MODERN MODULATION TYPES FOR 5G WIRELESS COMMUNICATION SYSTEMS

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Abstract

The fourth generation (4G) mobile communication network has been introduced in almost all countries. However, with the development of wireless mobile systems and the increase in the types of services, some problems arise in technologies that cannot support 4G. Today, technologists all over the world have started implementing 5G to meet the expectations of users. Index modulation is seen as a promising modulation in 5G. In this work, the characteristics of index modulation used in 5G are considered.

Keywords: LTE, OFDM, MIMO, index modulation, space domain index modulation.

Introduction

Wireless communication is the fastest growing segment of the economy. From 1980 to the present, wireless systems have evolved into 1G, 2G, and 3G. Currently, long-term evolution (LTE) as 4G systems are steadily expanding in global markets. By supporting several key technologies, namely multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM), cooperative communications, etc., 4G systems are capable of 1 Gbps for low mobility. up to 100 Mb/s and provides high mobility data speeds. MIMO, which uses multiple antennas at the transmitter and receiver, increases channel capacity without increasing transmission power. Reports show that in 2012, telecommunications infrastructure and equipment accounted for 25 percent of the average annual energy consumption by information and communication technology industries.

The Main Part

5G networks also have some weaknesses, such as high peak-to-average power ratio (PAPR) and susceptibility to inter-carrier interference (ICI). The PAPR problem arises from repeating frequency-uncorrelated inputs, which becomes more severe as the number of FFT points increases. ICI accompanying orthogonality violations is further exacerbated by Doppler effects. Therefore, it is necessary to find other effective schemes for OFDM that can solve these problems. Index modulation is an emerging signal modulation concept developed for, but not limited to, MIMO-OFDM communications. Index modulation modulates signals through some medium index, which can be real or virtual, such as the antenna, frequency carrier, and subcarrier. For example, by time interval, space-time matrix and antenna activation. Indexes are set to transmitted or received signals and typically consume little or no power at all. This means that the solution to the problems between spectral efficiency and energy efficiency can be achieved by index modulation. In addition, deactivating some OFDM subcarriers for index modulation significantly alleviates PAPR and ICI problems. These advantages make index modulation a competitive candidate for 5G wireless communication.

Each carrier can determine its next time slot behavior, i.e. transmission or idle, by decoding the signal sent by the source node and transmitting additional information to the destination node [1]. The circuits in [1, 2] perform index modulation by the transmitter. In fact, the concept of SM can be extended to the receiving side as well. In these works, in favor of zero forcing (ZF) or minimum mean square error (MMSE) precoding, SM (PSM) precoding is proposed, which activates one receiver antenna and transmits additional data per time slot. PSM is shown to outperform transmitter-side SM schemes and classical MIMO schemes for CSIT and multiple RF chain requirements. Based on its advantages, many works related to PSM have also been proposed [1-3].

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Space-time domain index modulation methods require the joint use of space and time resources for index modulation. In this case, the popular space-time keying (STSK), Trellis-coded spatial modulation (TCSM), space-time block-coded spatial modulation (STBC-SM) and differential spatial modulation (DSM) can be used.

In [4], one of the dispersion space-time matrices Q is selected for transmission in each communication period, thereby transferring additional log2(Q) bits to the information bits carried in the modulated symbols by matrix selection. By properly choosing the number of dispersion matrices, the size of the modulation scheme, and the number of transmitting and receiving antennas, STSK achieves a flexible balance between increasing diversity and increasing multiplexing. In addition, unlike the classical SM scheme, which only achieves received diversity, STSK also transmits the result.

To use the STSK potential, a generalized STSK (GSTSK) scheme was developed, which activates the P matrices from the Q dispersion matrices for transmission [5]. The above-reviewed works face the common problem that determining the optimal ML results in high computational complexity, especially for high-order modulation or a large number of transmit antennas. To solve this problem, researchers focused on designing low-complexity detectors for STSK and GSTSK systems [6-11].

DSM is proposed to avoid channel estimation difficulties in 5G communication systems. The main idea of DSM is to use time and space together to generate square unitary space-time matrices. Therefore, in traditional square DSM, the time interval in each transfer matrix is the same.

A traditional point-to-point DSM link has a signal-to-noise ratio (SNR) of 3dB while maintaining the data rate. Table 1 summarizes the results obtained by scientists on DSM.

Table 1. History of Differential Spatial Modulation (DSM).

Authors	Contribution
Bian el al.	The first proposed DSM, which completely abandons any CSI at the transmitter or receiver.
Wen et al.	DSM performance with 2 transmitting antennas is evaluated.
Li et al.	USA communications use DSM.
Bian et al.	It showed more results by exploring the DSM in detail.
Xiao et al.	A low-complexity detector for DSM that operates on the basis of set symbols.

Wen et al.	Development of a low-complexity near-ML detector for DSM that appeals to the idea of Viterbi decoding.
Li et al.	A detector for DSM using sphere decoding is designed.
Zhang et al.	For DSM, two transmission variants were used.
Rajashekar et al.	A full-diversity access method for DSM with independent transmitting antennas is proposed.
Zhang et al.	A prestructured auxiliary DSM (PDSM) scheme is proposed.
Xu et al.	A self-interference cancellation scheme for full-duplex systems using the DSM concept is proposed.
Li et al.	Antenna activation orders coded with gray codes.
Zhang et al.	A dual-core hybrid DSM (DH-DSM) scheme was proposed.

Conclusion

The rapid growth of wireless communication systems services requires the use of modern means of communication and the 5G network. It should be noted that the currently used modulation methods multiplexing (MIMO-OFDM) paradigm based on Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) paradigm, unfortunately, cannot meet this requirement. MIMO modulation achieves high spectral efficiency for the configuration. It leads to unsatisfactory energy efficiency due to high power antennas. Due to the development of new technologies, there is a great demand for index modulation.

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