International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Modeling of Microwave Power Amplifier

Rashmita Kumari Panigrahy

Electronic Science Department, Berhampur University, Bhanja Bihar, Berhampur, Odisha, India – 760007

Abstract: ***A time Delayed Artificial Neural Network (TDANN) model designed to predict the Dynamic behavior of microwave Power Amplifier based on Volterra Series model.***

Keywords: power amplifier, dynamic behavior model, neutral network, volterra series

1. Introduction

The work develops a neural network model for nonlinear dynamic behavior between input - output relationships of power amplifier. This procedure is a paradigm shift from other existing sensul behavior of modeled device used for the equivalent circuit's model topology (1). Transforming measured data into equation Curve fitting techniques (2) is an example for such existing models. Curve fitting technique is successful for well - behaved data trace satisfying a specific mathematical model for the object. Sharp change in the data trace due to the objects internal parameters results breakdown of the model. Therefore new techniques are necessary to develop models with smoothness and continuity. Neural network model, (3, 4) used in this paper. An advantage of neural network is it requires only simulated or measured data for training, and one disadvantage is existence of analytical expression necessary for electronic device simulation.

Adequate time - delayed inputs are necessary to characterize the memory effects of the time Domain approach, learning of nonlinear behavior response to different power levels becomes difficult. We trained the network with input - output time - domain data samples at different power level of power amplifier, simultaneously learning the dynamic nonlinear behavior. (5). This paper present vigorous nonlinear model of a power amplifier using neural network model.

2. Neural Network Model

Three layers feed - forward time - delayed neural network used to model the amplifier. The nonlinear hidden layer and linear output represented by the input time - domain voltage samples and their delayed,. The hyperbolic tangent function is chosen as a activation function for hidden neuron.

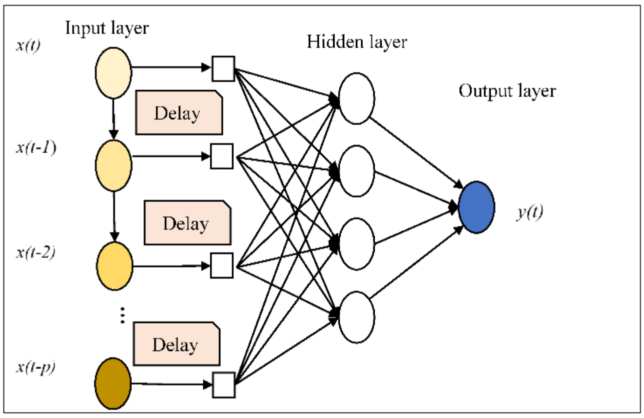

Figure 1: Feed forward TDNN architecture

The neural network used sinusoidal voltage waveforms as inputsto model a nonlinear power amplifierin which the amplifier amplifies at the output according to its available gain. . The time domain samples of input and output waveforms are used as the data base for validation, training and testing of the network. The bandwidth of the model is represent by the memory depth (N). For the best fitting to input and output data without over - fitting the number of hidden neuron is (H) is chosen. The neural network is trained with back propagation algorithm, for one thousand epochs.

3. Volterra Modeling

In a system mapping between input and output function space is characterize by Volterra approach. Volterra series is an extension of Taylor's series. The series can be described by both time - domain and frequency domain. The nonlinear dynamic behavior of power amplifier is represented by discrete formof Volterra series.

$$Y(t) = h0 + \sum_{k=0}^{p} h1(k)x(n-k) + \sum_{k1=1}^{p}\sum_{k2=0}^{p} h2(k1,k2)\, x(n-k1)\; x(n-k2) + + \sum_{k1=0}^{p}\sum_{k2=0}^{p}\sum_{k3=0}^{p} h3(k1,k2,k3) \times x(n-k1)x(n-k2)x(n-k3) \quad (1)$$

Where h0, h1, h2 - - - - hp are volterra kernel of the system. Generally hp is the pth order kernel of the series. Volterra series is a rigorous modeling for nonlinear dynamic characteristic. The volterra series is suitable for simulation of nonlinear microwave device and circuit, where low number of kernels used for device behavior. Inspite of several drawback for measurement of microwave frequencies, For the design of microwave circuitvolterra series is actually used. By considering Volterra series and its kernels for modelling of nonlinear electronic device with memory using the weights and bias values of a feed forward TDNN, after it has been trained with time domain measurement.

