candidate modulation scheme for 5G communication systems. This work presents the comparison UFMC and CP-OFDM on the basis of Peak to Average Power Ratio (PAPR) and Power Spectral Density (PSD) and analyze the performance of UFMC in Additive White Gaussian Noise (AWGN) channel using MATLAB. It is found that 40 dB reduction in out-of-band emission is seen in UFMC when compared to CP-OFDM with negligible increase inPAPR.

IV. PROPOSED METHODOLOGY:

4.1 5G Technology

5G is the fifth generation wireless technology for digital cellular networks that began wide deployment in 2019. As with previous standards, the covered areas are divided into regions called "cells", serviced by individual antennas. Virtually every major telecommunication service provider in the developed world is deploying antennas or intends to deploy them soon. The frequency spectrum of 5G is divided into millimeter waves, mid-band and low-band. Low-band uses a similar frequency range as the predecessor,4G. 5G millimeter wave is the fastest, with actual speeds often being 1–2 Gbit/s down. Frequencies are above 24 GHz reaching up to 72 GHz which is above the extremely high frequency band's lower boundary. The reach is short, so more cells are required. Millimeter waves have difficulty traversing many walls and windows, so indoor coverage is limited. 5G mid-band is the most widely deployed, in over 20 networks. Speeds in a 100 MHz wideband are usually 100–400 Mbit/s down. In the lab and occasionally in the field, speeds can go over a gigabit per second. Frequencies deployed are from 2.4 GHz to 4.2 GHz. Sprint and China Mobile are using 2.5 GHz, while others are mostly between 3.3 and 4.2 GHz, a range which offers increased reach. Many areas can be covered simply by upgrading existing towers, which lowers the cost. Performance - Speed 5G speeds will range from ~50Mbit/s to over 2 gigabit at the start, and is expected to grow to even 100Gbit/s, 100x faster than 4g. The fastest 5g, known as mm Wave, delivers speeds of up to and over 2Gbit/s. As of July 3, 2019, mm Wave had a top speed of 1.8Gbit/s on AT&T's.5G network, much faster than 4g's top speed of 23.6Mbit/s on T-

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Mobile's network. The problem with this though is that it cannot go through walls, trees, etc. because of the high frequency. The similarity in terms of throughput between 4G and 5G in the existing bands is because 4G already approaches the Shannon limit on data communication rates.5G speeds in the less common 42 millimeter wave spectrum with its much more abundant bandwidth and shorter range, and hence greater frequency reusability, can be substantially higher.

4.2 BASIC PRINCIPLE OF OFDM

Future broadband wireless communication systems require high-speed data rate transmissions through severe multipath propagation channels. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission technology for wireless digital communication systems because of its high-speed data rates, high spectral efficiency, high-quality service and robustness against narrow band interference and Frequency Selective (FS) fading. OFDM is an efficient modulation that splits a single signal into various low data rate subcarriers. This scheme allows simultaneous transmission of data without interference from each other. OFDM signals can easily adapt to severe channel conditions without complex time- domain equalization with high bandwidth efficiency. OFDM is an attractive technique for its robustness against narrow band channel interference, Inter Symbol Interference (ISI) and FS channels. However, the OFDM transmitted signal suffers from two major problems, i.e., high Peak to Average Power Ratio (PAPR) and Carrier 2 Frequency Offset (CFO). High PAPR is one of the most significant problems in OFDM, when the independent phases of subcarriers combine constructively. A High PAPR reduces the system efficiency and increases the system complexity. Several techniques, however, increase the Bit Error Rate (BER) while trying to decrease the PAPR.

4.3 OFDM SYSTEM MODEL

The block diagram of the OFDM system is shown in Figure 4.1 . In this system, the input data stream is converted into N parallel data streams each with symbol period Ts through a serial to the parallel converter. When the parallel symbol streams are generated, each data stream would be modulated and carried at different center frequencies. Then the N data symbols are mapped to bins of an IFFT. An IFFT transforms converts the frequency components of the spectrum into the time domain OFDM symbols, adds a prefix and transmits the resulting signal over the communication channel.

