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OFDM Index Modulation for 5G Wireless Networks

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ABSTRACT: 5G Wireless network demands for increasing higher data rates, better quality of service (QoS) and fully mobile & connected wireless network. OFDM (Orthogonal Frequency Division Multiplexing) is the solution for this demand of high data rate applications at low cost. Multicarrier transmission technique like OFDM with IM (Index Modulation) is the best choice over classical OFDM. Sending the information at the indices of active subcarriers is extra information source. In this work MIMO OFDM IM is proposed using frequency offset (Doppler shift) by combining MIMO (Multiple Input Multiple Output) & OFDM IM transmission techniques. The different low complexity transceiver structure of MIMO OFDM IM is developed with different channels on MATLAB platform. MIMO OFDM IM using frequency offset achieves significantly better BER (Bit Error Rate) performance than MIMO OFDM for several different channel configurations.

KEYWORDS: Bit error rate (BER), Multicarrier, Orthogonal frequency division multiplexing (OFDM), Index modulation (IM).

I.INTRODUCTION

Multicarrier transmission has become a key technology for wideband wireless digital communications in recent years. Orthogonal frequency division multiplexing (OFDM) has been included in many wireless standards to satisfy the increasing demand for high rate communication systems operating on frequency selective fading channels.

OFDM which can effectively combat the intersymbol symbol interference caused by the frequency selectivity of the wireless channel, has been the most popular multicarrier transmission technique in wireless communications and has become an integral part of IEEE 802.16 standards, namely Mobile Worldwide Interoperability Microwave Systems for Next-Generation Wireless Communication Systems (WiMAX) and the Long Term Evolution (LTE) project.

In frequency selective fading channels with mobile terminals reaching high vehicular speeds, the sub channel orthogonality is lost due to rapid variation of the wireless channel during the transmission of the OFDM block, and this leads to inter-channel interference (ICI) which affects the system implementation and performance considerably. Consequently, the design of OFDM systems that work effectively under high mobility conditions, is a challenging problem since mobility support is one of the key features of next generation broadband wireless communication systems. Recently, the channel estimation and equalization problems have been comprehensively studied in the literature for high mobility [1], [2].

Due to their benefits over single antenna systems, Multiple-input multiple-output (MIMO) transmission techniques have been also implemented in many practical applications. More recently, a novel concept known as spatial modulation (SM), which uses the spatial domain to convey information in addition to the classical signal constellations, has emerged as a promising MIMO transmission technique [3]– [5].

The SM technique has been proposed as an alternative to existing MIMO transmission strategies such as Vertical Bell Laboratories Layered Space-Time (V-BLAST) and space-time coding which are widely used in today's wireless standards. The fundamental principle of SM is an extension of two dimensional signal constellations (such as M-ary phase shift keying (M-PSK) and M-ary quadrature amplitude modulation (M-QAM), where M is the constellation size)

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to a new third dimension, which is the spatial (antenna) dimension. Therefore, in the SM scheme, the information is conveyed both by the amplitude/phase modulation techniques and by the selection of antenna indices. The SM principle has attracted considerable recent attention from researchers and several different SM-like transmission methods have been proposed and their performance analyses are given under perfect and imperfect channel state information (CSI) in recent works [6]. The application of the SM principle to the subcarriers of an OFDM system has been proposed in [4].

However, in this scheme, the number of active OFDM subcarriers varies for each OFDM block, andfurthermore, a kind of perfect feed forward is assumed from the transmitter to the receiver via the excess subcarriers to explicitly signal the mapping method for the subcarrier index selecting bits. Therefore, this scheme appears to be quite optimistic in terms of practical implementation. An enhanced subcarrier index modulation OFDM (ESIM-OFDM) scheme has been proposed in [3] which can operate without requiring feed forward signalling from the transmitter to the receiver. However, this scheme requires higher order modulations to reach the same spectral efficiency as that of classical OFDM.

II.OFDM-IM TECHNIQUE

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 incominginformation bits. A general method, by which the number of active subcarriers can be adjusted, and the incoming bits can be systematically mapped to these active subcarriers, is presented for the OFDM-IM scheme. Different mapping and detection techniques are proposed for the new scheme.First, to map the incoming information bits to the subcarrier indices, a simple look-up table is implemented and an ML detector is employed at the receiver.

