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Standard independent I/Q imbalance estimation and compensation scheme in OFDM direct-conversion transceivers

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Key words: In- and quadrature-phase (I/Q) imbalance; Orthogonal frequency division multiplexing (OFDM); Standard-independent

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Motivation

1. Direct-conversion transceivers are gaining increasing attention due to its low power consumption, but it suffers from a serious in- and quadrature-phase (I/Q) imbalance problem.
2. I/Q imbalance can limit severely the achievable operating signal-to-noise ratio at the receiver and, consequently, the supported constellation sizes and data rates.

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Main idea

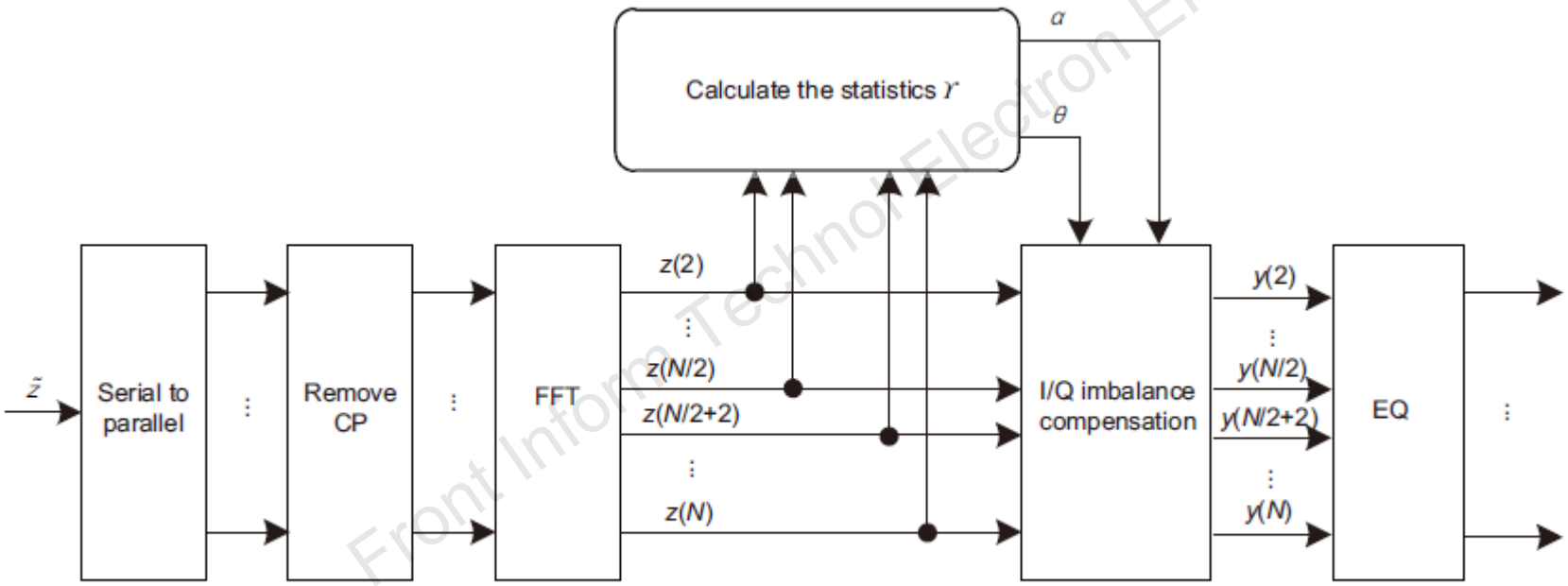
1. We investigate the effects of I/Q imbalance on orthogonal frequency-division multiplexing (OFDM) receivers, and then propose a new I/Q imbalance compensation schemes.
2. In the proposed method, a new statistic, which is robust against channel distortion, is used to estimate the I/Q imbalance parameters, then the I/Q imbalance is corrected in the frequency domain.

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Method

1. Evaluating the associated statistics of the observed signals and deriving the I/Q imbalance parameters according to the relationship between statistics and I/Q imbalance parameters.
2. Compensating the I/Q imbalances in the frequency domain using I/Q imbalance estimations on an designed OFDM receiver architecture.

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Fig. 3 Framework of the proposed I/Q imbalance compensation scheme in OFDM direct-conversion transceivers (CP: cyclic prefix; EQ: equalization)

Major results

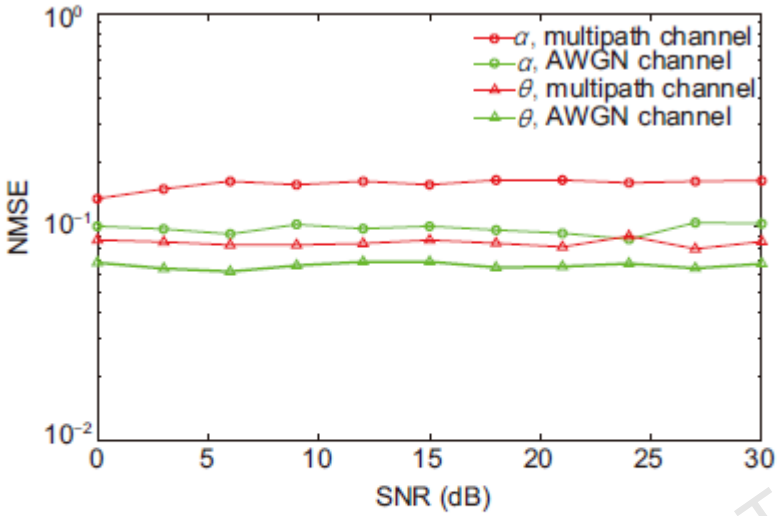


Fig. 4 Normalized mean-squared error (NMSE) of the estimated I/Q imbalance parameters versus the SNR of received signals (α: gain imbalance; θ: phase imbalance)

