Baseband/RF Co-simulation of IEEE 802.15.3C in Outdoor Environment at 60 GHz

Tarik Zarrouk, Moussa El Yahyaoui and Ali El Moussati

Abstract This paper presents propagation of millimeter wave in order to determine the evolution of signal in outdoor environment, we design a wireless transceiver and we evaluate the performance of the High Speed Interface Physical Layer (HSI PHY) of IEEE 802.15.3c standard for investigate the coverage performance of the 60 GHz WLAN. Co-simulation techniques between heterogeneous environment have been used, Advanced Design System (ADS2011) for radio frequency and Matlab/simulink for baseband signal; we have compared the performance of three modulations schemes (64QAM, 16QAM and QPSK) by measuring the Error Vector Magnitude (EVM).

Keywords Co-simulation · HSI PHY mode · IEEE 802.15.3c · 60 GHz

1 Introduction

The need for high data rate in radio communication application leads to think about a new technology. The 60 GHz frequency band has been identified to give answer to this need. The interest major of this band is the huge unlicensed bandwidth, its available in many countries which represent a great potential in term of capacity, efficiency. Whose these performances attract a several standardization [1, 2]. Among these standards, we find the IEEE 802.15.3C, ECMA387 and alliance WiGig.

The main objective of this paper is to simulate the HSI PHY mode of IEEE 802.15.3c standard in LOS environment, by using different modulation schemes (QPSK, 16-QAM and 64-QAM). At first we have developed a co-simulation techniques for simulate and evaluate the performance of this system whatever the frequency range, we have used Matlab/Simulink to simulate the digital signal

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processing part and ADS for the Radio Frequency (RF) one, combining these two environments was very important to properly simulate this mode.

Finally we have calculated the EVM for different modulation schemes according to distance and evaluate the feasibility of HSI PHY mode in outdoor environment of 60 GHz WLAN system and finding the impact of propagation environment using different modulation schemes (QPSK, 16-QAM and 64QAM).

In this paper, we have considered architecture Radio over Fiber mainly the electrical communication part, we have described the complete co-simulation architecture. Before concluding we have discussed all simulations and results.

2 Co-simulation Architecture

For investigating the performance of HSI PHY mode, a Matlab/Simulink-ADS co-simulation system is developed. To benefit from the easy generation and processing baseband digital I and Q signals of any type of modulation using Matlab/Simulink, and to exploit the wide range of simulation types using ADS. The general functional diagrams for the described layouts are presented in Fig. 1.

As mentioned above, the recent work is based on the IEEE 802.15.3c standard, which is the first IEEE wireless standard for data rates over 1 Gb/s, according to the report of TG3c [3], three PHYs for the mm-Wave PHY are defined; namely single carrier (SC), high speed interface (HSI) orthogonal frequency division multiplexing (OFDM) and audio video (AV). We focus our work on second mode, because it's designed for high speed bidirectional data transmission and uses OFDM techniques. The parameters of different modulation and coding schemes are given in Table 1.

We use the Matlab/Simulink environment to modeling the HSI PHY mode. Figure 2 shows the different blocks used in this mode. Random data bits are generated and coded by two LDPC encoders, the bit sequences are multiplexed, then interleaved by a block interleaver and inserted into the constellation mapper,

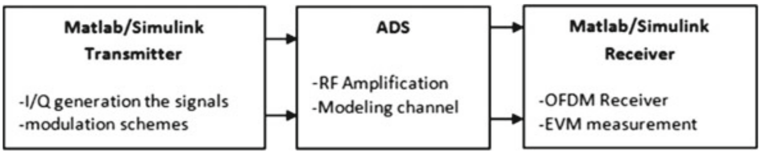

Fig. 1 General functional diagrams for the Matlab-ADS co-simulation system

Table 1 Modulation and coding schemes parameters

MCS index	Data rate (Mb/s)	Modulation scheme	FEC rate
1	1540	QPSK	1/2
5	4620	16-QAM	3/4
7	5775	64-QAM	5/8

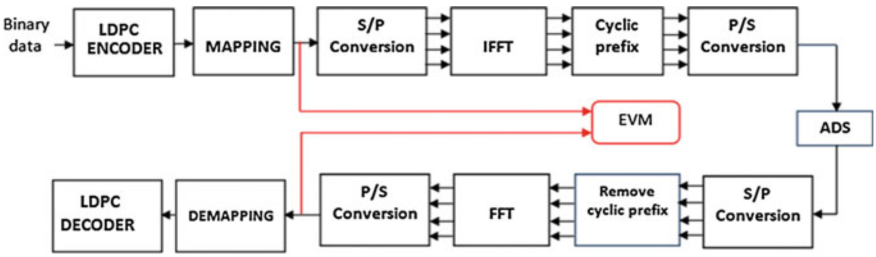

Fig. 2 HSI PHY mode of the IEEE 802.15.3c standard

the symbols generated are taken as input for tone interleaver, the IFFT block transforms these symbols in time domain (block OFDM transmitter), finally the I and Q OFDM modulation baseband generated from Simulink are simulated by ADS Agilent. The RF section up-converts the baseband signal to 60.48 GHz and amplifies it. Once the signal RF is received by the antenna, we apply a proper filtering and down-convert it.

The inverse operation is done to obtain the OFDM baseband signal, the receiver starts the processing of accumulated waveform data: the FFT Block transforms the symbols in frequency domain (OFDM receiver), then the bits are inserted into the constellation demapper for extracting the bitstream from the received complex stream, and passed into deinterleaver for synchronization with the bit interleaver of transmitter. Finally, we decoded by a LDPC decoder.