Then, a simple yet effective technique based on combinatorial number system is used to map the information bits to the subcarrier indices, and a log-likelihood ratio (LLR) detector is employed at the receiver to determine the most likely active subcarriers as well as corresponding constellation symbols.A theoretical error performance analysis based on bit error rate (BER) calculation is provided for the new scheme operating under ideal channel conditions.It is shown via MATLAB simulations that the proposed scheme achieves significantly better bit error rate (BER) performance than the classical OFDM.

Fig 1 shows OFDM index modulation block diagram. A total of m information bits enter the OFDM-IM transmitter for the transmission of each OFDM block. These m bits are then split into g groups each containing p bits, i.e., m = pg.
Each group of p-bits is mapped to an OFDM sub block of length n, where n = N * g and N is the number of OFDM subcarriers. Contrary to the classical OFDM, this mapping operation is not only performed by means of the modulated symbols, but also by the indices of the subcarriers.Inspiring from the SM concept, additional information bits are transmitted by a subset of the OFDM subcarrier indices. For each sub block, only k out of n available indices are employed for this purpose and they are determined by a selection procedure from a predefined set of active indices, based on the first p1 bits of the incoming p-bits sequence. Here, symbols corresponding to the inactive subcarriers are set to zero.The remaining p2 = k log2 M bits of this sequence are mapped on to the M-ary signal constellation to determine the data symbols that modulate the subcarriers having active indices, therefore, we have p = p1 + p2.

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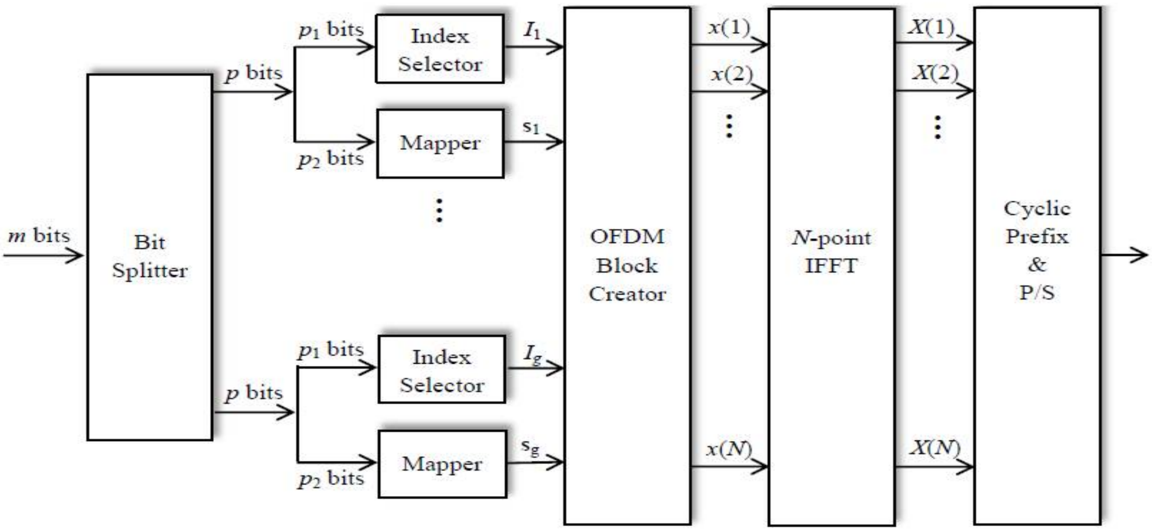

Fig 1: OFDM-IM Block Diagram

III.SIMULATION RESULTS

Simulation is performed by using MATLAB tool.