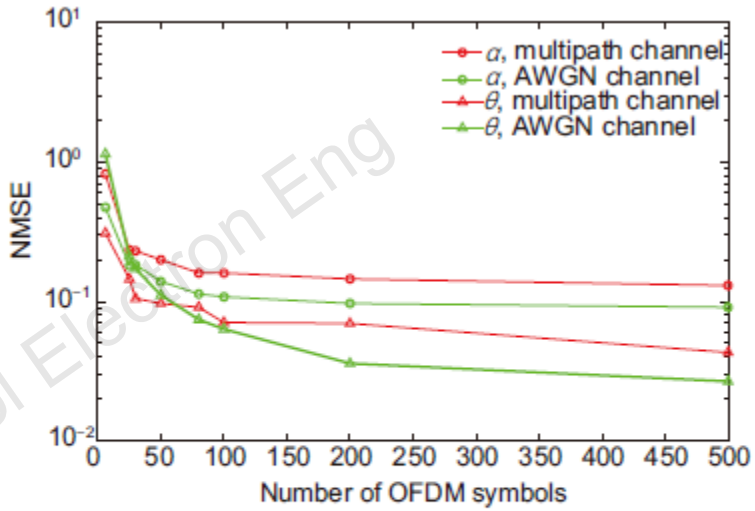


Fig. 5 Normalized mean-squared error (NMSE) of the estimated I/Q imbalance parameters versus the number of symbols (α: gain imbalance; θ: phase imbalance)

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It can be observed that the SNR has little influence on the estimation accuracy of the I/Q imbalance parameters. On the other hand, it can achieve better performance in AWGN environment than multipath environment.

Major results

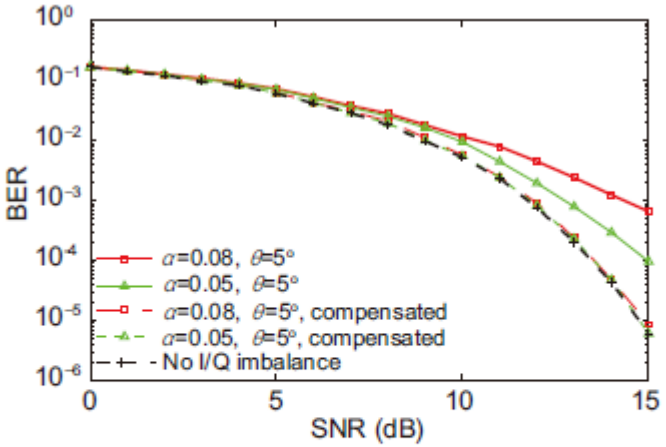


Fig. 6 Bit error rate (BER) of the compensated received signal at different SNRs in the AWGN with different gain imbalances (α: gain imbalance; θ: phase imbalance)

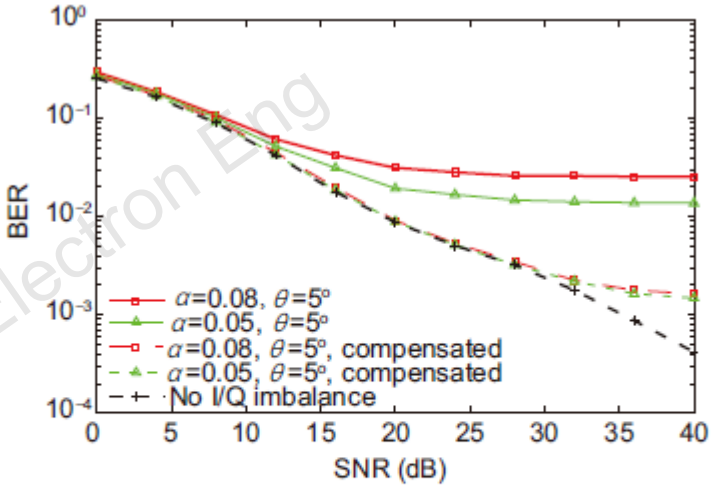


Fig. 7 Bit error rate (BER) of the compensated received signal at different SNRs in the multipath channel with different gain imbalances (α: gain imbalance; θ: phase imbalance)

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Simulation results show that: (1) if the I/Q imbalance is un-compensated, system performance will be severely degraded; (2) the BER performance of the OFDM system deteriorates with an increase in the gain/phase imbalance without the I/Q imbalance compensation; (3) the BER performance of the OFDM system can achieve BER performance close to the case without I/Q imbalance by applying the I/Q imbalance compensation, and different gain/phase imbalance factors have little effection on the BER performance.

Conclusions

1. The I/Q imbalance in OFDM direct-conversion receivers was the same as that of introducing interference from mirror subcarriers, which will destroy the orthogonality between the subcarriers and results in poor BER performance.
2. We designed a new statistic related only to the I/Q imbalance, and further estimated the I/Q imbalance parameters. In this way, the distortions introduced by the I/Q imbalance and the channel could be corrected independently by I/Q imbalance compensation and equalization.
3. Simulation results showed that the proposed method could achieve good performance in AWGN or multipath environments.

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