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# Spectrum Calculations for an Orthogonalized Non Linear System

***Er. Sukhwinder Partap Rana[1], Er. Harisharan Aggarwal[2]***
Research Scholar
Department: Electronics & Communication Engineering
Guru Gobind Singh College of Engg. & Technology
Guru Kashi University, Talwandi Sabo
Bathinda (PB)
sp_rana72@yahoo.com
Head of Department
Department: Electronics & Communication Engineering
Guru Gobind Singh College of Engg. & Technology
Guru Kashi University, Talwandi Sabo
Bathinda (PB)
hs5555@rediffmail.com

***Abstract*---It is important to understand the architecture of Non linear systems and the components that are responsible for introducing nonlinear distortion. In order to evaluate the effect of nonlinear distortion on system performance the modeling and simulation is the requirement of present scenario of modern wireless communication systems. We have presented the orthogonalization of the behavioral model is beneficial for the better prediction of nonlinear distortion and extracts the uncorrelated component of the nonlinear output that is responsible for the degradation of system performance. Orthogonalization of power series nonlinear model is performed.**

**Keywords**---Downlink dedicated physical channel, Wideband Code Division Multiple Access, Power Spectral Density

## I INTRODUCTION

Nonlinearity in wireless communication system is mainly introduced by nonlinear devices which are organized in the design of the transmitter and the receiver. In order to figure out the effect of nonlinear distortion on system performance, it is important to understand the architecture of these systems and the components that are responsible for introducing nonlinear distortion. It is also important to evaluate the modeling and simulation of these systems. Modeling and Simulation is an important step for an efficient design of modern wireless communication systems. Nonlinearity and nonlinear distortion is introduced by nonlinear behavior of nonlinear devices and their relationship to the performance of wireless communication system will be discussed. The main nonlinear devices that produce nonlinear distortion are power amplifiers, mixers in wireless transmitters and low noise amplifiers in wireless receivers[1].

A traditional method is to first linearize the system then perform model order reduction on the linear system. But it is well known that this method cannot give good approximation results. The ‘‘quadratic reduction method’’ presented is based on the idea of approximating the nonlinear system by a quadratic system through dropping the terms of more than two degree in Taylor expansion of the nonlinear term [1] . The bilinearization method proposed in [2] first approximating the original nonlinear system by a bilinear system, then doing order reduction on this approximate bilinear system by using the Volterra series representation of bilinear system in control theory. Variational equation model order reduction method in [3] is based on the variational equation theory in [1]. By this method, the original nonlinear system is changed into several linear systems, then order reduction is done on each linear system. Another reduction method is proposed in [4], which uses the derivatives of the state variable to form an orthogonal projection matrix, and then reduce the original system by projection with this orthogonal matrix. There are also some other nonlinear model order reduction methods such as the trajectory piecewise linear method in [5]. In this paper another method to achieve linearization is presented as Orthogonalized Nonlinear Model for nonlinear system.

## II NONLINEAR MODEL FOR ORTHOGONALIZATION

As studied in recent years, the orthogonalization of the nonlinear model require two main steps: the first is to compute of the orthogonal model coefficients from envelope coefficients and the second is to compute the PSDs of the linear and distortion components. Hence, given a set of envelope coefficients, the orthogonal model coefficients are computed by finding the correlation coefficients $\alpha_{nm}$ between $n$th- and $m$th-model branches [6]. This requires the computation of the higher-order spectra. A flow chart for the computation of the orthogonal model spectra is shown in Figure 1.

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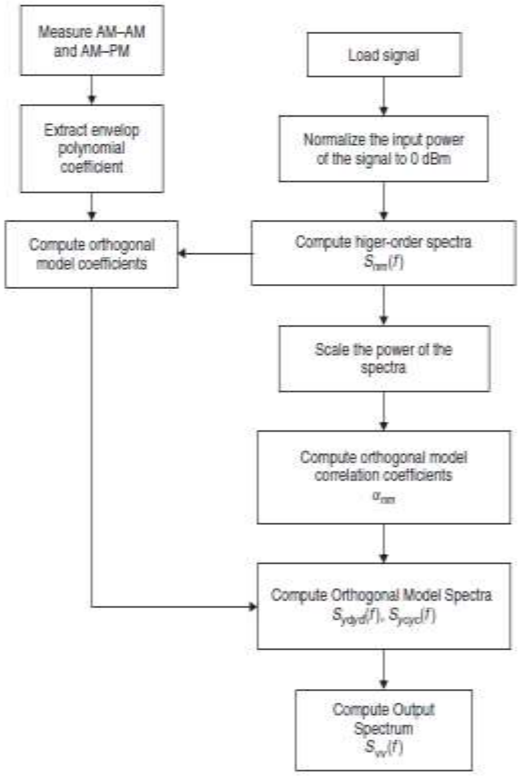


