Sensitivity of OFDM based WLANs to front-end impairments

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Multicarrier systems based on Orthogonal Frequency Division Multiplexing (OFDM) are gaining popularity in high-speed broadband wireless networks such as IEEE 802.11a and IEEE 802.11g Wireless LANs.

OFDM based systems have the advantage of simplified receiver design using low complexity frequency domain equalization. This makes them the preferred choice for high data rate applications in hostile channels. These systems have certain inherent disadvantages too, like high peak to average power ratio (PAPR) and transceiver performance sensitivity to front-end impairments like Phase noise, I/Q imbalance, Non-linearity of power amplifiers, and word length limitations of A/D converters. These impairments lead to degradation in the overall performance of the system. This degradation can be minimized at the cost of increase in receiver complexity.

In this paper, we present a study and an analysis of the impact of front-end impairments on OFDM based IEEE 802.11a transceiver performance in the presence of multipath channels. We also recommend design choices that serve as guidelines in defining the specifications for the RF and mixed-signal front end.

Firstly, we describe our simulation set up used to study the various system components of interest of a typical IEEE 802.11a wireless LAN transceiver. This includes digital baseband, front-end, and the relevant multipath channels.

Next, we delve into the details of the relevant front-end impairments (specified by the IEEE 802.11 committee) that have an impact on the error rate performance of the complete IEEE 802.11a system. The quantization effects of A/D and D/A converters are modeled and the impact of choosing different word lengths on the overall system performance is analyzed. Similarly, we analyze the effects of gain and phase imbalance in the IQ modulator/demodulator. The effect of these is quantified with respect to residual side band width (RSB). The Phase noise in the local oscillators leads to inter sub-carrier interference that is difficult to compensate. We have modeled phase noise as recommended by the IEEE committee. The power amplifiers (PA) used in the front-end may exhibit non-linearity that can lead to both in-band and out-of-band spectral distortions. We study the effects of PA non-linearity using the Rapp model.

Next, we present the results obtained from the simulation setup and analyze the effect of front-end impairments on error rate performance of IEEE 802.11a system both in AWGN and multipath channels (as specified by ETSI-BRAN). We observe that in the presence of front-end impairments a higher complexity equalizer design would be required.

Finally, we present guidelines for system designers to select front-end for a particular baseband implementation considering the kind of channels in which the transceiver has to operate. These recommendations will have baseband design perspective while keeping the full system in view.