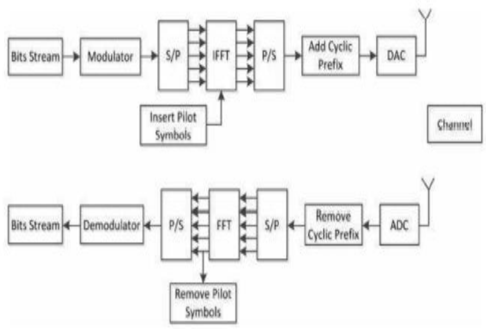

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Fig :4.1 Block Diagram of the OFDM System

This method of insertion of Guard Interval (GI) is used for frequency hopping and Radio Frequency (RF) convergence. The GI in OFDM system is used to remove ISI which is introduced between consecutive OFDM symbols. The delay spread of the multipath channel causes ISI in OFDM symbols. A guard band interval with no signal transmission could be used to remove ISI entirely, but it can produce ICI because of higher spectral components which occur due to quick change of waveform.spreading (FS) implementations. In PPN architecture, OQAM and GI can be used in two ways: Zero padding (ZP) and Cyclic Extension (CE). CE has been extended in two ways Cyclic Prefix (CP) or Cyclic Suffix (CS). In CP, a small part or portion of transmitted symbols is taken and repeated as the prefix of transmitted symbol. By prefixing the OFDM symbol, ISI is removed. The CP insertion is shown in Figure below. In ZP top and the bottom portion of the transmitted symbols are filled with zeros. An OFDM carrier signal is the sum of one or more OFDM symbols each consisting of orthogonal subcarriers, with baseband data on each subcarrier independently modulated using Quadrature Amplitude Modulation (QAM). This composite baseband signal is used to modulate an RF carrier. In an OFDM system, the input data bit stream has been encoded with 7 divided into groups of "n" bits and converted into complex numbers representing the mapped constellation point. The 64-QAM constellation (6 bits/symbol) can have a bitrate of 54Mbps while a Quadrature Phase Shift Keying(QPSK) constellation (2bits/symbol) may only be 12Mbps. Then 52 subcarriers of the IFFT block are loaded. 48 subcarriers contain the convolutional coding and Interleaving. Based on the modulation scheme each data stream is constellation points which are mapped into frequency offset indexes ranging from -26 to +26, skipping the 4 Pilot 44 and zero subcarriers. There were 4 Pilot subcarriers inserted into frequency offset index locations - 21, -7, +7, and +21. A zero subcarrier is a Null or DC subcarrier and is not to be used; it contains a 0 value. When the IFFT block is loaded, the IFFT is computed, giving a set of complex time-domain samples representing the combined OFDM sub carrier waveform.

4.4 OFDM TRANSMISSION IN WIRELESS CHANNEL

In wireless communications, the signal transmitted from the source typically will experience attenuation, scattering, reflection and refraction before it reaches the destination. These effects are usually modeled as one or several values are known as the channel response which is to be convolved with the transmitted signal. The response of the channel between the transmitter and the receiver is not fixed but varies with time and frequency.

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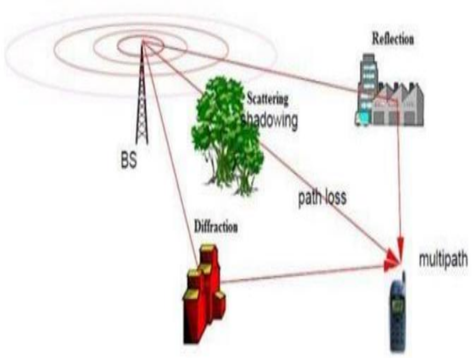

Fig: 4.2 Multipath Propagation

V RESULTS

In this simulation, OFDM, FBMC, GFDM modulations are investigated and compared using MATLAB 2018. The comparison is made using BER,PAPR.

