Physical Layer Simulation of IEEE 802.11ad

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https://github.com/armaank/IEEE802.11ad

***Abstract*—We simulate the a portion of the physical (PHY) layer of the IEEE 802.11ad standard for directional, multi-gigabit (DMG) wireless communication. The standard specifies a single carrier (SC)-PHY layer, that specifies four required modulation and coding schemes (MCS). We demonstrate a functional link over an additive white Gaussian noise (AWGN) channel and present bit-error-rate (BER) curves for each of the data rates in the DMG SC-PHY specification.**

***Index Terms*—IEEE802.11ad, WiGIG, wireless link simulations**

I. Introduction

IEEE 802.11ad was added to the 802.11 standard in 2012 as one of the first wireless standards to support multi-gigabit communications. The system achieves such high datarates by operating at the 60GHz band, with a 2GHz bandwidth, sacrificing range for tremendous throughput. Early applications of the standard include SoCs designed for virtual reality. The specification requires four different MCSs, however the core architecture of the DMG CS-PHY is illustrated below:

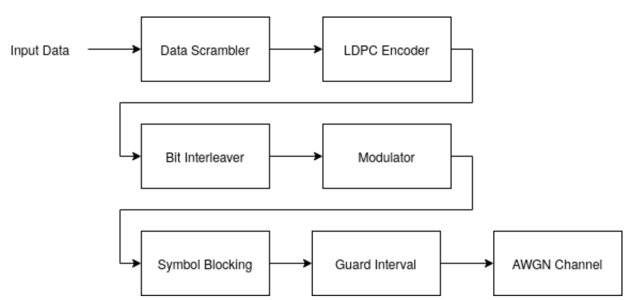

Fig. 1. Transmitter block diagram for the DMG SC-PHY specification in IEEE 802.11ad

II. 4QAM & 16QAM Performance

We were able to successfully match theoretical performance for both 4 and 16-ary QAM schemes over additive white Gaussian noise (AWGN) channels.

We simulated performance by computing the bit error rate for a single 1000 symbol packet, averaged over 10 iterations. BER curves and constellation diagrams for 4QAM can be seen in Fig. 2 and 3. BER curves and constellation diagrams for 16QAM can be seen in Fig. 6 and 7

Fig. 2. BER Curve for 4QAM over an AWGN channel

Fig. 3. 4QAM constellation

A. 4QAM

B. 16QAM

III. Equalizing a Moderate ISI Channel

Next, we attempt to equalize a frequency selective channel that introduces ISI, using a BPSK modulation scheme. We attempted several different adaptive filtering algorithms in an attempt to equalize the channel. Generally speaking, we found RLS based algorithms difficult to stabilize, and linear equalizers tended to require long training sequences. We found that we achieved the best performance using a decision feedback equalizer (DFE) with a signed-LMS algorithm.

We simulated the channel with $100,000$ symbols in order to ensure we met the performance specification of a BER less than 10^{-4} at 12dB, averaged over five iterations. We were able to successfully meet the specification, achieving a BER of approximately 10^{-6} at 12dB SNR.

IV. Maximizing Bit Rate via Coding

Finally, we attempted to further improve the performance of our wireless communication system by introducing error control codes. In order to maximize bit rate while still achieving the 10^{-6} BER requirement at 12dB SNR, we decided to increase the order of modulation and use turbo codes.

We used 16QAM and a code rate of $\frac{2}{3}$ for the turbo codes. We generated the BER curve in Fig. 8 using the standard 1000 symbol packet, averaged over five iterations. We were able to achieve a 2.667 bits per symbol, yielding a bit rate of 2666 bits per 1000 symbol packet.

V. Conclusion

We were able to successfully demonstrate understanding of communication theory fundamentals. We simulated AWGN

Fig. 4. BER Curve for 16QAM over an AWGN channel

Fig. 5. 16QAM constellation

Fig. 6. BER Curve for BPSK over a frequency selective channel

Fig. 7. BPSK constellation

and frequency selective channels, and corrected ISI both via adaptive equalization and error correcting codes.

Fig. 8. BER curve for 16QAM w/ using turbo error control codes