UDC 621.396

PERFORMANCE ANALYSIS OF CARRIER-AGGREGATED MULTI-ANTENNA 4×4 MIMO LTE-A FRONTHAUL

Chernyavsky A. A.
Institute of Telecommunication Systems,
Igor Sikorsky Kyiv Polytechnic Institute, Ukraine
E-mail: ruskc2beat@gmail.com

Анализ производительности мульти-антенны 4×4 MIMO с объединением несущих в сети LTE-A FRONTHAUL

В этой статье предлагается и экспериментально оценивается производительность многоантенных систем LTE-Advanced (LTE-A), реализующих мультиплексирование с пространственным разделением MIMO на многоядерном волокне, по сравнению с передачами SISO с одной антенной.

In this paper the performance of multi-antenna LTE-Advanced (LTE-A) systems implementing MIMO space division multiplexing on multicore fiber, compared to single-antenna SISO transmissions is proposed and evaluated experimentally.

As mentioned in [3], wireless data traffic explosion in the last decade has led to higher data rate requirements for wireless cellular networks which are expected to bring Gbps per mobile user by 2020. Mobile broadband network growth is expected to reach 10 billion subscribers by the year 2020, that may result in a compound annual growth rate (CAGR) of 5.4%. The traffic growth connected with this CAGR implies high network densification. To achieve this, new technology is proposed to be integrated in the next-generation networks including cloud radio access networks (C-RAN) and dense heterogeneous networks (HetNets) employing massive multiple-input-multiple-output (M-MIMO) and Carrier Aggregation.

There are two factors driving the capacity increase in LTE-A: First, the use of Carrier Aggregation, where the overall transmission bandwidth is increased by aggregating several signal carriers, each one known as a component carrier (CC). As depicted in Fig. 1, when Carrier Aggregation is used, each CC can serve a different cell, with the same or different coverage. Second, the support of massive MIMO improves the spectral efficiency by using a large number of antennas and accommodating dozens of users in the same radio channel. MIMO is used to increase the overall bitrate through the transmission of two or more different data streams on different antennas. The combined use of Carrier Aggregation and M-MIMO in different degrees defines next-generation 4.5G Pro and 4.9G LTE-A wireless standards. As depicted in Fig. 1, fronthaul antenna systems are usually installed on the top of roofs ensuring line-of-sight communication with mobile terminals. In order to provide M-MIMO connectivity, radio-over-fiber (RoF) transmission has been proposed to provide centralized multi-service delivery.

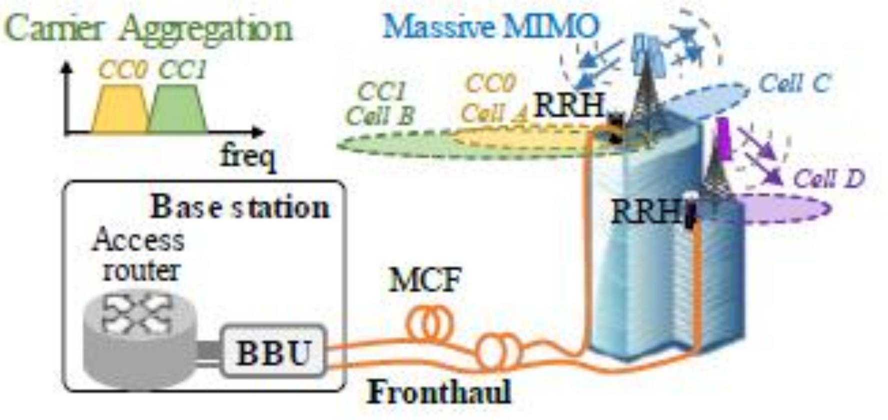

Fig. 1. Fronthaul scenario implementing radio-over-multicore fiber with massive MIMO and Carrier Aggregation

Current LTE-A cellular communication standard implements both aforementioned technologies to provide higher user data rates: multi-antenna MIMO transmission and Carrier Aggregation. Implementing MIMO, the same resources can be used in both frequency and time, separated only through the use of different reference signals (RS) to be received by several antennas. In this work, we configure the LTE-A signal to implement a single-antenna system or spatial multiplexed systems with two or four antennas. In Carrier Aggregation, the most used configuration comprises contiguous component carriers within the same operating frequency band (also called intra-band contiguous carriers). In 3GPP release R10 and R11, the intra-band contiguous aggregation in frequency division duplex (FDD) defines the maximum aggregated bandwidth of 40 MHz with two CCs maximum. Thus, in order to evaluate the most challenging case, in this study the 3GPP FDD LTE-A generator is configured to transmit two aggregated CCs of 20 MHz bandwidth each. The aggregated bandwidth of 40 MHz can be supported with a single transceiver. Each LTE-A 20 MHz CC comprises 100 resource blocks (RB) with 1201 subcarriers for the downlink (DL) and 1200 subcarriers for the uplink (UL). The difference in the number of subcarriers is based on the fact that, for DL signals, the DC subcarrier is not transmitted but counted, while UL signals are symmetric about DC and have no DC subcarrier.

