Repetitive Control Power Amplifier Linearization

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***Abstract*—In this project, repetitive control (RC), which is based on the internal model principle, is used for periodic signal tracking. Assuming that the distortion in a period will appear in the next period, RC algorithm determines related correcting signal, which will be overlaid to the original control signal. Thus, the system can exactly track periodic signals and eliminate harmonics. In this project, RC will be plugged into the DPD of a PA, in order to improve the linearity and robustness to measurement noise. The measured results have verified the proposed idea.**

***Index Terms*—Digital Predistortion (DPD), Power Amplifiers (PAs), Repetitive Control.**

I. Introduction

Repetitive control (RC), which is based on the internal model principle, has been widely used in many applications such as controllers of diverse power electronics converters [1]. In RC, the present control input is improved using errors acquired from the previous period, and this scheme is performed repetitively [2]. Hence, RC can exactly track periodic references as well as reject periodic disturbances, and thus, it can realize zero tracking error and low harmonic distortion. In the front end of a wireless communication system, the power amplifier (PA) is one of the most important components. It consumes the majority of the system power consumption, which has generally several watts in a 5G chip-level transmitter and hundreds of watts in a traditional large base station. Besides, it also generates most of nonlinearities in the system. Engineers used to try to achieve the trade-off between the output power and the linearity. For example, they used some analog circuit topologies to improve the linearity. However, in modern wireless communication systems such as 5G micro-base stations, engineers need to consider many important metrics in the PA design. In addition to high output power and linearity, the PA should have large peak to average power ratio to increase data rates and can support diverse communication standards to decrease the quantity of base stations, this requires high back-off efficiency and wide operating bandwidth. To remove the linearity from this complex trade-off, digital predistortion (DPD) has been proposed. The basic conception of DPD is to find the inverse function of the transfer function of PA, and then, the combination of the inverse system and the PA has linear responses. Conventional DPD includes direct learn and indirect learning architectures. However, conventional DPD cannot achieve delicate harmonic control and noise suppression. In this project, an indirect learning DPD based on dynamic deviation reduction based Volterra behavioral model [3] with a plug-in RC controller (see Fig. 1) is proposed. Traditionally, G_{inv} is the inverse of the closed-loop system, but it can also be a linear phase lead compensator:

$$G_{inv} = z^m$$

which provides a phase lead of

$$\theta = \mathrm{m}\frac{\omega}{\omega_n}\pi$$

to compensate the phase lag of the feedback control system using a lead step m (ω_n is Nyquist frequency). Thus, the transfer function of the RC becomes

$$\frac{U_{rc}(z)}{E(z)} = K_r \frac{z^{-N}Q(z)}{1 - z^{-N}Q(z)} z^m.$$

Therein Q(z) is generally a low-pass filter or a constant value that closing to 1 (e.g. 0.9). Since it is a plug-in algorithm, it does

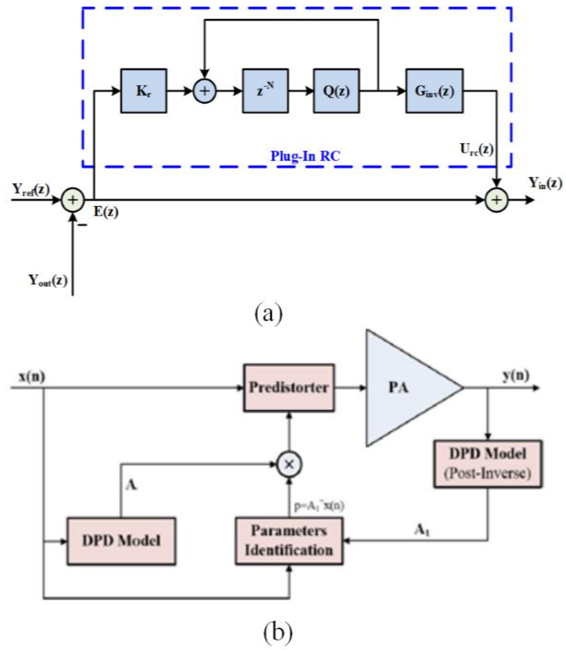

Fig. 1. (a) Plug-in RC controller and (b) an indirect learning DPD based on dynamic deviation reduction based Volterra behavioral model.

