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Modeling and performance analysis of OAM-GSM millimeter-wave wireless communication systems

Key words: Orbital angular momentum (OAM); Generalized spatial modulation (GSM); Millimeter-wave communication; Channel capacity; Energy efficiency; Bit error rate (BER)

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Motivation

1. The communication system needs to accommodate more users and a larger amount of data, and to meet higher quality-of-service (QoS) requirements.
2. In traditional wireless communication systems, the conventional degrees of freedom in frequency and time have been fully used. It is difficult to further improve the performance of communication systems with the degrees of freedom mentioned above.
3. Orbital angular momentum (OAM) technology can provide a new degree of freedom for wireless communication systems because of the theoretically infinite OAM states and natural orthogonality among different OAM states.

Main idea

1. OAM technology can provide a new degree of freedom for wireless communication systems by encoding and decoding information.
2. By combining OAM beams that have theoretically infinite and mutually orthogonal states with the generalized spatial modulation (GSM) strategy, a new OAM-GSM mmWave wireless communication system is designed.
3. A bit error rate (BER) model of the OAM-GSM system is established based on channel flip precoding.

Method

1. A uniform linear array composed of *M* OAM transmitting antennas is the transmitter of the OAM-GSM system. The receiver of the system consists of *M* groups of receiving antenna pairs, and each group of receiving antenna pairs contains two receiving antennas.

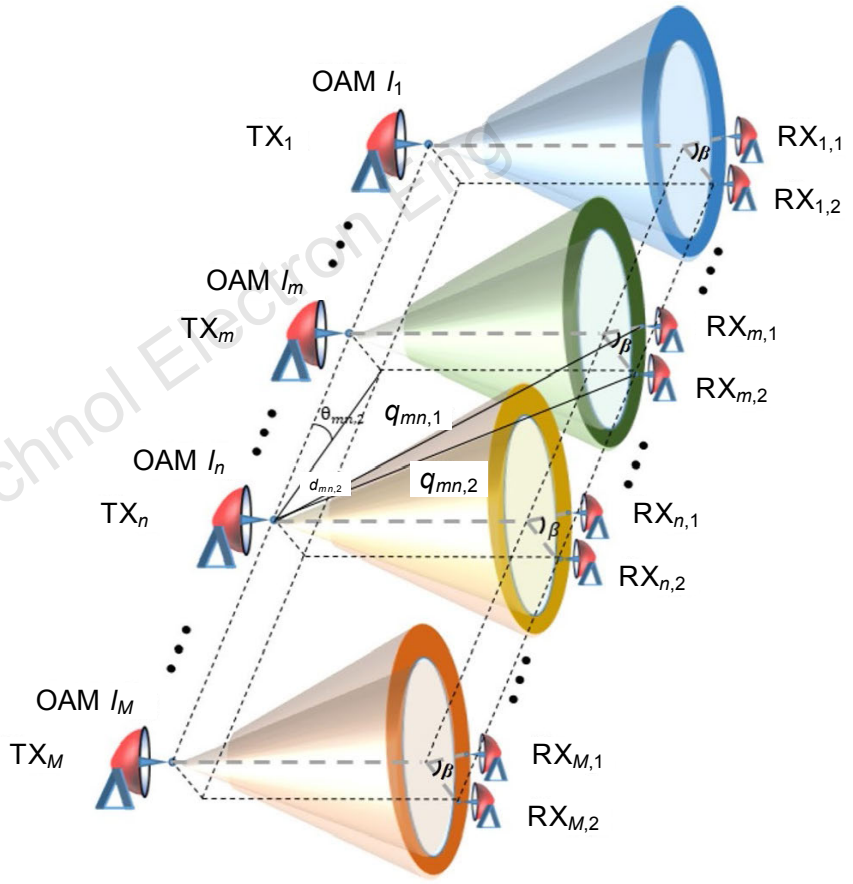

Fig. 2 Model diagram of OAM electromagnetic wave propagation in an OAM-GSM system

Method

2. Compared with a traditional GSM system, the OAM-GSM system not only loads information on the activated antenna combination and constellation symbols, but also loads part of the information on the OAM states of the transmitted OAM beams.

