Adaptive Algorithm for Digital Predistortion Using LS with Cholesky Decomposition

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Abstract— Digital predistortion is one of the most capable ways to compensate non-linear characteristic of a power amplifier. In this paper, a new approach which uses least square (LS) adaptive algorithm with cholesky decomposition is presented. If least square algorithm is combined with Cholesky decomposition for finding the inversion matrix of power amplifier model it not only provides high degree of improvement but also improves stability and decrease computation complexity.

Keywords: Power Amplifier; Digital Predistortion; LS; Cholesky Decomposition

I. INTRODUCTION

Power amplifier (PA) is a totally important part of trans- mitting system for wireless communication. high performance and linearity are without a doubt necessary necessities of power amplifiers but unfortunately, they may be hard to attain simultaneously, on the grounds that high performance PAs are nonlinear and linear PAs may have low effectiveness. if you want to achieve extra performance through running at higher output energy at the same time as nevertheless retaining spectral compliance, there are numerous methods for linearization of power amplifier, consisting of power back- off, feed-forward method, negative feedback and digital pre distortion. digital predistortion generation is widely used in cutting-edge wireless communication by means of its high precision, sturdy adaptability and simple implementation. on the other hand, in an effort to adapt to the nonlinear traits of the one-of-a-kind power amplifier, adaptive algorithm along with LS, LMS RMS and so on is used and performs a principal function in the digital predistortion machine. however, LS set of rules has the downside of random perturbations update weight values. The Cholesky decomposition is the maximum dependable decomposition method because of its traits of matrix measurement reduction, scale invariance and matrix perturbation insensitivity.

Volterra series is the most regularly used complex series to model power amplifiers. For simplicity, Volterra series is generally deployed in its simplified shape, as an instance, memory polynomial

II. ADAPTIVE ALGORITHM

A. DPD Overview

Predistortion is a method used to improve the linearity of radio transmitter amplifiers. The predistortion circuit is an inverse version of amplifier's benefit and phase characteristics and when combined with the amplifier, produces a common system that is more linear and reduces the amplifier's distor- tion. In essence, "inverse distortion" is brought into the input of the amplifier, thereby cancelling any non-linearity the amplifier would possibly have.

Predistortion is a cost-saving and power efficiency approach. Radio power amplifiers have a tendency to emerge as extra non-linear as their output power increases towards their most rated output. Predistortion is a manner to get greater usable power from the amplifier, without having to construct a larger, less efficient and greater expensive amplifier.

Digital pre-distortion (DPD) is a baseband signal process- ing method that corrects for impairments inherent to RF power amplifiers (PAs). these impairments cause out-of-band emissions or spectral regrowth and in-band distortion which correlates with an elevated bit-errors-price (BER). Wideband signals with a high peak-to-average ratio, as is feature of LTE/4G transmitters, are particularly at risk of these unwanted outcomes.

Predistortion system architectures are divided into two types. One is direct learning structure, which have to identify the PA nonlinear characteristics and then discover the inverse characteristics of PA, which is of high computational complex- ity. any other type is the indirect learning structure [4], which doesn't want to locate the inverse nonlinear characteristics of PA. As a result, the indirect learning structure is extra appealing to the adaptive set of rules.

The simplified model of the memory polynomial is given

$$z(n) = \sum_{q=0}^{Q} . \sum_{k=1}^{K} a_{kq} \mathrm{x}(\mathrm{n}-\mathrm{q})|\mathrm{x}(\mathrm{n}-\mathrm{q})|^{k-1} \quad (1)$$

B. Cholesky Decomposition:

Solving large system of simultaneous linear equations (SLE) has been a major challenging problem for many real-world engineering/science applications.

In matrix notation, at set of SLE can be represented as:

$$[A][X] = [B] \quad (2)$$

Where,

A= known coefficient matrix, with dimension A[n][n] B= known right-hand-side (RHS) 1xN vector

X= unknown vector.