4. The Proposed Model

To modelling indiscriminate power amplifier, the inputs to the device are sinusoidal voltage waveforms which the amplifier amplifies at the output according to its available gain. . The time domain samples of input and output waveforms are used the data base for validation, training and testing of the network. The memory depth (N) is chosen to represent the bandwidth of the model. The number of hidden neurons (H) is selected to provide the optimum input and output data fitting without sacrificing accuracy. The back propagation approach is used to train the neural network over a thousand epochs. Data sets for the input - output training have been constructed using cascading samples from each source power level. The neural network has been trained using all the data for each of the interest input power levels, allowing for the creation of a nonlinear model that can characterize both low and high nonlinear distortion.

5. Result and Discussions

The network is trained for eight different power levels in step is 2.5dBm starting from 0dBm to 20dBm.

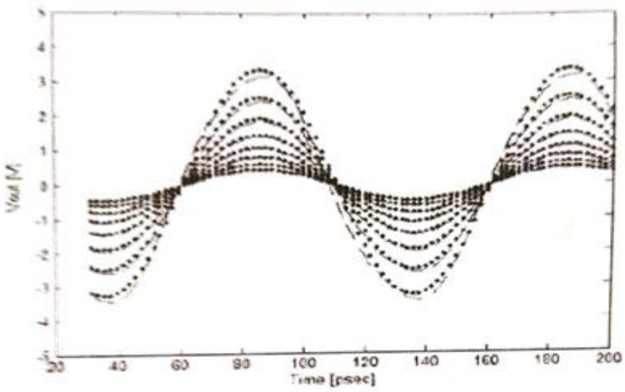

Figure 2: Volterra Series approximation using TDNN

The model input consist of the present voltage signal x (t) along with four previous delayed samples. The network parameters are trained (weights and bias values) have set to built the volterra series model for the amplifier, including upto the 3rd order kernels in the approximations.

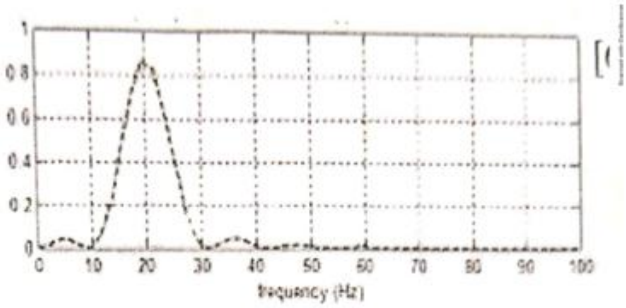

Figure 3: Fourier Transform of the Volterra Data

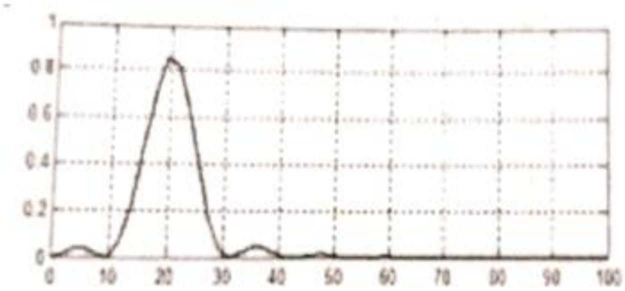

Figure 4: Fourier Transform of the TDNN Data

TDNN having 16 hidden neurons provided good results with mean square error of 1e - 04. Figure 2 shows the result for volterra series approximation built using the TDNN. The dotted lines for the original data and solid lines for the TDNN generated data. The Fourier Transforms of the original and TDNN data are shown in Figure 3 and Figure 4 respectively. Close approximation on Figure 2 comparison of figure 3 and 4 indicates that the model suggested in this work gives the results very close to the original.

6. Conclusion

The nonlinear dynamic behavior of power Amplifier based on feed - forward TDNN have been presented. Validity of the modelling approach for high distortion and memory characterize by measurements. This method employs time domain characterization data.

References

[1] Q. J. Zhang, K. C. Gupta and V. K. Devabhaktuni, Artificial Neural Network for RF and Miicrowave Design - From Theory to practice, IEEE Transactions on Microwave Theory and Techniques 51: 1339 - 1350, 2003.
[2] G. stegmayer, M. Pirola, G. Orengo, andO. Chiotti, Towards a Volterra series representation from a neural network model, WSEAS trans Syst 3 (2004), 432 - 437
[3] J. Wood and D. E. Root (Editors), Fundamentals of nonlinear behavioral modeling for RF and microwave design, Artech House, Boston, 2005
[4] M. R. GMeireles, P. E. M. Almeida and M. G. Simoes, A compressive review for industrial applicability of Artificial Neural Networks, IEEE Transactions on Industrial Electronics5: 585 - 601, 2003.
[5] G. Stegmayer, Volterra series and Neural Networks to model an electronic device nonlinear, proceeding of the IEEE International Joint Conference on Neural Networks, (IJCNN), pages 2907 - 2910, July 26 - 29,