Digital Pre-distortion Linearization Modeling Based on Cloud Platform

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Abstract. To solve the problem of multiple power amplifiers digital pre-distortion linearization modeling in the concurrent processing and avoid the defects of traditional technology in processing digital pre-distortion power amplifier system, provide a method of digital pre-distortion linearization modeling based on cloud platform. Through the remote measurement of the input signal and output signal in the amplifier system and the linearization modeling on cloud computing, extract digital pre-distortion linearization model parameters, set up power amplifier system behavior model and make the amplifiers linearization.

Introduction

The main function of power amplifier (PA) is to amplify the modulated signal to the need of power; it’s an indispensable key component in modern wireless communication system. But the nonlinear characteristics of PA lead to the regeneration or extension of out-of-band signal spectrum and the interference of adjacent channel. Especially in broadband communication, it influences memory obviously and affects the normal transmission of the communication system seriously.

At present it adopts PA digital pre-distortion techniques to avoid the adjacent channel interference and signal distortion mainly. But with the development of wireless communication technology, transmission signal is from 3G to 4G, even 5G, the training data required for digital pre-distortion modeling is getting larger and larger, traditional digital pre-distortion system based on hardware chip technology will produce the loop delay problems and does not support the remote and parallel processing of parameter extraction. Also the pre-distortion algorithm based on neural network is easy to fall into local convergence; big data training cannot solve problems in the modeling process.

With the matures of cloud computing technology, provide a method of digital pre-distortion linearization modeling based on cloud platform in order to satisfy the concurrent processing requirements of the multiple power amplifier digital pre-distortion linearization and the remote measurement and control of the signal. The use of cloud computing and cloud platform can improve the efficiency of digital pre-distortion linearization. At the same time, it can also avoid purchasing a large number of expensive hardware.

The System Model

Establish the digital pre-distortion linearization system model on cloud computing for the parameter extraction of digital pre-distortion linearization. The system model includes the application server, parameter extraction server, cloud storage server, vector signal generator, spectrum analyzer, power amplifier, attenuator, coupler and load.

Build power amplifier test hardware environment. Test device uses homemade Doherty amplifier, vector signal generator (VSG) uses Agilent E4438C; power amplifier uses Agilent N5769A; spectrum analyzer uses E4448A (including acquisition board); vector signal analysis software VSA89600. The system model is as shown in Figure 1.
Figure 1. Digital pre-distortion system model.

First of all, VSG and PC using GPIO port to connect together, and then use the cloud platform of user interaction module software download the test signal to signal generator VSG E4438C. Baseband signal is input into the power amplifier. Power amplifier through the attenuator connects to the matched load. On the other side, the power amplifier through the coupler connects to the spectrum analyzer E4448A to show the power output. The spectrum analyzer with acquisition board and the vector signal analyzer VSA89600 can make the frequency to baseband and capture the real-time power output data.

Secondly, in order to implement cloud computing for modeling, it needs to build cloud platform with the application server, parameter extraction server and the cloud storage server. The application server deploying the computing platform of the whole system is used to deal with the complete Http requests and corresponding in the cloud; finish more power amplifier pre-distortion processing requests for centralized management, dynamic migration and task scheduling; Parameter extraction server is used to remote data transmission and finish the power amplifier nonlinear characteristic parameters extraction; the cloud storage server is used to store the nonlinear characteristic parameters of the amplifier.

Digital Pre-distortion Linearization Modeling

A digital pre-distortion linearization based on cloud platform parameter extraction method mainly contains capture the original data sequence, capture data modeling, adjust time delay, normalization of data, behavior model extraction and pre-distortion parameters extraction. Specific as follows:

1. Use spectrometer of the acquisition card and signal generator synchronous to capture a long continuous sequence of the original input signal and power amplifier output signal, such as 20000 data points.

2. Capture the largest power amplifier output power point as the center, intercept a shorter data, such as 3000 data points to extract the training data parameters.