We will analyze the performance of four-antenna LTE-A system implementing 4×4 MIMO spatial multiplexing of four data streams for a single user. We evaluate the performance of LTE-A signal implementing 4×4 MIMO spatial multiplexing and Carrier Aggregation for different frequency bands (fc) and different carrier separation (Δf). Fig. 2(a) shows the EVM of both aggregated carriers for different carrier separation (Δf) maintaining the center frequency at fc=2.655 GHz (center of FDD band 7).

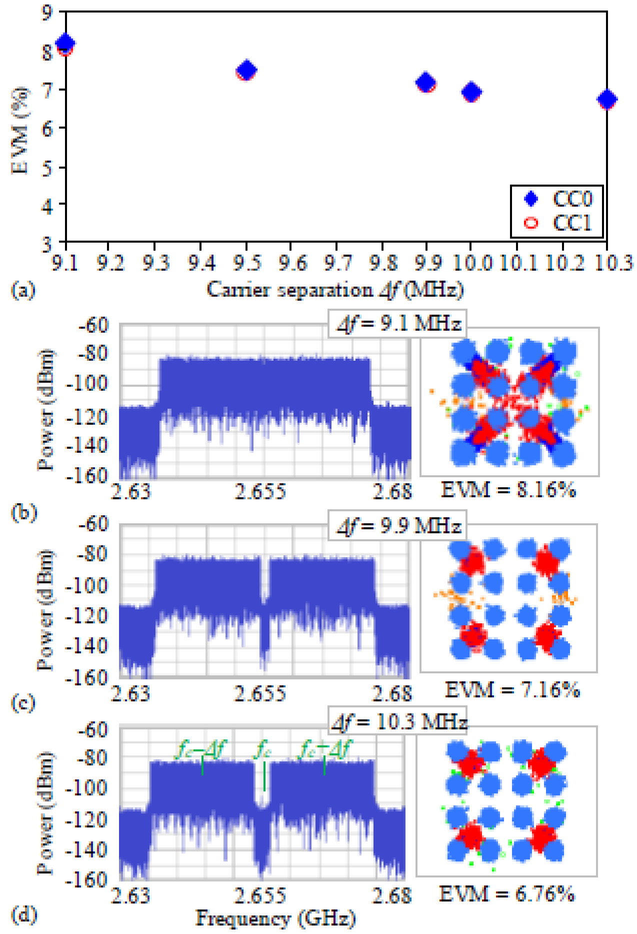

Fig. 2. (a) Measured EVM for two 20 MHz LTE-A 4×4 MIMO CCs vs. carrier separation and measured spectrum (ch1, RBW=1.27 kHz) and constellations for (b) Δf=9.1 MHz, (c) Δf=9.9 MHz, and (d) Δf=10.3 MHz

Comparing the measured spectrum in Fig. 2(b)-(d), for Δf=±9.1 MHz the 20 MHz carriers start overlapping in spectrum which increases the EVM to 8.16% compared with the EVM of 6.76% obtained with Δf=±10.3 MHz.

This paper proposes and evaluates experimentally the performance of multiple-antenna RoF fronthaul over MCF media implementing MIMO and Carrier Aggregation. Different configurations of single- and multiple-antenna systems can be developed assigning one or a group of cores of the MCF to each system. In this work we have evaluated the four-antenna LTE-A system implementing 4×4 MIMO spatial multiplexing.

The experimental evaluation is performed including also Carrier Aggregation with two carriers at the maximum regulated bandwidth.

The experimental results confirm that Carrier Aggregation doesn't affect the signal quality as long as the carriers are not overlapped in spectrum. More carriers could be provided in the same or different frequency bands employing the proposed fiber fronthaul architecture.

References

1. Jun-ichi Kani, "Solutions for future mobile fronthaul and access-network convergence," in Proc. Optical Fiber Communications Conference and Exhibition (OFC), paper W1H.1, March 2016.
2. Kanesan T. et al., "Solution to reduce nonlinearity in LTE RoF system for an efficient DAS topology: A brief review," in Proc. Int. Symp. on Comm. Systems, Networks and Digital Signal Processing (CSNDSP), July 2016.
3. Morant M. Performance Analysis of Carrier-Aggregated Multiantenna 4 × 4 MIMO LTE-A Fronthaul by Spatial Multiplexing on Multicore Fiber / M. Morant, R. Llorente // Journal of Lightwave Technology, Vol.: 36 Issue 2. – Jan.15, 2018. – pp. 594-600.
4. Selim M. et al., "Fronthaul cell outage compensation for 5G networks," IEEE Communications Magazine, vol. 54, no. 8, pp. 169-175, 2016.