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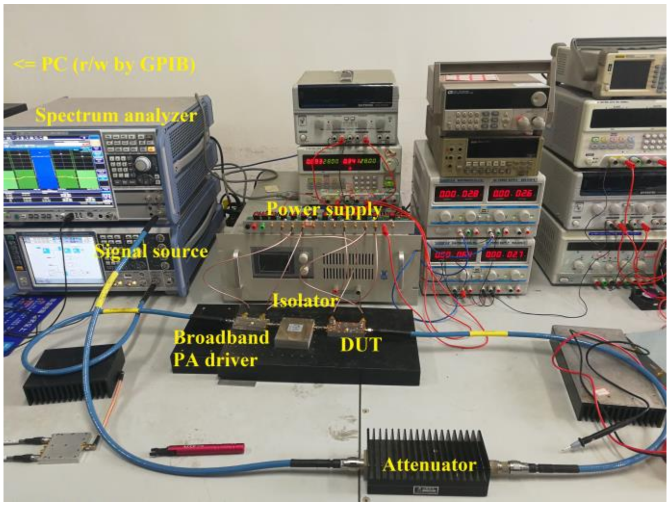

Fig. 2. Measurement platform.

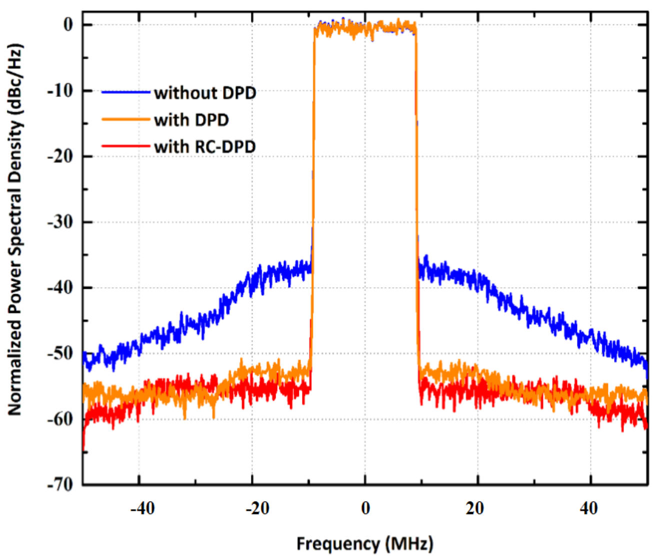

Fig. 3. Measured results.

not change the structure of the indirect learning DPD algorithm.

II. Results

To verify the proposed RC-DPD algorithm, a broadband ring-resonator PA is used [4]. The overall setup is shown in Fig. 2 and the measured results including the comparison between results of RC-DPD and traditional DPD is presented in Fig. 3. It can be seen that the performance has been improved. In laboratory environment, the modulated signal we used is actually periodic since it is only an artificially coded signal segment, and thus, RC-DPD can perform well. However, the input modulated signal is unpredictable and not periodic in practice. Hence, the proposed technique can only be used for improving carrier signal.

III. Conclusion and Discussion

RC is used as a plug-in algorithm in indirect learning DPD based on dynamic deviation reduction based Volterra behavioral model to realize linearity improvement and noise suppression in this project. A practical broadband PA is used to verify the proposed algorithm, and the measured results show that the proposed method performs well as expected.

A. *Future career plans*

I hope I can contribute to the industry and academia with exploring new things. The RF field has many attractive topics such as integrated circuits for 5G/6G wireless communications, radar imaging for intelligent transportation, and cryo-CMOS for quantum technologies. My plan is to pursue the Ph.D. degree in the area of RF/mmWave/THz circuits and systems, and work in academia to generate cutting edge technologies in the future.

B. *Impact of the MTT-S Scholarship*

It is a great honor to be a recipient of the IEEE MTT-S undergraduate scholarship. This award has become a strong driving force in my continuing research. It motivates me to work in the RF field, and to design fancy circuits to resolve challenging problems in academia and industry

C. *Impression on MTT-S Sponsored Conference*

By attending IEEE IMS 2019, I have seen many top-tier researches from universities and companies in the RF field. It reminds me that there are many interesting topics and research opportunities in this amazing field, and inspires me to conduct interdisciplinary studies. I also had the opportunity to interact with global leading professionals attending the conference, which dramatically expands my vision.

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