**Figure 1 Flow Chart for Computing the Orthogonal Spectra**

## III RESULTS AND DISCUSSIONS

As shown in Figure 2 (a), Figure 3 (a), Figure 4 (a), Figure 5 (a) the total output spectrum and the uncorrelated distortion spectrum of four different customized forward-link WCDMA signals; forward-link 1DPCH,forward-link 3DPCH and 16DPCH and a reverse-link 5DPCH signal respectively, all simulated at $P_{in} = -5$ dBm, which is the 1-dB compression point of the PA. Note that the shape of the uncorrelated components based on the signal and its statistics. Figure 2 (b), Figure 3 (b), Figure 4 (b), Figure 5 (b) represents the probability density functions of these four different signals respectively.

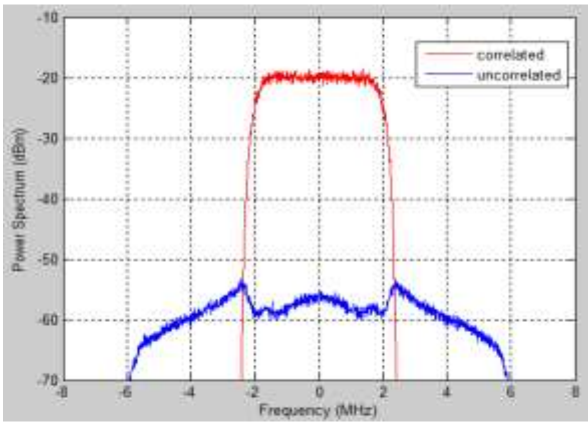


**Figure 2 (a) Output Spectrum of a Nonlinearity Partitioned into Correlated and Uncorrelated Components; Forward Link 1 DPCH**

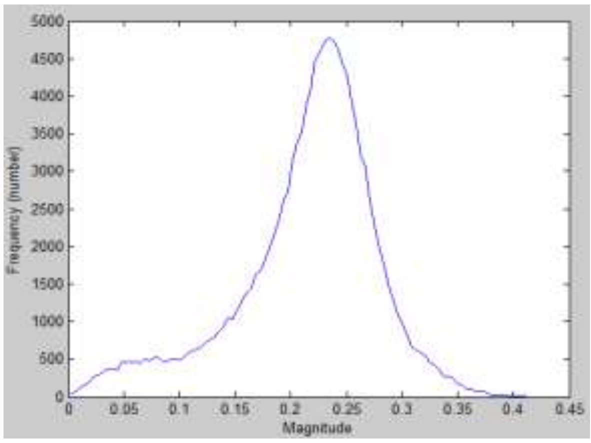


**Figure 2 (b) Probability Density Function of 1DPCH WCDMA Signals.**

As shown in Figures 3 (a) and 5 (a), In 3DPCH and 5DPCH cases, the uncorrelated distortion inside the main channel is below spectral regrowth in the adjacent channel. As shown in Figure 4 (a), the case of 16DPCH represents the worst case since it represents the highest Peak-to Average Ratio (PAR). The shape of the uncorrelated spectrum similar to that of Gaussian signals which is flat over the signal bandwidth since its distribution can be approximated by a Gaussian distribution by the central limit theorem.

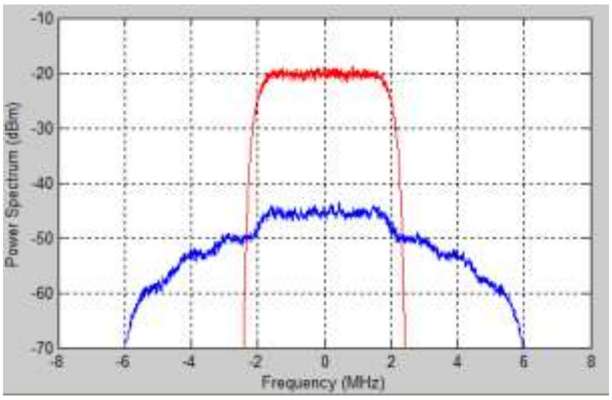


**Figure 3 (a) Output Spectrum of a Nonlinearity Partitioned into Correlated and Uncorrelated Components; Forward Link 3 DPCH**