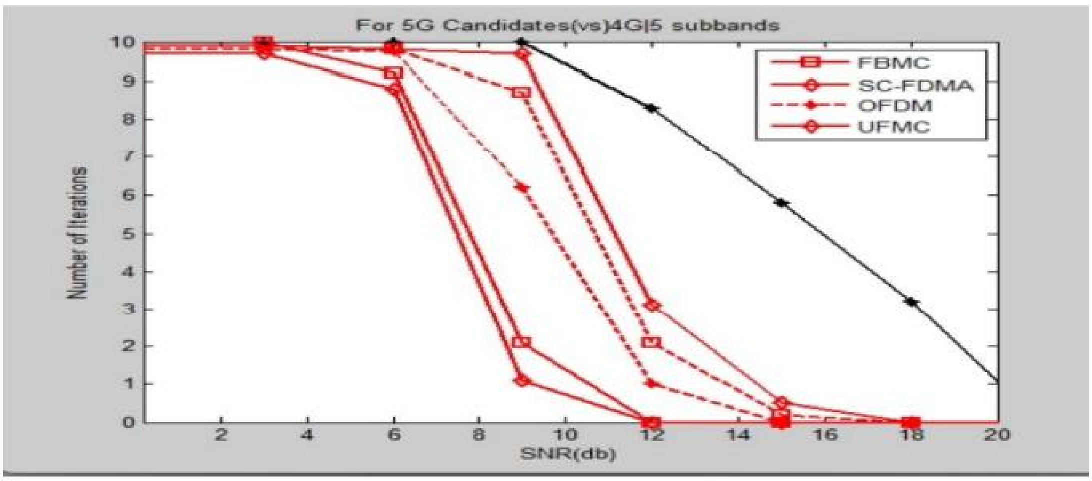

Fig:5.1 For OFDM number of iterations to SNR(db) characteristics is high

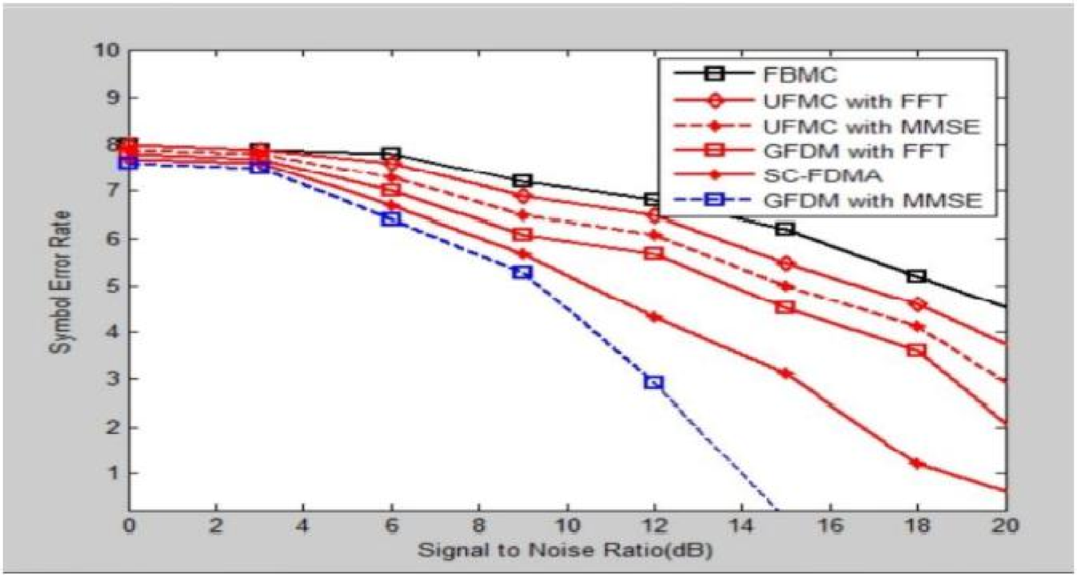

Fig:5.2 For FBMC symbol error rate to signal to noise ratio(dB) characteristics is high

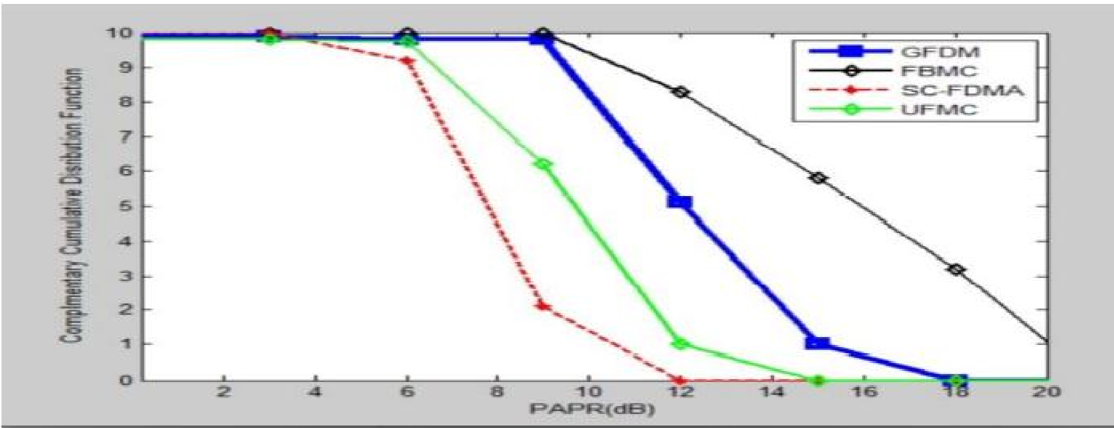

Fig:5.3 For FBMC complementary cumulative distribution function to PAPR(dB) characteristics is high