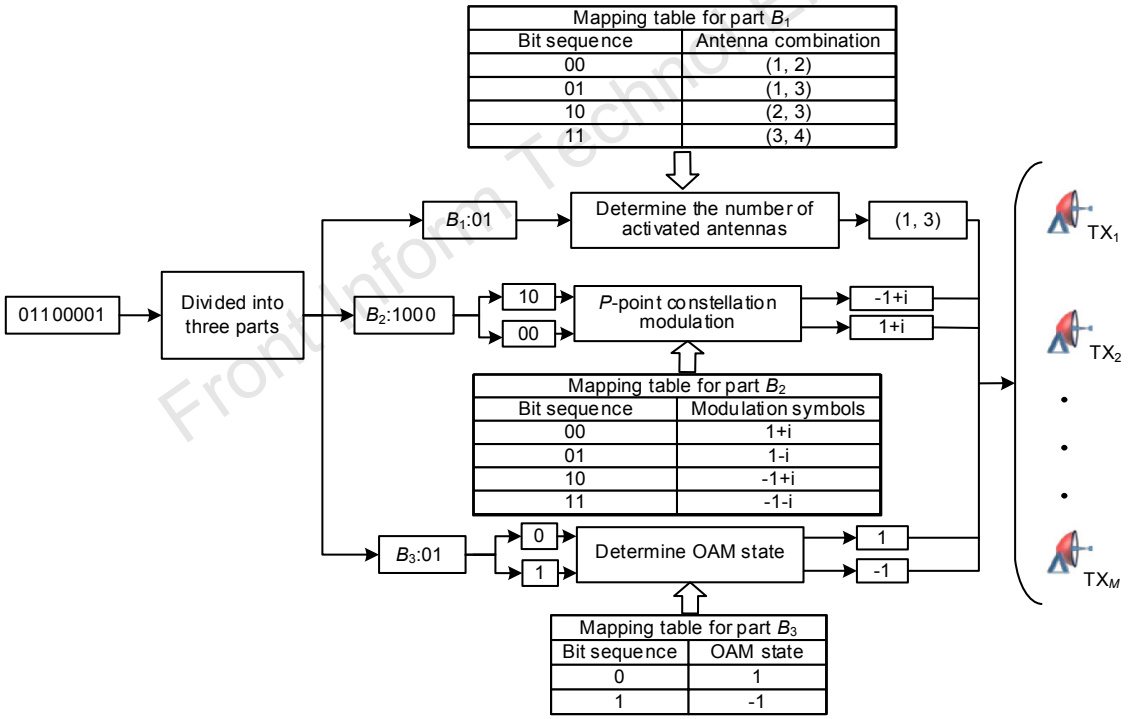

Fig. 3 Schematic of bit mapping at the transmitter of the OAM-GSM system

Method

3. The receiver of the OAM-GSM system needs to detect all information sent by the transmitter, including information of the activated antenna combination, modulation symbols, and OAM states.

