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Using LDPC coding and AMC to mitigate received power imbalance in carrier aggregation communication system

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Abstract: When a carrier aggregation communication system suffers from receiving power imbalance (RPI) in its antenna array due to design flaw, operator's negligence etc. the system performance may be degraded to an unacceptable level. Specifically in this paper a carrier aggregation communication system with two carrier links while one link suffers RPI is considered, various modulation techniques, such as QPSK, 16 QAM and 64 QAM and/or coding schemes, Convolution Code (CC) and Low Density Parity Check Code (LDPC) are implemented in the system performance simulation to investigate the system behavior when it has the design request to maintain the same system performance in each link when the RPI has values of 7 or 10 dB.

Keywords: array antenna, carrier aggregation, Adaptive Modulation and Coding (AMC), Received Power Imbalance (RPI), Low Density Parity Check (LDPC), Convolution Code (CC), QPSK, 16 QAM, 64 QA M

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

In the next generation communication system such as IMT-Advanced it has been specified to support the system peak data rate higher than 500 Mbps; this requires providing a system bandwidth of more than 100 MHz to support this high data rate. However, it is fundamentally impossible to implement with only one carrier in the system to achieve such wide bandwidth. Certain schemes need be designed to aggregate several carriers, in contiguous or non-contiguous fashion, to generate required wideband channel. In the contiguous scheme it aggregates several carriers that are located in the same frequency band while in the non-contiguous aggregation schemes the carriers can be aggregated from the same or different frequency bands. When aggregating multiple carriers in carrier aggregation (CA) communication system [1] it needs to implement multiple transceivers and antennas then antenna receiving power imbalance (RPI) may incur due to design flaw, operator's negligence etc. [2, 3]. The CA communication system [1] considered in this paper is utilizing two transceiver sets to aggregate two non-contiguous carriers from different frequency bands such that each carrier can depend on its channel environment to select its most suitable modulation format and coding scheme; with this manipulation the carrier signals received at the receiver terminal will not be interfered each other. The range of RPI may be from 0 dB to 10 dB [2, 3]; if RPI happens the system performance will be somewhat degraded and consequently the system quality of service will not be maintained during the data transmission. How to reduce the RPI in CA communication system becomes an important and inevitable issue.

Low Density Parity Check (LDPC) coding scheme has been widely discussed in the wireless communication systems due to its prevailing performance, simple and structured coding and decoding schemes; its performance in binary input additive white Gaussian noise channel is only 0.0045 dB off from the Shannon limit [4, 5]. LDPC coding will be implemented in the carrier aggregated communication system that involves RPI in its antenna array as considered in this paper to investigate its possible system performance improvement comparing with the commonly implemented coding scheme such as Convolution Code (CC). A quasi-cyclic LDPC code is considered since it has less encoding complexity than the normal randomly constructed LDPC codes [4, 5]. The parity check matrix of a quasi-cyclic LDPC can be partitioned into six sub-matrices; the reason for this decomposition is for its less

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complexity and rapid encoding process [5]. At the receiver end we apply the decoding algorithm as discussed in [4] to decode the received LDPC coded signals.

2 System structure of a carrier aggregation communication system

A non-contiguous carrier aggregation communication system with two carrier links has the system structure as shown in Fig. 1 [1] with RPI effect existing between receiving antennas due to design flaw or operator's negligence. The range of this RPI may be from 0 to 10 dB [2, 3]; this RPI is shown in the figure by ΔG. After the transmitted data passing through the channel encoder and the mapper they are modulated with carrier frequencies f_1 and f_2, pass through the linear power amplifier (LPA) and transmit over the channel. Only additive white Gaussian noise (AWGN) channel, with zero mean and variance N_0, is considered; the other factor such as multipath fading is beyond our scope of discussion. At the receiver terminal; the received modulated signal passes through the bandpass filter (BPF), low pass filter (LPF) and be translated into baseband format and then the original data signal is recovered through the demodulation and decoding processes. It assumes that the system is synchronized between the transmitter and receiver terminals in the carrier phase, timing etc., and the transmitter terminal acknowledges that in the second antenna the RPI effect has been induced but not its magnitude. With this system structure that consists of two non-contiguously aggregated links with carrier frequencies f_1 and f_2 as shown in the figure they will be received only in its own receiving terminal without introducing any interference to its neighboring link.

