

To Study the Nonlinear Effects Related To PAPR and PAS in Wireless System

Rajvansh Sehamby, Dr. Jyoteesh Malhotra.*

Department Of ECE, Guru Nanak Dev University, RC-Jalandhar, Punjab.

*Email: rajvanshrv@gmail.com

ABSTRACT

A communication system is provided that includes a transmitter device and a receiver device. The transmitter device transmits input data as a transmitted signal having the known non-linear distortion (NLD) characteristic. The receiver receives a received signal that represents a channel affected version of the transmitted signal and that has the known NLD characteristic. The received signal includes power amplifier distortion (PAD) induced by the transmitter device's power amplifier. To reduce the NLD by reducing the PAPR of multicarrier system and PADs at transmitter side by using techniques and simulation in MATLAB.

Keywords: Non-linear effects, PAPR and Pas, Non-linear distortion.

INTRODUCTION

Nonlinearity in wireless communication systems usually exists in the RF front ends and is produced by nonlinear devices such as power amplifiers, low-noise amplifiers, mixers, etc. Nonlinearity is responsible for introducing signal components that contribute to degrading system performance in a similar fashion to system noise, interference or channel impairments. In order to understand the effects of nonlinear distortion on the performance of wireless communication systems, it is important to understand the architecture of these systems and the components that are responsible for introducing nonlinear distortion. On the other hand, it is also important to understand how these systems can be modelled and simulated. Modelling and simulation of nonlinear systems is an important step towards the efficient design of modern communication systems. In this, an overview of nonlinearity and nonlinear distortion in wireless systems is given. The common sources of nonlinearity in wireless communication system are presented. Then, the concept of nonlinear distortion produced by the nonlinear behaviour and its relationship to the performance of wireless systems is given in the further report.

I. TECHNICAL FIELD

The disclosed embodiments generally relate to methods and apparatus for wirelessly communicating signals, and more particularly to methods and apparatus for reducing distortion in wideband communication signal prior to transmission and for making the distortion more deterministic, and for estimating and cancelling distortion in a received wideband communication signal.

II. BACKGROUND

Many high-speed wireless networks use wideband modulation techniques. Examples include multi-carrier communication systems, such as an orthogonal frequency division multiplexing (OFDM) system or an orthogonal frequency division multiple access (OFDMA) system, as well as spread spectrum systems based on various code division multiple access (CDMA) and Wideband CDMA (WCDMA) standards.

Wireless communication devices implement a power amplifier to amplify a transmit signal waveform prior to transmission. An ideal power amplifier would be a linear device. However, real power amplifiers are only linear within certain practical limits. Any real power amplifier device can be characterized by plotting a response curve that plots its input signal power versus output signal power. In most cases, the response curve is essentially linear over a certain range of input signal powers, but then transitions to a non-linear range. Some power amplifiers, such as traveling wave tube amplifiers, even exhibit nonlinear input to output characteristics prior to the compression region of the PA. With respect to power amplifiers in which a portion of the response curve is essentially linear, as the input signal power increases the power amplifier eventually begins to saturate. At this point, the response curve transitions into the non-linear range where the output signal power amplitude compresses and no longer increases linearly. Operation of the power amplifier in the non-linear range causes "clipping" of modulated transmission signal and distorts the modulated transmission signal. Thus, when a power amplifier device non-linearly amplifies transmit information sequences, traditional transmission methods may experience an increase in channel estimation errors due to distortion induced by the power amplifier and an increase in the out-of-band signal power due to the

distortion induced onto the information signal by the power amplifier.

One characteristic of the waveforms used in systems described above is that they can have relatively large peak-to-average power ratios (PAPRs). For instance, in a multi-carrier communication system, a multi-carrier transmission is composed of a number of independent signals, where each signal is centered a different frequency (commonly referred to as “carrier” frequencies). In multi-carrier communication systems, the signals are combined together as vector. An inverse fast Fourier transform (IFFT) is usually performed on the vector to produce a discrete time domain signal which is converted to a continuous time domain signal and transmitted. When multiple independent complex valued signals residing on multiple carrier frequencies are summed this can result in a transmit signal that is characterized by a relatively large peak-to-average power ratio (PAPR). As used herein the term PAPR refers to the ratio of the peaks of the amplitude of the signal to the average amplitude of the signal.