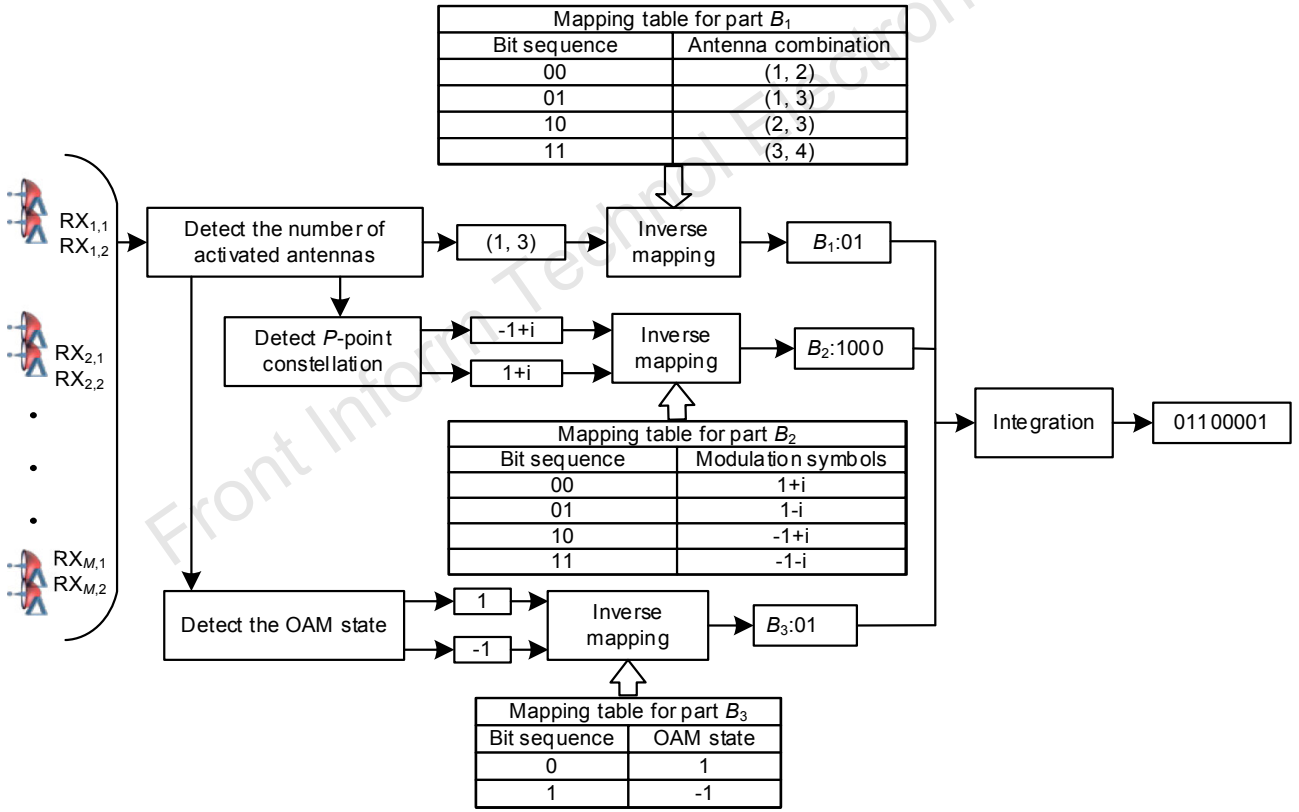

Fig. 4 Structure diagram of the receiver of the OAM-GSM system

Major results

Capacity

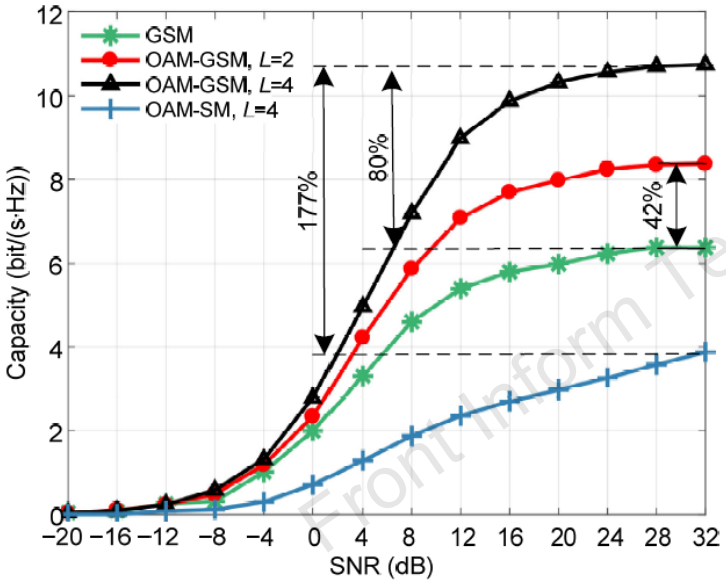

Fig. 10 Capacity of the OAM-GSM system, OAM-SM system, and traditional GSM system with respect to the transmission SNR

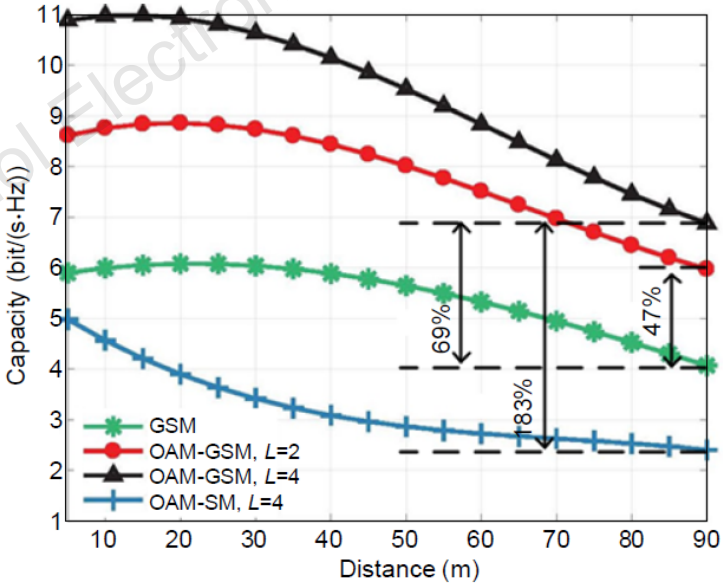

Fig. 11 Capacity of the OAM-GSM system, OAM-SM system, and traditional GSM system with respect to the transmission distance