In Fig. 1, the link with normal receiving antenna is shown in the upper link with '-1' attached after the text to each of the upper link functional block. The normal link uses CC, specifically with (2, 1, 6) coding, and depending on the channel environment it can choose QPSK, 16QAM or 64QAM as its data modulation format. The other link with RPI effect is shown in the lower link of Fig. 1 with '-2' attached after the text to each of the lower link functional block. The RPI link uses QPSK modulation and LDPC coding with code rate 1/2 to transmit data. The number of columns and rows in the LDPC code base matrix are 4 and 8 with code rate 1/2 [5]. A quasi-cyclic LDPC code with prime number 281 is used in the code construction, and

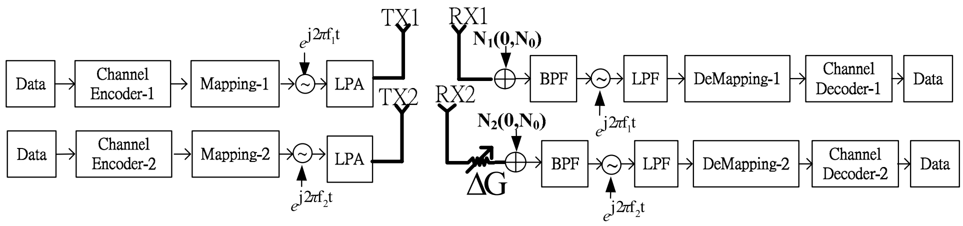

Fig. 1. A Carrier Aggregation communication system with received power imbalance (RPI)

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from rule of thumb 15 iterations [5] is selected in this paper for the LDPC coding/decoding.

3 System performance simulation

With system architecture as shown in Fig. 1, the system performances are simulated with RPI is either 7 or 10 dB. The system performance, Bit Error Rate (BER) vs. Signal to Noise Ratio (SNR), has the results as shown in Fig. 2. This SNR is the signal to noise ratio without taking into account of the RPI effect; this curve will be parallel shifted to the right for an amount of ΔG, corresponding to the RPI value, to maintain the same BER performance as the situation without incurring RPI. If data is modulated with QPSK modulation and if the receiving antenna suffers RPI effect then the system performances in these two carrier links could not reach the same level no matter which coding scheme is adopted. On the other hand when 64 QAM modulation is implemented; if it uses CC then only the RPI link with 7 dB imbalance can have the same performance as the normal link, as designated by the letter C in Fig. 2. Similarly at the location designed by the letter A it is the location where when it implements LDPC coding in the RPI link with 7 dB imbalance it can get the same performance as the normal link that uses 16 QAM modulation with CC. Finally in RPI link with 10 dB imbalance the link performance of having QPSK modulation with LDPC coding can reach the same level as the normal link when it transmits data with 64 QAM and with CC as represented at the location designated by the letter B.

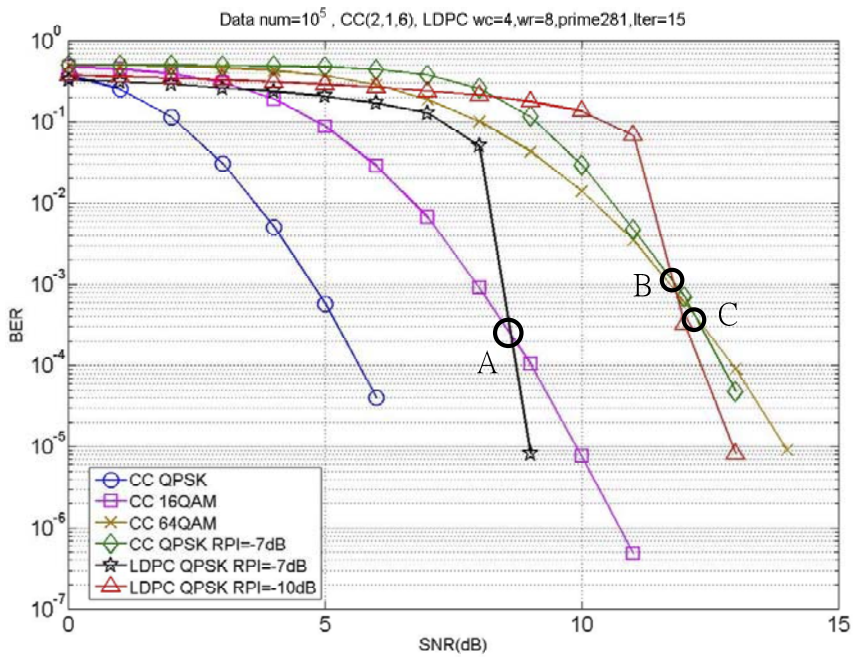

Fig. 2. System Performance Comparisons

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4 Conclusion

In the future communication the use of carrier aggregation transmission to generate wide bandwidth for high speed data transmission will become indispensible; however the system performance will be degraded when receiving power imbalance exists in antenna array at the receiver terminal. In this paper it considered specifically for two carriers communication system with one link suffered RPI effect and under the design request of maintaining these two links at the same performance level; and to investigate how the implementation with AMC scheme would affect the system behavior when the channel is affected with AWGN.

From system performance simulation results as shown in Fig. 2 by implementing various modulation formats such as QPSK, 16 QAM and 64 QAM and coding schemes such as CC and LDPC code it exists system performances cross-over points, where the same system performance can be reached with different modulation formats and /or different coding schemes; and consequently we can manipulate to implement the AMC scheme in the system design procedure that to select a proper modulation format such as QPSK, 16 QAM or 64 QAM and combining with certain coding scheme, such as CC or LDPC to reduce the RPI effect in the CA communication system to accomplish the best system performance under different communication environment.

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