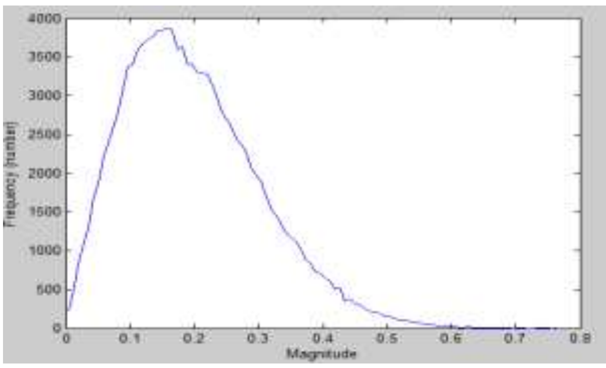


**Figure 3 (b) Probability Density Function of forward link 3DPCH WCDMA signals**

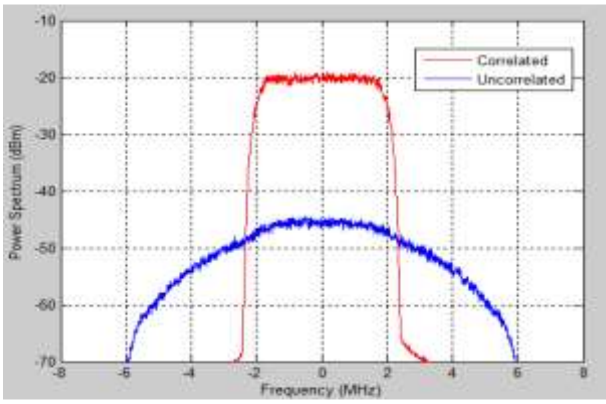


**Figure 4 (a) Output Spectrum of a Nonlinearity Partitioned into Correlated and Uncorrelated Components; Forward Link 16 DPCH**

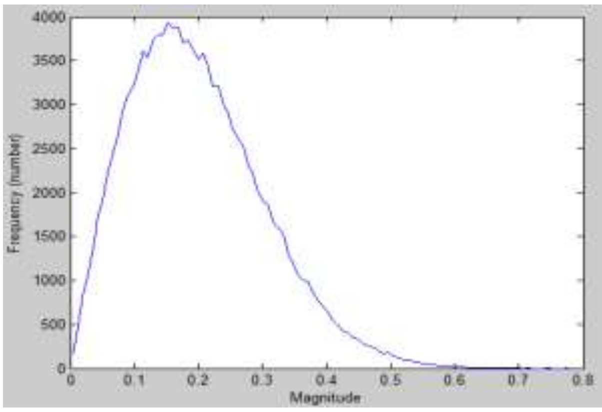


**Figure 4 (b) Probability Density Function of forward link 16 DPCH WCDMA signals**

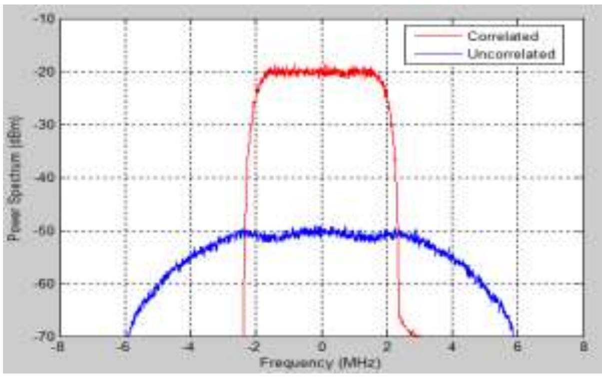


**Figure 5 (a) Output Spectrum of a Nonlinearity Partitioned into Correlated and Uncorrelated Components; Reverse Link 5 DPCH**

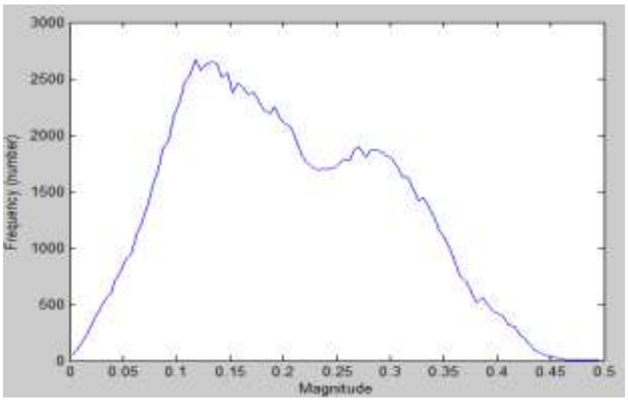


**Figure 5 (b) Probability Density Function of reverse link 5 DPCH WCDMA signals**

To develop the uncorrelated spectrum of multisine signal by using multisine signal as a input signal, same approach can be used as studied earlier.

## IV CONCLUSION

we have studied the orthogonalization of the behavioral model is beneficial for the better prediction of nonlinear distortion and extracts the uncorrelated component of the nonlinear output that is responsible for the degradation of system performance. Orthogonalization of power series nonlinear model is performed and it can also be done for other nonlinear models.

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