Major results

Bit error rate

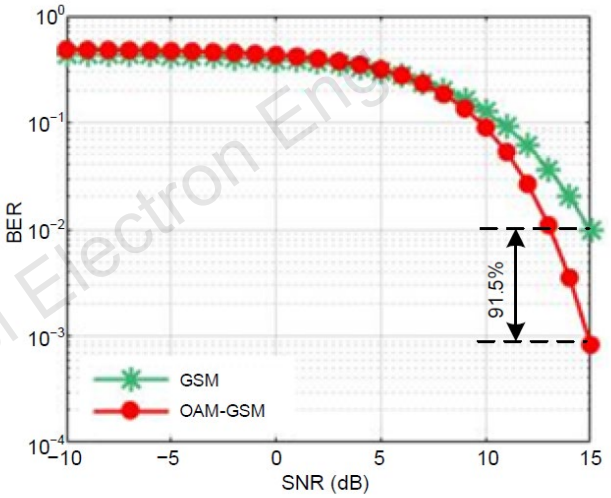

Fig. 5 BER vs. SNR in the OAM-GSM system and traditional GSM system

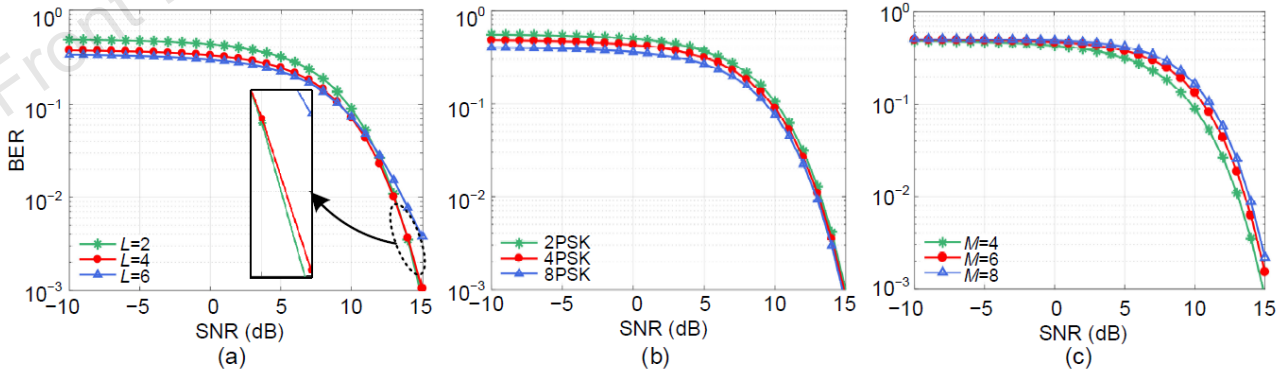

Fig. 6 BER of the OAM-GSM system changing with SNR considering different numbers of optional OAM states (a), different modulation modes of *P*-point constellation modulation (b), and different numbers of transmitting antennas (c)

