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This is a copy of the author's accepted version of a paper subsequently published in the proceedings of the 14th Mediterranean Conference on Embedded Computing (MECO'2025) & International Conference on Cyber-Physical Systems and Internet-of-Things (CPS&IoT'2025), Budva, Montenegro, 10 - 13 Jun 2025.

The final published version will be available online at:

<https://doi.org/10.1109/MECO66322.2025.11049205>

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DPD Linearisation of Transmitters for 5G Wireless Networks

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Abstract—This paper, presents an effective low power Digital predistortion (DPD) based linearisation technique of power amplifiers (PA) and transmitters for 5G IoT networks. The developed algorithm computes the coefficients which pre-distort the PA input signal stored in the look-up tables (LUT). A 20 MHz OFDM 16-QAM signal at power amplifier input is used. The Adjacent Channel Leakage Ratio (ACLR) improvement of about 10 dB to 50 dB at 3.5 GHz, and the Error Vector Magnitude (EVM) reduction of about 13 dB at output of linearised power amplifier and transmitter are achieved. The nonlinear distortion of the power amplifier (Analog Devices HMC930A-DIE GaAs, pHEMT, MMIC, and 0.25 W) using a 20 MHz 16-QAM OFDM waveforms is evaluated.

Keywords—*Digital Pre-Distortion (DPD); Linearization; Power Amplifiers (PAs); Transmitters; Spectral efficiency; Power Spectra, EVM; and ACPR.*

I. INTRODUCTION

In 5G IoT systems using modulation types which have high crest factors [1-7], designing a PA with high efficiency is an integral part of the process and with high crest factor modulation [7], majority of the linearity is lost [7]. As the design is optimized for high efficiency, linearity is compromised [7]. In areas of low power and high data rate linearization has become a critical area of research. Digital predistortion (DPD) can provide great low power cost-effective linearity achieving optimal Adjacent Channel Leakage Ratio (ACLR) and the Error Vector Magnitude (EVM) performance without compromising efficiency.

With this background on the demands placed on low power transceivers, there has been increased research in low power

DPD linearisation algorithms. Many of the existing algorithms rely heavily on being used in devices whose application is not limited by power consumption. Some of the Existing DPD algorithms include Memoryless [8], Weiner [9], Memory Polynomial [8], Generalized Memory Polynomial [8-11]. In fixed point hardware, implementation of linear computations has far less implications to power and area. The proposed DPD approach is using linear solvers to correct the second and third PA non-linearity.

In this paper, we explored a low power computationally less intense linearisation solution that is relatively simple but effective DPD method for mm-Wave RF amplifiers using LUTs that are generated with polynomial fitting algorithm implemented in MATLAB.

An evaluation and performance analysis of the nonlinear distortion behavior of a RF power amplifier in cellular 5G IoT systems using a 20 MHz OFDM 16-QAM modulated waveform are presented in this paper.

The paper is organised as follows. Section II demonstrates the algorithm and simulation setup. In section III, simulation results for a 20 MHz OFDM 16-QAM waveform, with and without DPD linearisation technique for the power amplifiers are evaluated and presented. The conclusion is described in section IV.

II. ALGORITHM AND SIMULATION SETUP

A. DPD Algorithm

In this section, we'll discuss the DPD algorithm used for this linearization. DPD LUTs are generated by the algorithm. In Fig 1(b) shows a 20 MHz OFDM 16-QAM signal is injected through a predistorter.

