Index modulation for 5G networks

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ABSTRACT- Multicarrier transmission has been proved quite beneficial for Wireless and Wideband Communication community. 4G wireless systems has availed several features in today's fast world in the field of wireless communications. But the researchers still need to seek solutions for increasing demand for higher data rates, better quality of service, fully mobile systems and lower latency. Along with these services, problems relating to data integrity and security are needed to be fulfilled. Recent developments on 5G and beyond wireless networks can help in availing these services. A new emerging Modulation technique called Index Modulation is proving to be quite futile and innovative for paving way towards 5G networks. IM has three significant variants from which it evolved: Spatial Modulation (SM), Channel Modulation (CM) and Orthogonal Frequency Division Multiplexing with Index Modulation (OFDM-IM), which are seem to be

helpful for providing application scenarios as needed in future wireless networks.

Orthogonal Frequency Division Multiplexing (OFDM). It is suitable for frequency selective fading channels. OFDM divides the wide band frequency channel into narrow flat sub band channels. It mainly combats the effect of multipath reception. Incorporating Index Modulation with OFDM leads to an Index Modulation technique OFDM-IM which can be used in 5G and beyond networks. Orthogonal Frequency Division Multiplexing with Index Modulation (OFDM-IM) allows on-off mechanism of subcarriers based on the use. In this paper it is observed that OFDM-IM with interleaved grouping outperforms classical OFDM for small modulation index and certain ranges of signal-to-noise ratio. Finally the effects of modulation types on the performance of OFDM-IM are studied.

Keywords- Index Modulation, Orthogonal Frequency Division Multiplexing, M-ary Technique.

1.INTRODUCTION :

Wireless networks community has increased the use of smart phones along with an explosive increase in use mobile data services. 5G networks are foreseen to launch around 2020. [4]
The wireless networks are still needed to provide high data rates, high spectral and energy efficiency. Inherent high peak-to-average power ratio (PAPR) is also a problem which further, also necessitates expensive and complex power amplifiers. Therefore, Advanced Modulation Techniques are very much needed. Unfortunately, The currently used modulation techniques based on Multi-Input-Multi-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM), are not sufficient in satisfying such requirements.

The recently emerging Index Modulation (IM) techniques is a promising candidate that has the potential to meet the 5G requirements.[2] 5G wireless networks are anticipated to have ten times high spectral and energy efficiency than current 4G networks. It is foreseen to support data rates upto 10Gbps. Volume of IP address has been recorded to increase by factor 100, from under 3 exabytes in 2010 to over 190 exabytes by 2018, and exceeding to 500 exabytes by 2020. Along with high volume of data, the numbers of devices are continuing to grow exponentially. The number of devices could reach the tens or even hundreds of billions by the time 5G comes to fruition, due to many new applications beyond personal communications.[1]
Index Modulation is a simple digital modulation technique which is energy efficient and works on high spectrum signal. Index Modulation is a modulation technique wherein on-off keying scheme is applied. The mapping of the symbols with subcarriers and turning the communication blocks on/off is done. These communication blocks may be antennas, relays, matrices, dispersion units, mixers. Index Modulation consists of a vast number of modulation techniques which can use multiple inputs and outputs like MIMO or single input, output like SISO, It can also be orthogonal, non orthogonal system, single phase, and multi phase system. In several cases single building block can be used like for Spatial Modulation, Antennas are used. In OFDM-IM subcarriers of signals are used to control the signal status. More the number of building blocks, greater is the spectral efficiency. In this scheme, information is conveyed not only by M-ary signal constellations as in classical OFDM, but also by the indices of the subcarriers, which are activated according to the

incoming information bits. Considering the index selection bits, only a subset of available subcarriers is activated, while the remaining subcarriers are set to zero and not used for conveying information through ordinary modulation[4]. Two forms of Index Modulation: Spatial Modulation technique and OFDM-IM techniques both require fewer resources as compared to traditional OFDM-MIMO. As only few need transmit antennas or subcarriers respectively are activated but they still tend to provide higher energy efficiency.

2.LITERATURE SURVEY:

1. Authors J. G. Andrews in the paper ``What will 5G be?'[1] Explained how Introduction of 5G in current wireless networks could affect the user-services. It shows What are the changes to be expected as 5G arrives. The need of 5 networks is also understood. It summarized all the wonderful expectations that 5G hold for the communication networks.