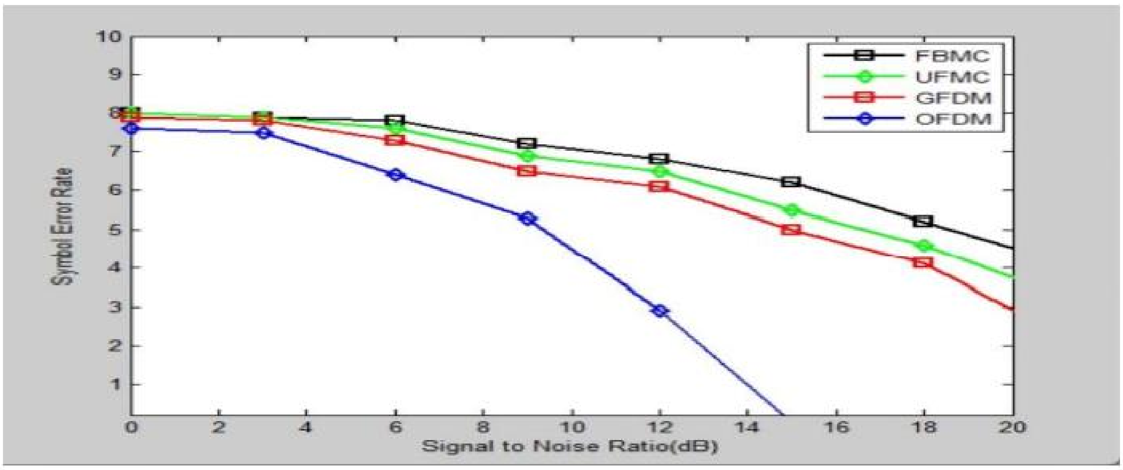

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Fig:5.4 For FBMC symbol error rate to signal to noise ratio(dB) characteristics is high

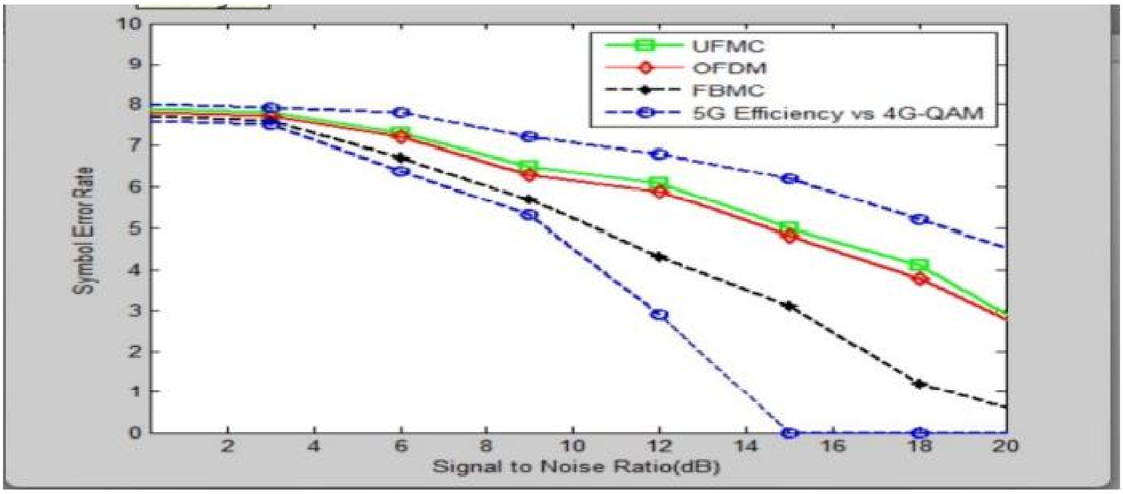

Fig:5.5 For 4G-QAM symbol error rate to signal to noise ratio(dB) characteristics is highv

V|.CONCLUSION

This study has presented the recent research progress on1-D and multidimensional IM techniques. Moreover, con-siderations regarding the utilization of these IM schemes for next-generation wireless communication are provided. Especially, IM schemes presented in the literature have been first grouped regarding their application dimensions. Later, we have categorized these IM techniques considering the requirements of eMBB, mMTC, and URLLC, including SE, EE, system complexity, reliability, and latency. In addition to the information bits carried by QAM/PSK, IM carries extra bits by utilizing the indices of information-bearing transmit entities. As a result, an increase in the number of utilized IM entities, such as time slots, subcarriers, Tx antennas, and RF mirrors, offers a high SE for IM-based schemes. Hence, multi dimensional IM options have been considered as promising solutions for eMBB applications and use cases. At this point, we con-clude that further research on the joint utilization of othernew possible entities will be beneficial to enhance the SE of IM systems.

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