Concerning transmission in radio frequency, the microwave subjected to a lot of attenuations in free space by rain or atmospheric absorption, it can reach 16 dB/km at 60 GHz for atmospheric absorption and reach 16 dB for 25 mm/h for rain attenuation, these attenuations decrease the quality of service (QoS), why it was necessary to take into consideration these influences.

Figure 3 presents the different components used for transmit the signal in RF. The model RF realized in ADS is shown in Fig. 3, the I and Q OFDM components are generated from Simulink model, amplified and shifted to 6 GHz by intermediate frequency, the transmission power delivered is 27 dBm [2], after we up convert the signal to 60 GHz using a quadrature injection locked oscillator, then the signal

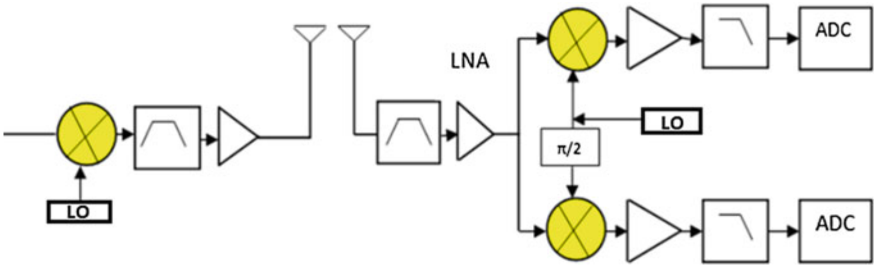

Fig. 3 RF architecture at 60 GHz for LoS environment

passes through a channel modeled for LoS environment, we only consider the atmospheric attenuation, Eq. (1) present the path loss is:

$$PL(d)[dB] = PL(d0)[dB] + 10 * n * \log 10(d/d0) + \Sigma Xq \quad (1)$$

PL (d0): is the path loss at reference distance, 10n * Log10 (d/d0) is the path loss at relative distance, d0 is the reference distance, n refers the path loss exponent and Xq is the additional attenuation due to specific obstruction by object.

At reception, the signal captured by antenna at 60 GHz, a direct conversion receiver made for down convert the signal, it is filtered by band selection filter and the low noise amplifier (LNA) amplified the signal, then a quadrature mixer to a local oscillator having a frequency 60 GHz extracted the bit stream I and Q; finally the I and Q are filtered by pass band filter.

3 Simulation and Results

We have using a co-simulation techniques composed of Matlab/Simulink for baseband and ADS for radio link. Firstly, we validate the transmit power (Fig. 4a), Fig. 4b shows the received spectrum in outdoor environment. We analyses the quality of received signal, by simulation the EVM in different modulation schemes, at first we consider the modulation QPSK, 16-QAM and 64-QAM, Table 1 presents the modulation and coding scheme (MCS) used and their parameters:

Figure 5 presents the variation of EVM measurement varying the wireless link for different modulation schemes.

Analyzing the graph, an EVM = 20 % and a distance lower than 100 m we notice that is preferable to use the modulation schemes 64QAM, cause of high throughput compared to other modulations and the modulation QPSK supports attenuations more than other modulation, the EVM reach 20 % for a distance 200 m.

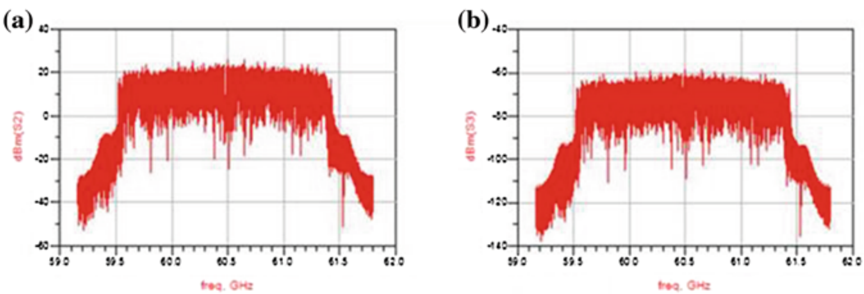

Fig. 4 Transmit and received spectrum in outdoor environment (LoS)

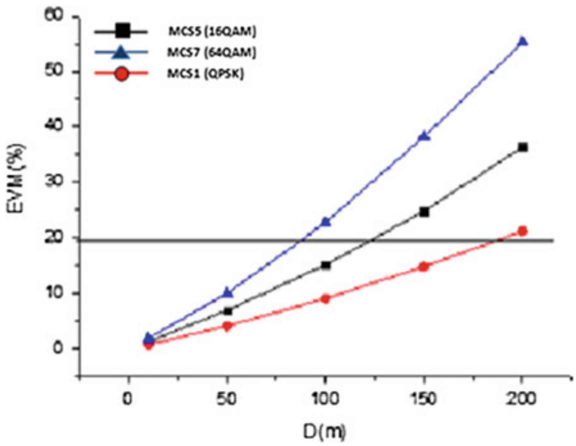

Fig. 5 EVM measurement according to distance link

As a perspective of this work, we can be implemented an algorithm which allows adaptation in terms of modulation and coding of the transmitter based on the quality of the transmission link [4].

4 Conclusion

In this paper we have evaluate the performance of PHY HSI mode of IEEE 802.15.3C at 60 GHz, using two heterogeneous environment using two software, design the complete architecture and simulation the EVM of different modulation schemes to predict the modulation schemes appropriate for a defined distance.

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