3. Intercept the original input data and the power amplifier output data to delay adjustment using cross-correlation method.

\[
\bar{A}_m = \frac{1}{N} \sum_{i=0}^{N-1} A_m(i)
\]

(1)
\[ \bar{A}_{\text{out}} = \frac{1}{N} \sum_{i=0}^{N-1} A_{\text{out}}(i) \]  

(2)

\[
C_{\tilde{A}_\text{in}, \tilde{A}_\text{out}}(m) = \begin{cases} 
\sum_{n=0}^{N-m-1} (A_{\text{in}}(n+m) - \bar{A}_{\text{in}})(A_{\text{out}}(n) - \bar{A}_{\text{out}}) & m \geq 0 \\
\sum_{n=0}^{N+m-1} (A_{\text{in}}(n-m) - \bar{A}_{\text{in}})(A_{\text{out}}(n) - \bar{A}_{\text{out}}) & m < 0
\end{cases}
\]  

(3)

Among them, \( \bar{A}_{\text{in}}(i) \) and \( \bar{A}_{\text{out}}(i) \) each represent the input and output signal amplitude, \( N \) is on behalf of the modeling data points, \( \bar{A}_{\text{in}} \) and \( \bar{A}_{\text{out}} \) represent the average amplitude of the input and output signal, \( m \) is on behalf of delay adjustment mobile points, \( C_{\tilde{A}_\text{in}, \tilde{A}_\text{out}}(m) \) is for the corresponding after mutual covariance value. Find the maximum value of the \( C_{\tilde{A}_\text{in}, \tilde{A}_\text{out}}(m) \). Combine with the actual sampling rate \( f_s \), signal delay time can be calculated, the computation formula is as follows:

\[ \tau = m_{\max} \times \frac{1}{f_s} \]  

(4)

Among them \( \tau \) is the delay time, \( m_{\max} \) is maximum mutual covariance adjustment of corresponding points.

(4) Normalize process the amplifier input and output data, namely the maximum power input sequence point and output sequence point adjust to 1.

(5) The normalization of data modeling can be used for the power amplifier behavior model, based on the cloud big data processing ability and the concurrent processing capability, use real value RBF neural network model. Normalization of input data is as input signals of the model, the normalized data after the power output is as model of the output signal, through the cloud of python scientific computing module, conclude the AM/AM and AM/PM nonlinear characteristic figures of model. Evaluate the model precision through the normalized mean square error (NMSE) modeling.

(6) The output data is as input signals of the model, the input data is as a model of the output signal, extract pre-distortion parameters, complete a parameter extraction.

(7) Repeat steps (1)-(6), extracted and updated parameters again, until the algorithm convergence.

The Simulation Results

Select WCDMA carrier signal test signal, its signal bandwidth is 15 MHZ, sampling rate is 92.16 MSaPS, PAPR is equal to 8.2, the output signal generated by the VSG is input into the test amplifier, VSA gain amplifier input and output sample data. Complete the power amplifier behavior model parameter extraction, then the power amplifier linearization experiments, on the platform in accordance with the digital pre-distortion linearization method based on cloud computing for power amplifier linearization. Through the cloud platform calculation module get the model AM/AM and AM/PM nonlinear characteristics figures. As shown in Figure 2.
Conclusions

Compare with the existing technology, this paper proposed the method of multiple power amplifier system concurrent produces digital pre-distortion processing request using the cloud unified centralized management, unified deployment of hardware environment of remote data acquisition system and training model. It greatly reduces the hardware cost. The digital pre-distortion use cloud computing to implement based on the analysis of the cloud data processing, storage, computing power, greatly improve the pre-distortion parameter training processing power and speed. Combine the cloud big data parallel processing technology, such as the virtualization technology, optimize technology, the better adaptive algorithm, it can meet the requirements for actual linearity model, so that the system has practical application value.

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