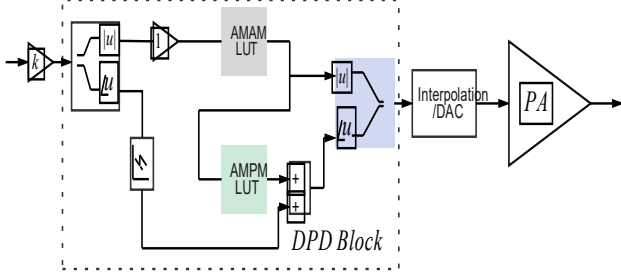
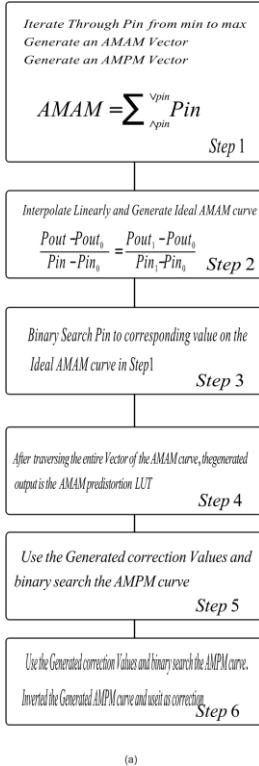
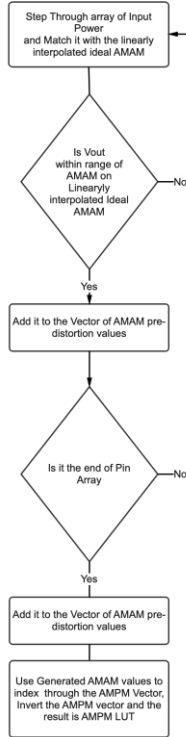


Fig. 1. Block diagram of the DPD-based lineariser

We inject a Tone into the PA model, between min input power (in dBm) and max input power (in dBm). We generate 40 linearly interpolated points normalized to 1 to determine the PA polynomial coefficients. It computes the gain vs input power (dBm) to generate the LUT. Coefficients are determined by a polynomial interpolation using MATLAB.



(a)



(b)

Fig. 2. (a) Steps to execute the algorithm (b) Algorithm Flow chart

B. Simulation Setup

In the experiment as shown in Fig 3, we setup the PA testbench in ADS and swept the input power from min to max using a CW tone, this will generate the PA AMAM and AMPM curves that are then taken into the MATLAB testbench. In Simulink we create two vectors for the AMAM, AMPM these then form the PA model as shown Fig. 4. The testbench is setup using the AMAM/AMPM LUTs that are generated from the algorithm shown in Fig. 2. We then inject a 20 MHz OFDM 16-QAM signal into the PA and plot the spectrum with and without the DPD enabled. Results from this simulation are discussed in Section II.

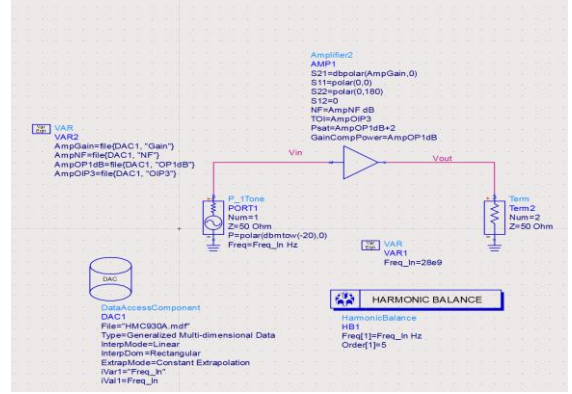


Fig. 3. Keysight ADS setup to generate AMAM/AMPM PA curves using Analog Devices HMC930A-DIE GaAs, pHEMT, MMIC, 0.25 W Power Amplifier.

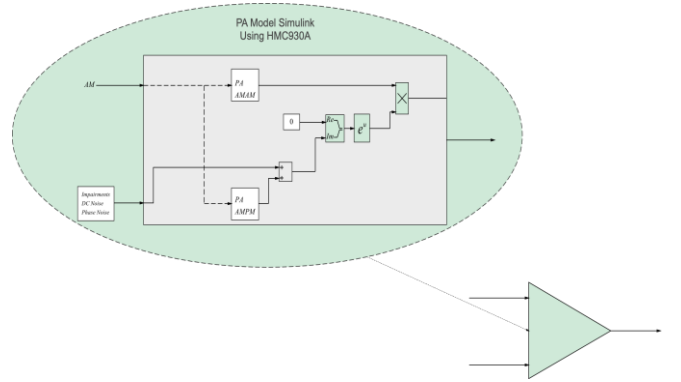


Fig. 4. Matlab/Simulink Setup of PA Model.