When a modulated transmission signal waveform has a large PAPR, the transmission signal waveform will include a number of amplitude peaks that often exceed the transmitter's power amplifier (PA) capabilities. If the amplitude of the modulated transmission signal is too large the transmitter PA will saturate, and peaks in the transmitted signal waveform are cut-off or “clipped.” When the peaks of the modulated transmission signal are clipped this causes harmonic distortions in the transmit signal, and a significant amount of information is lost. Distortion can reduce the effectiveness of signal transmission from the transmitter to a receiver and can interfere with in-band and out-of-band communications. Such non-linear transmission may cause significant out-of-band interference (i.e., interference outside the signal bandwidth, such as in the adjacent channels and/or other user channels), and also may induce undesired in-band interference, which adds distortion to the transmitted information bits and also to the channel training information. Furthermore, improper synthesis of the channel training information may lead to further channel estimation errors at the receiver. Thus, non-linear amplification of high peak-to-average power ratio signals and improper channel training information design may, in the receiver, result in unacceptably high channel estimation errors on the receiver side and excessively high bit error rates and/or symbol error rates of received signals and can significantly degrade the receiver demodulated BER/SER. Thus, one concern is how to reduce the PAPR of a multi-carrier transmission, and combat any remaining distortion that result due to the large PAPR.

Accordingly, in systems that use waveforms having relatively large peak-to-average power ratios (PAPRs), what are needed are methods, systems and apparatus that can reduce non-linear distortion prior to transmission, and subsequently estimate and cancel any remaining non-linear distortion after transmission. Such systems should reduce distortion noise and improve power efficiency in peak-limited channels. It would be desirable if these techniques can allow the transmit power amplifier to operate at low input backoff (IBO) levels in a highly energy efficient manner to increase battery life, while still achieving acceptable distortion cancellation at the receiver to provide high performance channel estimation and improve operation in multipath fading channels.

III. LITERATURE

Nonlinear PA: When considering a nonlinear PA, we propose a general pre distortion architecture, which can be applied to a wide class of envelope tracking (ET) amplifiers, see Figure 1. With respect to the state of-the-art architecture, Wang et al. (2005) and Jeong et al. (2009) have studied pre distortion in which the pre distorter affects only the signal to be transmitted, and therefore it is not a general one. Furthermore, using the proposed architecture, the performance of the optimal and adaptive pre distorters for the linear filters and the ET amplifier are demonstrated.

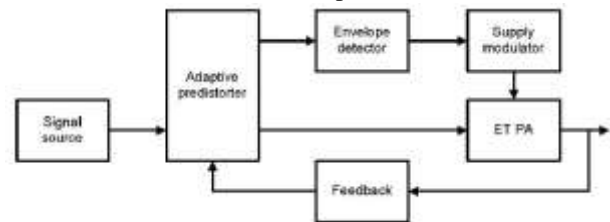


Fig 1: Simplified block diagram of an ET PA structure including the adaptive pre distortion concept.

In addition, to study the convergence of the time misalignment compensation method developed, recursive solutions of the algorithm are considered. Earlier studies (Wang et al. 2005) considered only the one-shot compensation method, which cannot necessarily be applied because of the use of the simplified pre distorter and amplifier models. The performance of the time misalignment compensation methods for linear filters and the ET amplifier with optimal and adaptive pre distorters are demonstrated in a detailed manner.

