Non Linear Channel Effects Compensation on OFDM Satellite Communication Systems by Neural Network-based Predistorter

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Abstract

This paper presents a novel technique for linearization of digital satellite channel on OFDM signal transmission systems. The proposed technique is based on the use of neural network for signal predistortion to compensate the nonlinearity effects. The simulation results show that neural network-based predisorter is very effective for mitigate the nonlinearities degradation. Furthermore, the proposed scheme is also adaptive to respond the time varying properties of digital satellite channel.

1.Introduction

With the advent of broadband applications and the recent availability of adequate frequency bands, wireless satellite high-speed communications are becoming very attractive. Various techniques have been studied to achieve high-quality signal transmission using minimum available resources, and one of the most effective techniques for this goal is using Orthogonal Frequency Division Multiplexing (OFDM) signal [1].

One of problem in application OFDM system on Satellite Communications is non-linearity both in RF and IF equipment. In IF stage of transmitter, this non-linearity is inherent in OFDM signal, because OFDM system have high peak-to-average ratios [2]. Non-linearity amplifiers may cause both ISI and ICI in the system. Especially, if the amplifiers are not designed with proper output back off, the clipping distortion may cause severe degradation [1]. On the other hand, it is well known that satellite communications systems suffer from both power and bandwidth limitations. Because of the power limitation, it is desirable that the RF stage of satellite repeater or transponder, which usually consists of travelling wave tube amplifier, operating in saturation so as to obtain maximum radiated power and maximum efficiency of operation. At saturation region, the transponder is highly nonlinear, exhibiting both nonlinear input amplitude to output amplitude characteristic and nonlinear input amplitude to output phase characteristics. Both of these nonlinear affects can lead to significant signal distortion and system performance impairment.

It is well known that application of predistorter technique will eliminate the nonlinear effects of digital satellite channel. However, predistorter design is difficult for nonlinearly channel which also has time-varying properties come from both failure or environments. Thus, different approach must be employed to solve the preditorter design problem. In this paper, the author uses neural network structures for nonlinear effect compensation on OFDM satellite communication systems. By developing the neural network-based predistorter, linearization of digital satellite channel for such wideband application can be performed.

2.Neural Network-based Predistorter

It is well known that application of predistorter technique effectively eliminate the nonlinear effects of digital satellite channel. Moreover, if we have a predistorter inserted before digital satellite channel, we do not need an equalizer to compensate the nonlinearity on the receiver side. By virtue of those reasons, it is desirable to design the predistorter for wideband linearization to support the OFDM signals which have a very large dynamic range of signal envelope.

Focusing our attention on the predistorer linearization technique for OFDM satellite communication sysems, the author proposed neural network-based predistorter for compensates the time varying nonlinear distortion of satellite channel which represented by [3]:

AM/AM conversion : $A(r) = \alpha_a . r / (1+\beta_a . r^2)$
AM/PM conversion : $\phi(r) = \alpha_p . r / (1+\beta_p . r^2)$
With α_a, α_p, β_a and β_p parameters are varied with time.

Block diagram of the proposed neural network-based predistorter in baseband can be shown as figure 4. The RF modulator and demodulator are omitted in the diagram since their effects cancel.

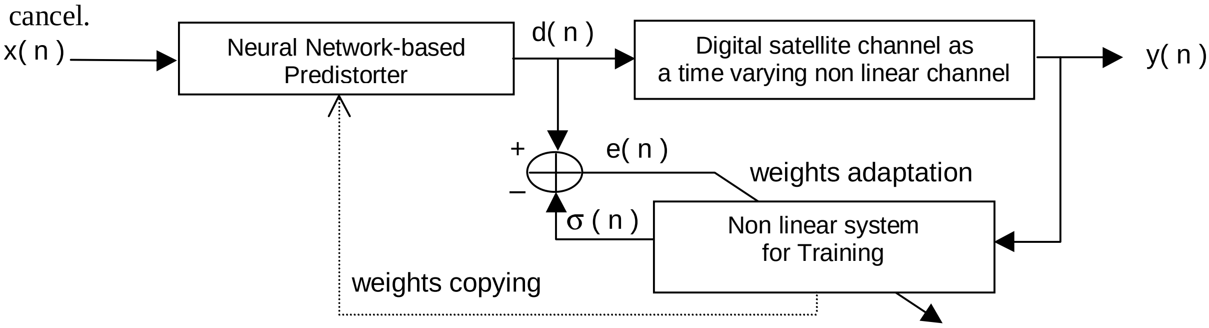

Figure 4

In that figure, the desired value of output y[n] of the overall system is x[n]. The desired value for learning nonlinear system is given by :

$d[n] = \sigma[\mathbf{x}(n)]$,

Where σ is the nonlinear system function for predistorter and the learning nonlinear system and **x**[n] is a vector of sampled input given by :

$\mathbf{x}(n) = \{ x[n], x[n-1], \dots, x[n-N+1] \}$

The output y[n] of overall system is fed to trained nonlinear system. The error signal e[n] between the output of the trained nonlinear system and the desired value d[n] is used to train the the trained nonlinear system. The contents of the trained nonlinear system are copied into the predistorter nonlinear system for each weight update. If the error signal or innovation is zero, the y[n] and x[n] are equal. Therefore, the output of digital satellite channel is free of nonlinear effects.

3.Simulation Result

For the purpose of complete analysis of neural-network application for nonlinear effects compensation, the author has developed time-varying non-linear models which represent the OFDM satellite channel. In order to investigate the performance of predistorter, Monte Carlo Simulation have performed for various type nonlinear channel models. According to the simulation results, neural network-based predistorter displays good for linearization of digital satellite channel as shown in figure 6 :

Digital satellite channel linearization by Neural Network-based Predistorter

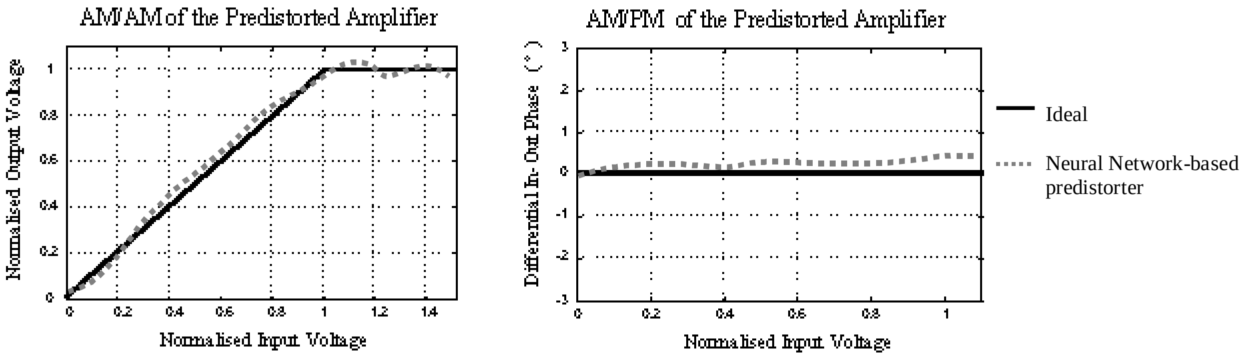

Figure 6

4.References

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