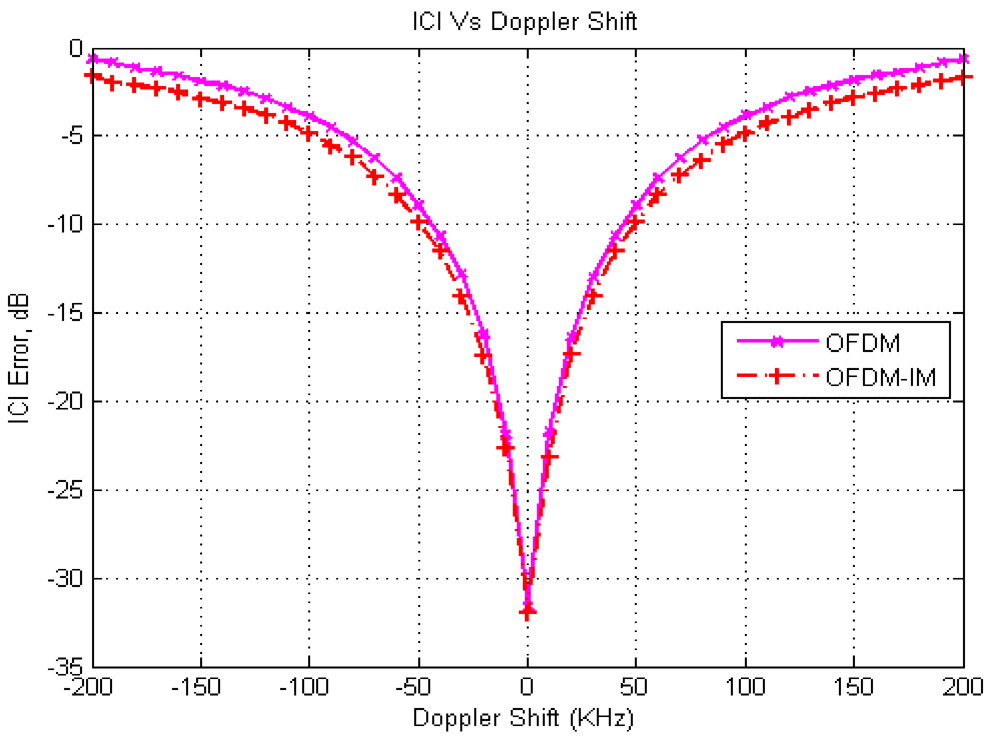

Fig 2: OFDM_IM Performance with Doppler Shift

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From figures 2 and 3, it can be seen that OFDM-IM has better BER performance compared to classical OFDM. Figure 2 shows. OFDM-IM has better BER performance with different Doppler shift for ICI error. From figure 3, it can be seen that OFDM-IM gives better BER performance in all different channels.

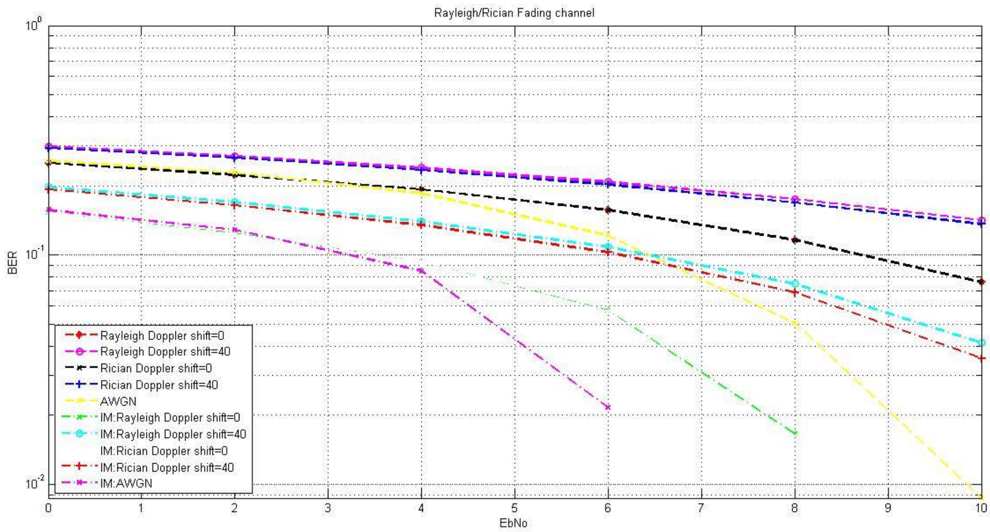

Fig 3: OFDM_IM Performance with different channels

IV.CONCLUSION

A novel scheme called MIMO-OFDM with index modulation has been proposed as an alternative multicarrier transmission technique for 5G networks. It has been shown in figure 2 and 3 via MATLAB simulations that the proposed scheme can provide significant BER performance improvements over classical MIMO-OFDM for several different channel configurations.

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