Cholesky Decomposition involve 3 step to find the value of [x]:

Step 1: Matrix Factorization phase

In this step, the coefficient matrix can be decomposed (or factorized) into

$$A = u^H u \quad (3)$$

Step 1.1: Compute numerator:

$$Sum = a_{ij} + \sum_{k=1}^{i-1} (u_{ki} u_{kj}) \quad (4)$$

Step 1.2 For off-diagonal term:

$$u_{ij} = \frac{Sum}{u_{ii}} \quad (5)$$

else, if diagonal term:

$$u_{ii} = \sqrt{Sum} \quad (6)$$

Step 2: Forward Solution phase

$$[u^H][u][X] = [B] \quad (7)$$

Let say,

$$[u][X] = [Y] \quad (8)$$

Then

$$[u^H][Y] = [B] \quad (9)$$

$$Y_j = \frac{-B_j - \sum_{i=1}^{j-1} u_{ij} Y_i}{u_{jj}} \quad (10)$$

Step 3: Backward Solution phase

Since is an upper triangular matrix can be efficiently solved for the original unknown vector [X].

C. Parameter Extraction

Algorithm Predistortion system in actual engineering, the error e(n) of predistortion signals z(n) and its estimated signals $z^e(n)$ can't completely ideal is equal to zero, only according to certain rules of the best minimize error signal. Predistortion of the input-output relationship for convenience of description, transcribe into matrix form:

$$z = Xa \quad (11)$$

Where:

$$z = [z(0), \dots, z(N-1)]^T \quad (12)$$

$$a = [a_{1,0}, a_{3,0}, \dots, a_{k,0}, \dots a_{1,q}, \dots, a_{k,q}]^T \quad (13)$$

Define:

$$x_{kq} = x(n-q)|x(n-q)|^{k-1} \quad (14)$$

Then

$$\boldsymbol{X} = [\boldsymbol{x}_{1,0}, \boldsymbol{x}_{3,0}, \dots, \boldsymbol{x}_{k,0}, \dots \boldsymbol{x}_{1,q}, \dots, \boldsymbol{x}_{k,q}]^T \quad (15)$$

Where,

u = upper triangular matrix

Equation (1) applied to the pre distorter training module A, the input-output relationship is given by:

$$\boldsymbol{z}^e(\boldsymbol{n}) = \sum_{q=0}^{Q} \cdot \sum_{k=1}^{K} \boldsymbol{a}_{kq} \frac{\boldsymbol{y}(\boldsymbol{n}-\boldsymbol{q})}{\boldsymbol{G}} \left| \frac{\boldsymbol{y}(\boldsymbol{n}-\boldsymbol{q})}{\boldsymbol{G}} \right|^{\boldsymbol{k}-1} \quad (16)$$

Equation (16) can be written in the form of matrix:

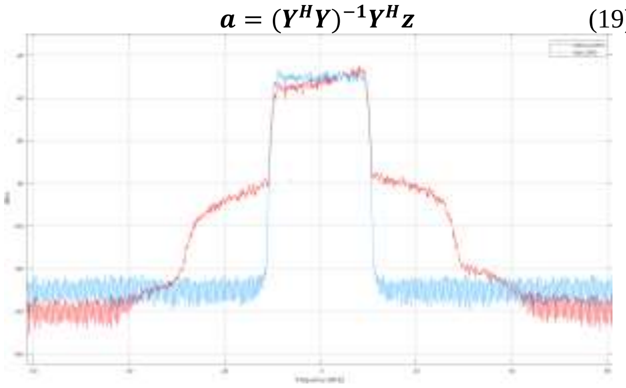
$$\boldsymbol{z}^e = \boldsymbol{Y}\boldsymbol{a} \quad (17)$$

The estimated error between the output $z^e(n)$ and the output of the predistorter z(n) is:

$$\boldsymbol{e}(\boldsymbol{n}) = \boldsymbol{z}(\boldsymbol{n}) - \boldsymbol{z}^e(\boldsymbol{n}) \quad (18)$$

Using the least squares theory, the optimal solution for the memory polynomial coefficients of the predistorter training module is:

$$\boldsymbol{a} = (\boldsymbol{Y}^H\boldsymbol{Y})^{-1}\boldsymbol{Y}^H\boldsymbol{z} \quad (19)$$



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