Influence of the nonlinearities of power amplifier on a transmitter / receiver for wireless local area network standard HIPERLAN 2

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ABSTRACT

This paper presents some results of transmitter/receiver simulation for the new local area network standard HIPERLAN 2. In the first part, this standard and its parameters used during the simulations are briefly described, then the influence of the nonlinearity of an RF power amplifier to its performance is examined (influence to ACPR, spectral regrowth and EVM is at the center of interest).

INTRODUCTION

The HIPERLAN 2 is a new standard for high performance wireless local area networks and is based on principle of Orthogonal Frequency Division Multiplexing (OFDM). This principle is also included in LAN standard IEEE 802.11 and also in Digital Video Broadcasting (DVB) and Digital Audio Broadcasting (DAB) standards. HIPERLAN 2 standard allows the sending of data with high bit rates from 6Mb/s to 54Mb/s according to the different type of symbol mapping and channel coding.

HIPERLAN2 SIMULATED SYSTEM

The block schematic of simulated HIPERLAN 2 transmitter/receiver principle is in figure 1. This schematic is based on the standard described in (1). The input data stream is scrambled with a length-127 scrambler and passed through a convolutional coder with the rate of 1/2. Different coding rates are maintained by bits puncturing. Interleaved bits are then mapped using BPSK, QPSK, 16QAM or 64QAM. Mapped bits are OFDM modulated using the IFFT of length 64 (53 complex symbols are zero padded to length 64 to allow use of FFT algorithms). OFDM bursts consist of Preamble (used e.g. for channel estimation) and Payload (part used for data transmission). The Baseband signal is translated to an RF carrier and passed through a nonlinear power amplifier and channel model to the receiver. The amplifier given as an example in the CAD software HPADS and developed by Motorola, with AM/AM and AM/PM characteristics shown in figure 2, was used. In the receiver, after translating to the baseband, the

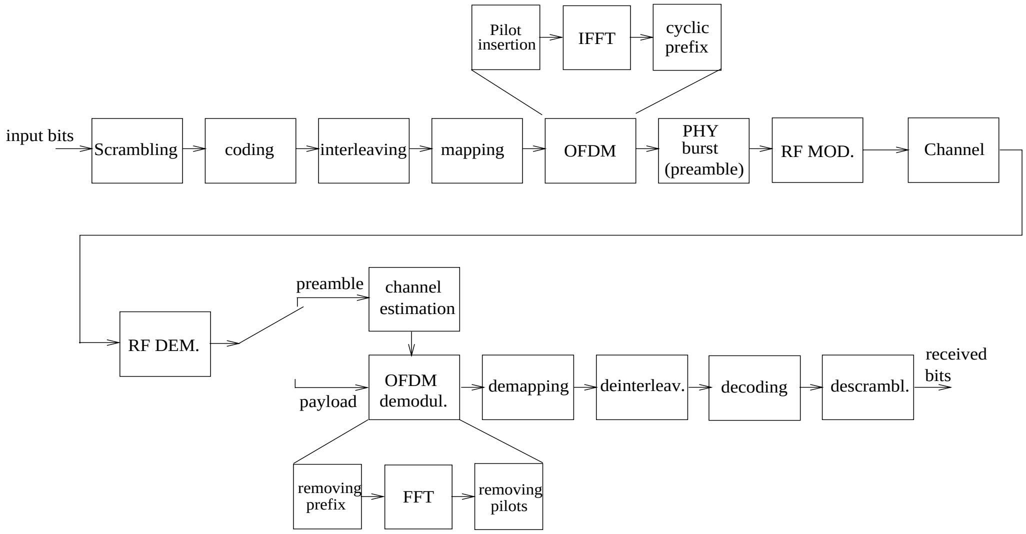

Figure 1: Schematic of simulated system

physical burst is divided to preamble and data part. Preamble is used for example for channel estimation and the data part is decoded using blocks inverse to those in the transmitter.

PRINCIPAL PERFORMANCE PARAMETERS

There are these four main parameters which can be used for the evaluation of the effects of the nonlinearities to the performance of communication systems:

- Adjacent Channel Protection Ratio (ACPR)
- Error Vector Magnitude (EVM)
- Bit Error Ratio (BER)
- Power Spectrum

ACPR which characterizes perturbations outside the channel can be defined as:

$$ACPR = 10log_{10}\left(\frac{\int P_{MainChannel}}{\int P_{AdjacentChannel}}\right) \quad (1)$$

The ACPR is calculated separately for the left and right adjacent channel, as the spectral regrowths in these channels are not same.

EVM on the other side, characterizes the distortion effects to the signal in the main channel. It is defined as :

$$EVM(rms) = \sqrt{\frac{1}{N}\sum_{1}^{N}|E(k)|^2} \quad (2)$$

where $E(k)$ are error vectors (error between demodulated constellation points Z(k) and ideal constellation points S(k)):