2.Authors Xiang Cheng, Meng Zhang, Miaowen Wen and Liuqing Yang in "Index Modulation for 5G: Striving to Do More with Less"[2] provided the foreseen way 5G networks will better the communication in terms of spectral efficiency, energy efficiency and higher data rates. It reviewed the Index modulation techniques like Spatial Modulation (SM) and OFDM-IM and why they are better compared to existing OFDM-MIMO system.

3.Authors E.Basar, U.Aygolu, E.Panayand, H.V. Poor in their paper, "Orthogonal Frequency Division Multiplexing with Index Modulation,"[3] proposed A novel multicarrier scheme called OFDM with index modulation, which uses the indices of the active subcarriers to transmit data. It has been observed that the proposed scheme achieves significantly better BER performance than classical OFDM under different channel conditions.

4.Authors Erthugal Basar, Miaowen Wen, Raed Mesleh, Marco Di Renzo, Yue Xiao and Harald Haas in their paper "Index Modulation techniques for Next- Generation for Wireless Networks,"[4] reviewed the basic principles, advantages/disadvantages, the most recent and promising developments and possible implementation scenarios of SM, CM and OFDM-IM systems, which come forward as three promising forms of the IM concept. It has been found that among these three promising IM forms, SM and OFDM-IM can be implemented with a low-cost transceiver structure

3.SYSTEM MODEL:

In traditional OFDM the entire wide band frequency selective fading channel is divided into narrow flat sub band channels. It mainly combats the effect of multipath reception. OFDM is widely popular Multi-carrier Transmission technique. It satisfies the increasing demand of higher data rates. It also has attractive features like efficient implementation and its ruggedness towards Inter symbol Interference [6]

3.1 OFDM-IM:

In past few years, the modified versions of OFDM seem worthy of meeting needs of 5G networks. . OFDM-IM is a multicarrier scheme which is inspired by Spatial Modulation. This makes OFDM-IM a strong candidate for 5G networks and beyond. In OFDM-IM the IM scheme of activating only requires entity is performed. This means IM is done on subcarriers of OFDM signal. [4]. The input signal is splitted into Subcarriers Index Selectors and M-ary constellation bits. Only a set of subcarriers are activated based on the application and data requirements. The remaining, inactive subcarriers are set to zero and these do not convey any information. Respecive M-ary constellation bits are transferred through these indices. This means that OFDM-IM can transfer information and data symbols through classical OFDM scheme as well as, by using indices of active subcarriers. These indices are used for transmission of corresponding M-ary symbols.[4][6]

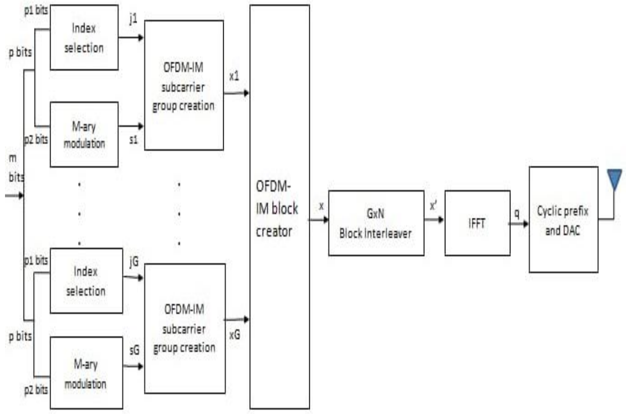

Figure 1: Transmitter structure of OFDM-IM

The block diagram of the OFDM-IM transmitter is given in Figure 1. This scheme transmits 'm' bits per OFDM frame over a frequency selective Raleigh fading channel as follows. First B bits are divided into G groups and each group has p bits, i.e., m= pG. Each group of p bits is assigned to one of G OFDM subblock having length of each subblock as n. Thus, the total number of OFDM subcarriers N, is nG. In classical OFDM, all n subcarriers in an OFDM subblock are active and carry in total n M- ary signal constellation symbols, while in OFDM-IM, not all subcarriers are active. A subcarrier is defined as active if the subcarrier carries an M-ary signal constellation symbol and otherwise defined as inactive if the subcarrier carries zero. In OFDM-IM, not only active subcarriers but also the indices of active subcarriers carry information.[4]