Major results

OAM-GSM system based on channel flip precoding

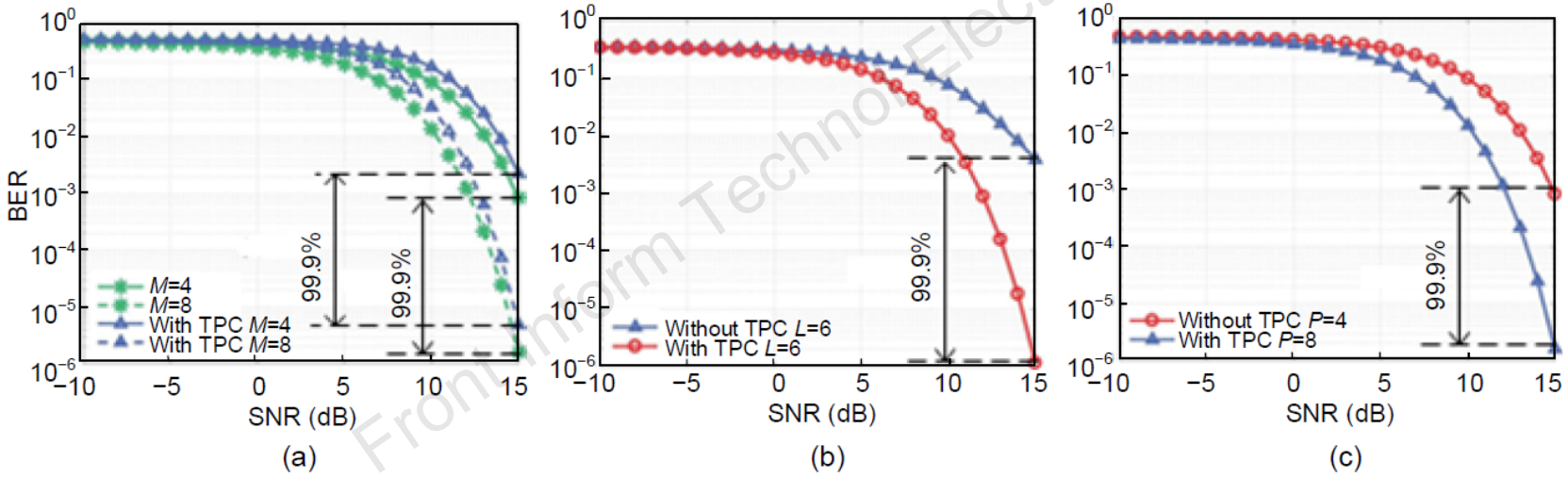

Fig. 7 BER of the OAM-GSM system with or without precoding changing with SNR considering different numbers of transmitting antennas (a), different numbers of optional OAM states (b), and different modulation modes of *P*-point constellation modulation (c)

Major results

Energy efficiency

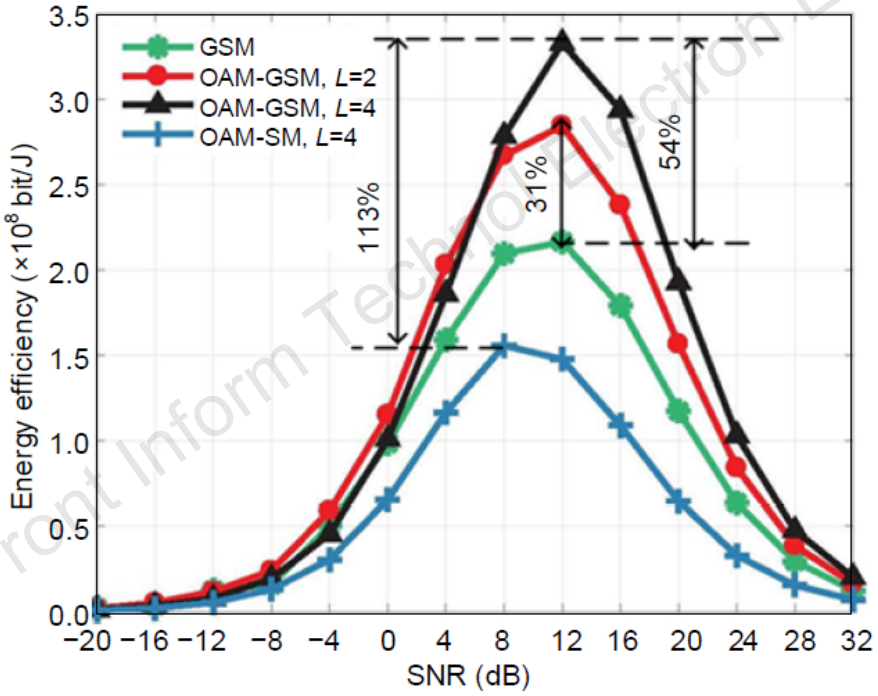

Fig. 12 Energy efficiency of the OAM-GSM system, OAM-SM system, and traditional GSM system with respect to the transmission SNR

Conclusions

1. Inspired by the idea of using OAM states to encode and decode signals, an OAM-GSM mmWave wireless communication system is designed.

2. The BER model of an OAM-GSM system based on channel flip precoding is established.

3. Compared with traditional GSM systems, the OAM-GSM mmWave wireless communication system offers a significant performance improvement.