$$E(k) = \frac{Z(k)W^{-k} - C_0}{C_1} - S(k) \quad (3)$$

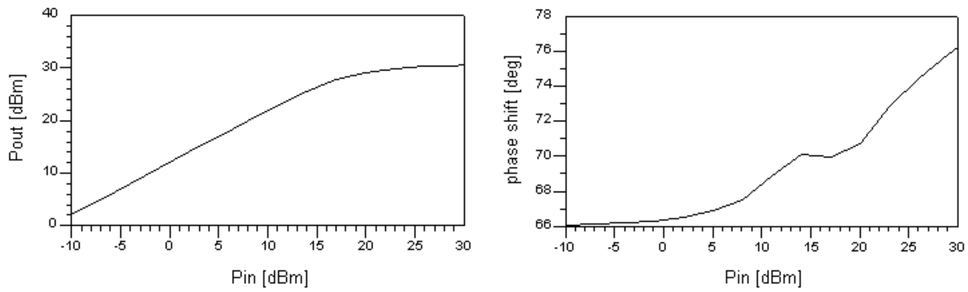

Figure 2: AM/AM and AM/PM characteristics of PA

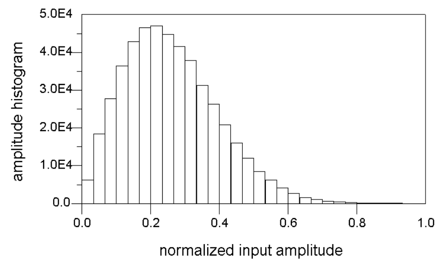

Figure 3: Histogram of HIPERLAN2 signal amplitudes

The constants C_0, C_1 and W^{-k} are used for the compensation of modulator/demodulator imperfections. For more informations, see Lecheminoux (3).

EXPERIMENTS

All the experiments were done using an ADS simulation software package and MATLAB software. In ADS, cosimulation of a dataflow simulator for baseband simulations, with an envelope circuit simulator for the amplifier model was used. During the simulations, uplink burst with short preamble and QPSK mapping was used. The simulated AM/AM and AM/PM characteristics of an amplifier and a histogram of the baseband HIPERLAN2 signal normalized amplitudes are shown in figure 2 and 3 respectively. The effects of passing the signal through a nonlinear amplifier can also be demonstrated using a constellation diagram. The example how the ideal QPSK constellation points are deformated by the amplifier is shown in figure [5] for the value of input average power 15 dBm.

The out-of-band distortion effects of a nonlinear amplifier are characterized by the ACPR as a function of mean input power (figure 4) and by the power spectrum for three values of mean input power (figure 5). The exact parameters of ACPR calculations for HIPERLAN2 standard are not defined yet, so the power in the main and adjacent channels was calculated in a 9 MHZ bandwidth. In the figure, both the ACPR_{left} and ACPR_{right} are shown. For the EVM calculations, the signal from power amplifier was demodulated, preamble was removed and EVM RMS was computed for the 150 constellation points as the exact definition of the EVM calculations for HIPERLAN2 was not available yet. For the simulations, the modulator/demodulator imperfections were ommited to examine only the influence of the amplifier. The resulting EVM as a function of input mean power is in figure 5.

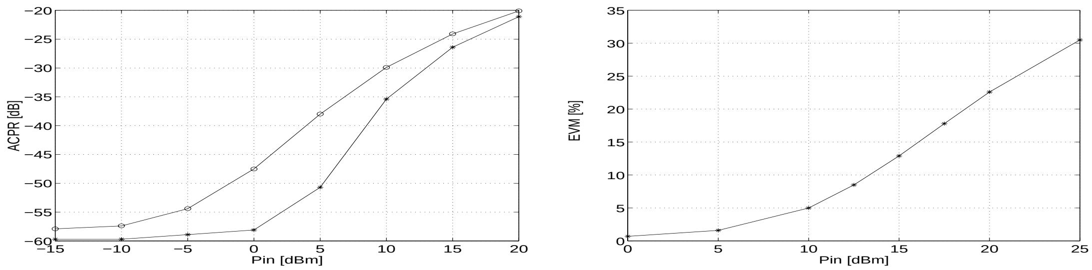

Figure 4: ACPR (left) and EVM (right) as a functions of mean input power.

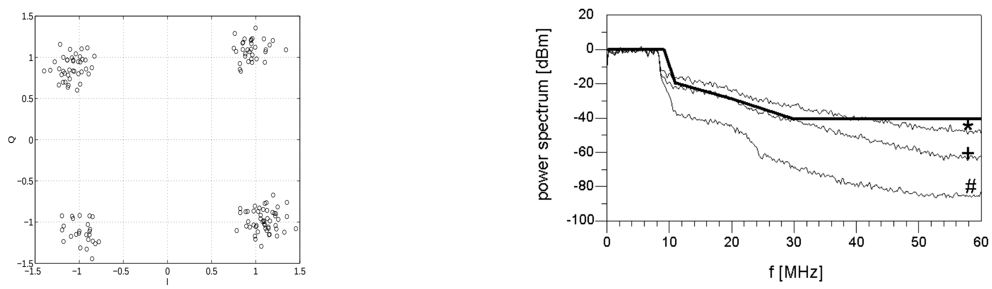

Figure 5: Example of a constellation diagram (left), power spectras for mean input power equal to 5(#), 15(+) and 20($\star$) dBm (right).

CONCLUSION

The effects of the power amplifier nonlinearities to ACPR, EVM, constellation diagram and power spectrum are demonstrated using the pictures shown above. With rising average input power the ACPR is decreasing and the power spectrum in the adjacent channel regrowths, so for the high power values, the transmitter power mask defined in [1] cannot be fulfilled. Increasing the mean input power, the EVM is also increasing which can result in a bad decision for the received symbols. There was no exact value of EVM limit defined for the HIPERLAN 2 system at the time of writing this paper, for the other standards this value is mostly around 12 % . To minimize these undesirable effects, some linearization method like predistortion could be used ,otherwise the amplifier input power has to be limited, so the amplifier cannot be very efficient.

REFERENCES

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