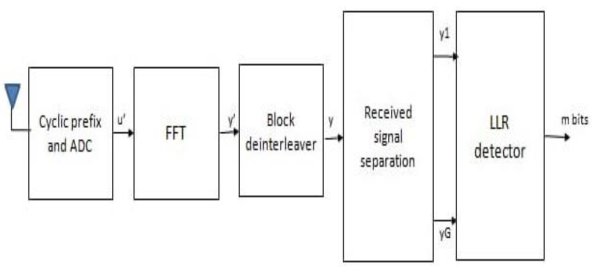

Figure 2. Receiver structure of OFDM-IM

The receiver detects both the information bits on the active subcarriers and the indices of those active subcarriers. Based on the kind of symbols it is carrying, the subcarrier status is determined as active or inactive.[

4.IMPLEMENTATION RESULTS

4.1 OFDM-IM

1) Table 1.Input Parameters for OFDM-IM simulation

Parameters	Value
Number of data subcarriers	64
Number of ActiveSubcarriers	6
nTx	2
nRx	2
Number of datastreams/block	4
Utilized Modulation	16 PSK QAM
M	2
Message Constraint length	7
Pilot insertion length	3+3j
Encoding Technique	Convolution
Channel Utilized	Rayleigh
Decoding Technique	Viterbi

2)

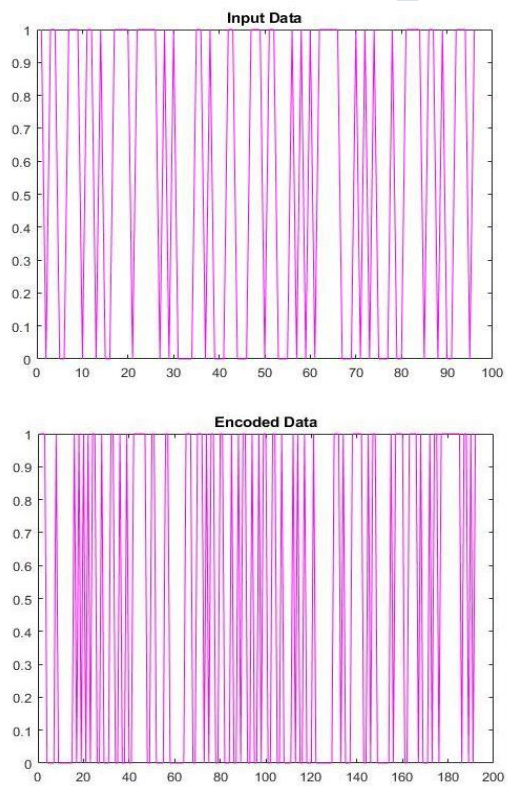

Figure 3.Input and Encoded data signals

In telecommunication, a convolutional code is a type of error-correcting code that generates parity symbols via the sliding application of a Boolean polynomial function to a data stream. The sliding application represents the 'convolution' of the encoder over the data, which gives rise to the term 'convolutional coding.[5]

3)

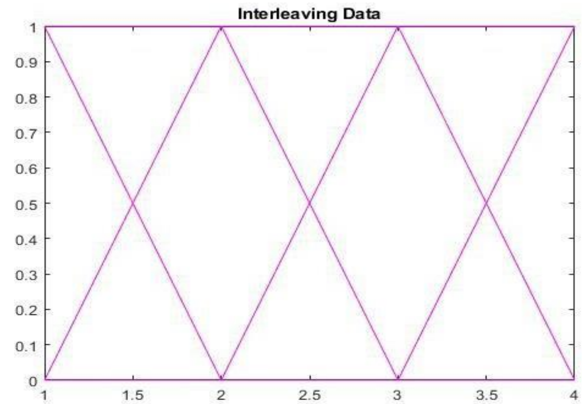

Figure 4.Interleaving of data

Interleaving is frequently used in digital communication and storage system to improve the performance of forward error correcting codes.

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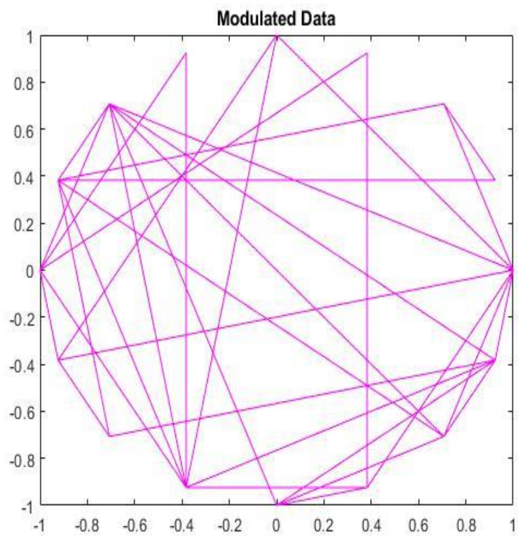