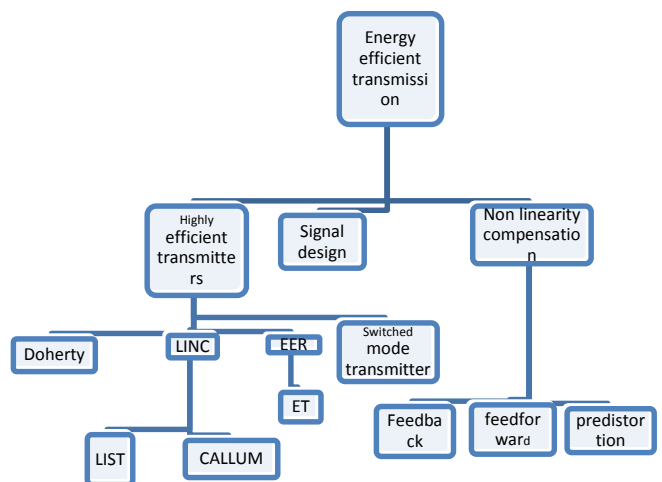


Fig 2: Classification of energy-efficient transmission possibilities.

Highly efficient transmitters: To achieve energy-efficient transmission in wireless communication, three different methods are considered, namely highly efficient transmitters, signal design, and nonlinearity compensation. The classification of these methods is shown in Figure 2. Note that all the three methods can be combined together. The pre distortion of the envelope tracking amplifier is discussed. In this section, highly efficient transmitters are discussed.

Models for nonlinear power amplifiers: In practice, the power amplifier operates more or less in the nonlinear region, i.e., the response of the PA is nonlinear. For that reason, when studying the compensation of the nonlinear

PA, it is essential to use an accurate enough model for the nonlinearities. In the literature, the nonlinear PA models are usually classified to behavioural or empirical models and the models based on the physical descriptions of the PA (Kenington 2002, Pedro & Maas 2005). In the latter, electric components (e.g., inductors and capacitors) that comprise the PA are modelled. The detailed PA internal structures need to be modelled, and therefore the simulations using the model based on the physical descriptions of the PA could be time consuming. In addition, it is challenging to model, for example, Memory effects of the PA. These models are appropriate to circuit-level simulations (Pedro & Maas 2005). In the behavioural modelling, the PA is treated as a black box, i.e., the internal structure of the PA is not known. The modelling is based only on the observations of the input and output signals of the PA. The behavioural modelling approach is widely used in the literature, see e.g., (Pedro & Maas 2005, Hammi et al. 2010, Tehrani et al. 2010, Ghannouchi & Hammi 2009) and references therein. Figure3 shows a simplified diagram of the PA model classification.

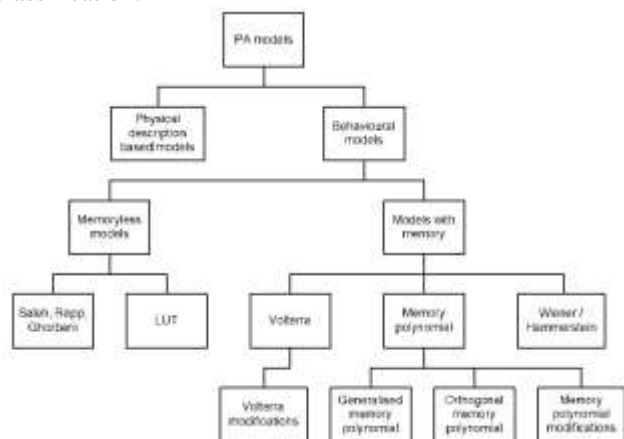


Fig 3: PA model classification

PAPR: Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal.

The major disadvantages of a high PAPR are-

1. Increased complexity in the analog to digital and digital to analog converter.
2. Reduction is efficiency of RF amplifiers.

PAPR reduction techniques: It varies according to the needs of the system and is dependent on various factors. PAPR reduction capacity, increase in power in transmit signal, loss in data rate, complexity of computation and increase in the bit-error rate at the receiver end are various factors which are taken into account before adopting a PAPR reduction technique of the system.

The PAPR reduction techniques on which we would work upon and compare in our later stages are as follows:

AMPLITUDE CLIPPING AND FILTERING

A threshold value of the amplitude is set in this process and any sub-carrier having amplitude more than that value is clipped or that sub-carrier is filtered to bring out a lower PAPR value.

SELECTED MAPPING

In this a set of sufficiently different data blocks representing the information same as the original data blocks are selected. Selection of data blocks with low PAPR value makes it suitable for transmission.

PARTIAL TRANSMIT SEQUENCE

Transmitting only part of data of varying sub-carrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique.