III. RESULTS

In this paper, a digital predistortion framework for efficient linearization of RF PA and transmitters is presented. The proposed DPD solution was experimented and validated with OFDM 16-QAM waveforms using an Analog Devices HMC930A GaAs, pHEMT, MMIC, 0.25 W power amplifier operating at 3.5 GHz. As shown in Fig. 6. The transmit EVM was also calculate and constellations plotted at the PA output with and without DPD, this showed an improvement of approximately 13 dB. The PSD was also plotted and shown an improvement of ACLR of about 10 dB to 50 dB. This has

shown the effectiveness of this linearization technique and is among the first in current literature for low power implementations.

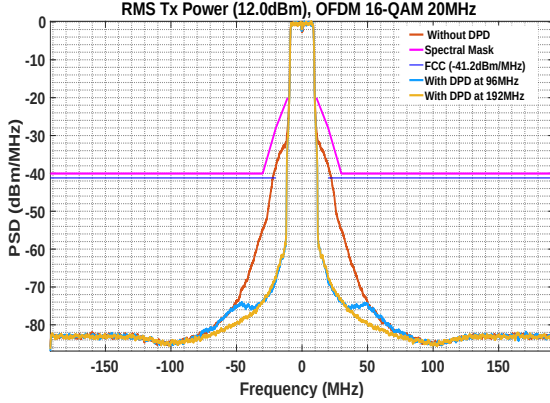


Fig. 5. Simulated output power spectra of the PA with channel bandwidth of 20 MHz.

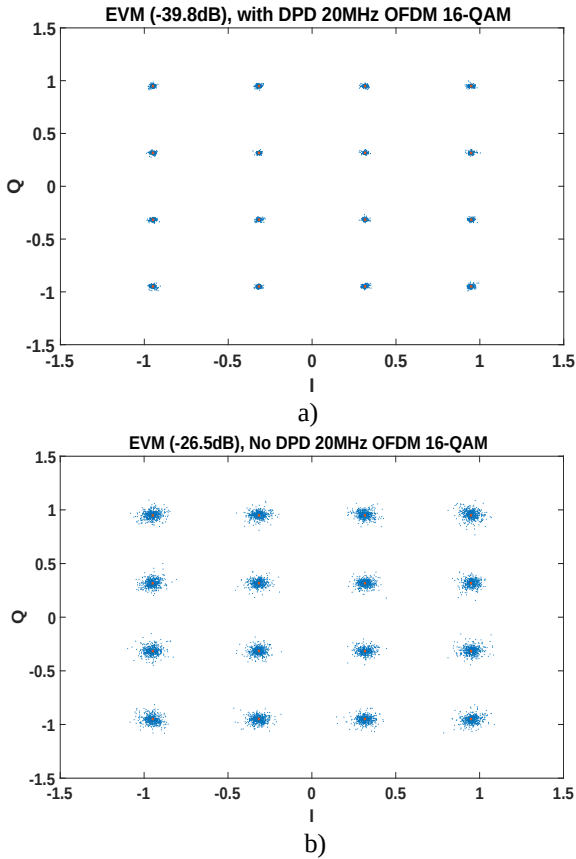


Fig. 6. Constellation results at 3.5 GHz (a) without DPD and (b) with DPD.

IV. CONCLUSION

In this paper, an effective low power Digital predistortion (DPD) based linearisation technique of power amplifiers (PA) and transmitters for 5G IoT networks has been presented. Simulated output power spectra of the PA for a 20 MHz OFDM 16-QAM input signal with and without DPD have been presented. The Adjacent Channel Leakage Ratio (ACLR) improvement of about 10 dB to 50 dB at 3.5 GHz, has been achieved. The Error Vector Magnitude (EVM) reduction of about 13 dB at output of linearised power amplifier have been achieved too. The power amplifier (Analog Devices HMC930A-DIE GaAs, pHEMT, MMIC, and 0.25 W) as device under test has been used.

ACKNOWLEDGMENT

This work was supported by a WIUT-UOW Research collaboration funded project under grant RCF2022-003 and is partly supported by the Engineering and Physical Sciences Research Council (EPSRC), UK under grant EP/X041581

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