Figure 5.Modulated data

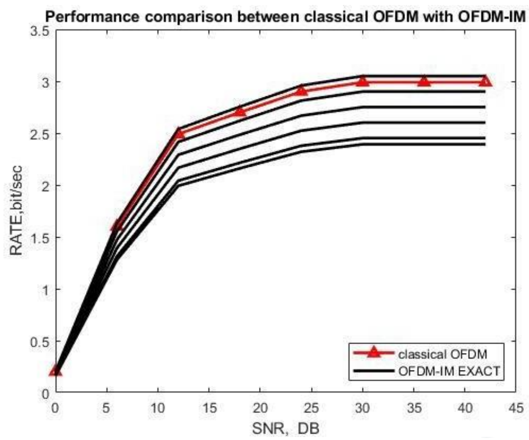
Psk is a digital modulation scheme that conveys data by changing the phase of reference signal.M-ary PSK is a modulation scheme where data bits select one of the M phase shifted versions of the carrier to transmit the data.

4.2ACHIEVABLE RATE

To show variation of performance with respect to modulation index we present an example with L=8 and 8-PSK in Fig.6, where m varies from 1 to 5. As can be seen, besides m=1 , in which case OFDM-IM and classical OFDM have the same entropy at the channel input, OFDM-IM with m =2 and m=3 also have the potential to outperform classical OFDM despite smaller input entropy. For m=4 and m= 5, the input entropies are too small to exploit the channel, thus leading to a smaller achievable rate than classical OFDM.[7]

Figure 6. Performance Comparison between Classical OFDM and OFDM-IM.

4.3 EFFECT OF MODULATION ON ACHIEVABLE RATE



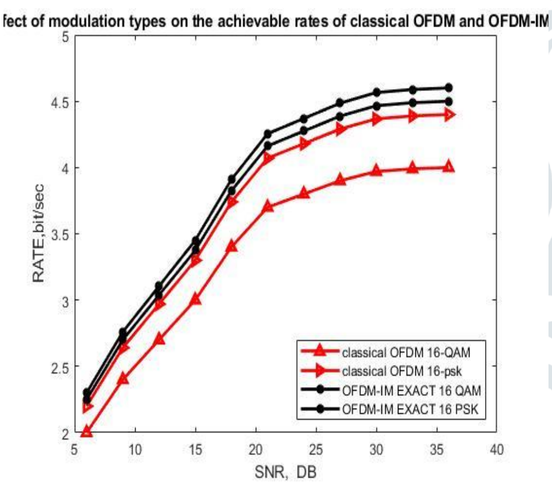


Figure 7.Effect of modulation

An example for the comparison between 16- PSK and 16-QAM inputs is shown in Fig.7, where the simulation parameters are L=16 and (a) m=1; (b) m=2. Different from the conclusion drawn in spatial modulation that PSK may be better than QAM , from the figure we see that QAM is always more favorable than PSK for OFDM-IM in the sense of higher achievable rate. On the other hand, we see that OFDM-IM with and shows an SNR gain of nearly 1 dB over classical OFDM for a large SNR range when both employ 16-PSK modulation whereas very little gain is found when both employ 16-QAMmodulation.[7]

4.4 ADVANTAGES OF OFDM-IM OVER OFDM

The advantages of OFDM-IM can be clearly seen over OFDM as follows:
1. Most Important factor is Adjustable Number of Active Subcarriers of OFDM-IM which is not possible in OFDM. This adjustment of subcarriers helps us achieve desired BER or spectral efficiency.
2. It has better BER performance over OFDM. This can be due to the fact that information bits carried have low error probability.
3. As we can keep subcarriers inactive, OFDM-IM can reduce PAPR.
4. It is robust to Inter-carrier Interference compared to OFDM.

4. CONCLUSION

OFDM-IM is an useful techniques in today's wireless communication world. Ituse subcarriers for data transfer. It can be observed through Implementation results that OFDM-IM has an edge over OFDM as activated subcarriers are utilized. By using Interleaving Grouping method in OFDM-IM, lower bound could be used to predict optimal subcarrier activation strategy. Transmit power is saved by activating only a subset of subcarriers along with M-ary QAM symbols. Using Gray encoding method helps in avoiding heavy performance loss. Thus the superiority of OFDM-IM is seen over OFDM.

5. REFERENCES:

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