IV. ISSUES & CHALLENGES

Sr.no	Issues & Challenges	Improvement	EDA tool
1	Reduction of PAPRs	Decreasing the harmonic of multicarrier signal	MATLAB Simulink Communication systems Block
2	Accurate, high performance at receiver	Eliminating the receiver distortion	MATLAB Simulink Communication systems Block
3	Estimating & eliminating NLDs at transmitter side	Improving & advancing the traditional FFT algorithms and modulation coding techniques at transmitter.	MATLAB Simulink Communication systems Block

1. To find the Bit Error Rate (BER) of an OFDM System and plot it against Signal-to-Noise Ratio (SNR).

BLOCK DIAGRAM:

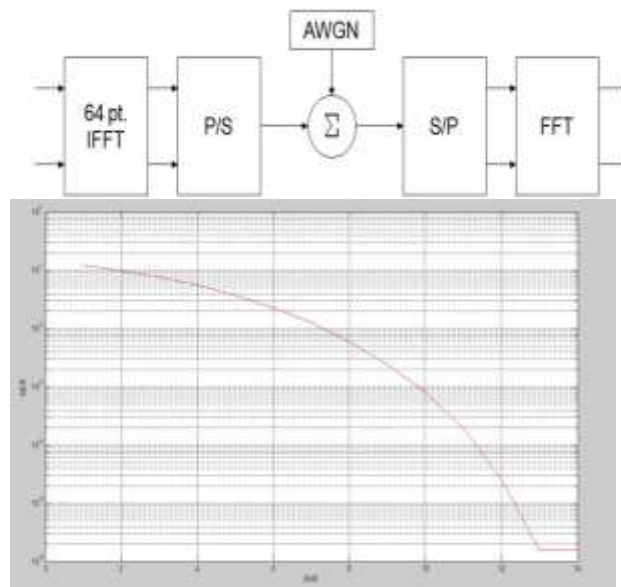


Fig: BER vs. SNR Plot of an OFDM System

2. Selected Mapping (SLM) is one of the techniques used for peak-to-average power ratio (PAPR) reduction in OFDM systems. In this .m file it is

simulated for a QPSK modulated, 64-subband OFDM symbols.

V. FUTURE SCOPE

Embodiments may have improved channel estimation and/or BER performance over traditional techniques. Some performance improvements are subsequent to receiver operation such that little degradation in signal-to-noise ratio (SNR) is experienced from receiver distortion cancellation resulting in optimal communication link bit error rate (BER) performance.

In addition, embodiments may jointly provide for robust synchronisation, low peak –to– average ratios (PARs), and accurate, high performance channel estimation at the receiver due to the elimination of receiver distortion, among other things. Low PARs may be achieved because embodiments may enable a transmitter’s power amplifier to be operated more efficiently.

In addition, for battery-powered apparatus, improved battery life may be achieved, because the power amplifier may be operated at a higher efficiency than using traditional techniques. More specifically, the transmitter battery life is significantly increased when the transmitter power amplifier is enabled to operate at low back off levels because this allows the power amplifier to work in a highly energy efficient manner.

VI. CONCLUSION

To improve the wireless communication system by eliminating the NLDs at transmitter section rather than at receiver side and hence increasing the SNR and improve the BER of signal by reducing the PAPRs of multi-carrier.

OFDM is a very attractive technique for multicarrier transmission and has become one of the standard choices for high – speed data transmission over a communication channel. It has various advantages; but also has one major drawback: it has a very high PAPR.

In this report the different properties of an OFDM System are analysed and the advantages and disadvantages of this system are understood. The bit – error – rate is also plotted against the signal – to – noise ratio to understand the performance of the OFDM system.

I have also aimed at investigating some of the techniques which are in common use to reduce the high PAPR of the system. Among the three techniques that we took up for study, I found out that Amplitude Clipping and filtering results in Data Loss, whereas, Selected Mapping (SLM) and Partial Transmit Sequence (PTS) do not affect the data. From the comparison of the SLM and PTS techniques, I could infer that PTS is more effective in PAPR reduction.

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