DESIGN OF A NEW PREDISTORTER USING LOW FREQUENCY SECOND ORDER INTERMODULATIONS OF A HARMONIC GENERATOR

Hyung-Soon Jang, Young Kim, Sung-Uk Kim, Ik-Soo Chang, * Yong-Chae Jeong

Department of Electronic Engineering Sogang University Shinsudong Mapogu Seoul,Korea

Phone: +82-2-703-0581, Fax: +82-2-703-0581, E-mail: janggas@hanmail.net

* Dept. of Information and Communication Engineering

Chonbuk National University in Korea

Abstract **In this paper, a predistorter is proposed using low frequency second order intermodulations-(IMs) of a new harmonic generator. The harmonic generator consists of four diodes biased independently. We take a low frequency intermodulation signal ($\omega_2 - \omega_1$) from a proposed harmonic generator. They are operated on different nonlinear operation points respectively. A vector modulator, in which fundamental signal is modulated with second intermodulation signal($\omega_2 - \omega_1$) derived from the proposed low frequency harmonic generator, generates predistorted IM components, and as a results, this predistorter suppresses intermodulation distortion signals of power amplifier effectively. The suggested predistorter has been manufactured to operate in Korean PCS base-station transmitting band (1840-1870MHz). The test results show that the 3rd IM is cancelled more than 20dB and the 5th IM is cancelled about 10dB for CW(two-tone) signals. The predistorter improves the adjacent channel power ratio(ACPR) more than 10dB in CDMA(IS-95) signals.**

Key words: **low frequency second order IMs, power – amplifier, predistorter**

1. Introduction

At present, it may be inconvenient to live without mobile communication systems. In the past, the voice quality of communications was the only essential issue. However, it becomes that most people regard the transmission of a lot of data as an important thing in communication. Because of this circumstance, more complex modulation and demodulation methods, and broadband channel width are required for mobile communication systems. The input signals of a power amplifier may be a single broad band FA or mixed multi FA. When the main signals are amplified in the power amplifier, unwanted harmonics and intermodulation distortion components are generated spontaneously. In result, generated IM components increase the data error rate and interfere a transmission of adjacent channel signals and decrease the efficiency of power amplifier.

These unwanted components can be cancelled by linearizer[1]–[4]. In this paper, a predistortion method is used for linearization of an RF power amplifier. It simply involves the creation of a distortion characteristic which is precisely complementary to the distortion characteristic of the RF amplifier and cascading the two in order to ensure that the resulting system has little or no input-output distortion. The proposed predistorter controls IM3 and IM5 individually so that we overcome disadvantages of a conventional predistorter, such as narrow bandwidth and low improvements of IMs, and guarantee a wide dynamic range[1]-[4].

2. Operation of the circuits

The proposed harmonic generator has a simple structure form. The harmonic generator consist of four diodes with similar characteristics, which is operated on different nonlinear operation points by biasing respectively, generates an envelope of a main signal without low frequency devices.

Input and output signals of harmonic generator are expressed as follows.

$$E_i = A(\cos w_1 t + \cos w_2 t) = AS_i \quad (1)$$

$$E_o = K_1 AS_i + K_2 A^2 S_i^2 + K_3 A^3 S_i^3 + K_4 A^4 S_i^4 + \ldots \quad (2)$$

Where $S_i = \cos w_1 t + \cos w_2 t$

Unlike other predistorters which can be seen in many literatures, a desired signal obtained from the harmonic generator is just a second order intermodulation signal.

$$H_2 = K_2 A^2 S_i^2 = K_2 A^2 + \frac{1}{2} K_2 A[\cos 2w_1 t + \cos 2w_2 t + \cos(w_1 - w_2)t + \cos(w_2 + w_1)t] \quad (3)$$

The desired signal(w_1 - w_2) is an element of second order harmonics(H_2) as shown equation (1), (2) and (3). The level of signal(w_1 - w_2) generated from the harmonic generator is big enough to be modulated with fundamental signal in the vector modulator and the variable gain amplifiers(VGAs) control the gain of the modulated signals to cancel the IMs.

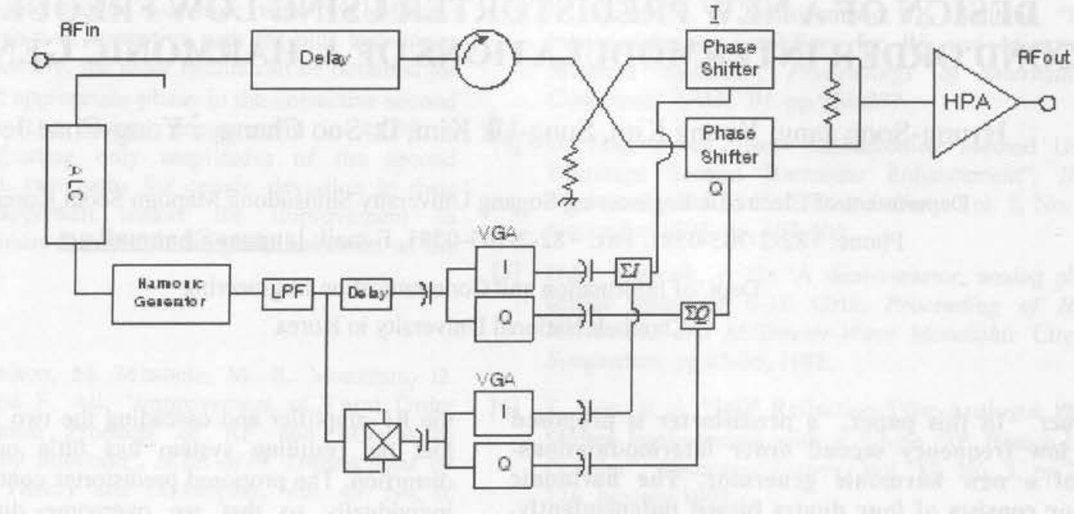

Fig. 1 A schematic of the proposed Linearization Power Amplifier

Fig.1 shows a structure of the proposed predistorter. The IM generator uses the structure of vector modulator composed of I and Q components. This predistorter controls the amplitude and phase of intermodulaton distortion components at the same time. It provides faster adjustment of phase and amplitude than that provided with conventional controllers consisting of variable phase shifter and variable attenuator. The automatic level control(ALC) circuit at the input port stabilizes the device making constant harmonic and IM signals. The signal($2w_1$ - $2w_2$) also can be generated by multiplying the envelope obtained from the harmonic generator. This signal is summed with the generated signal (w_2- w_1) and its gain is controlled to cancel the IM5.

Fig.2 shows a detailed circuit of harmonic generator proposed in this paper. The harmonic generator has four bias voltage controllers and four diodes are biased separately to generate only desired second order IM term. The signal(w_1 - w_2), generated from the harmonic generator on the proper bias conditions, and multiplied 2(w_1- w_2) signal are modulated with a main signal in the IM generator and then the vector modulator controls the predistorted IM signals individually.

A simulation of Fig. 2 has been performed with ADS2001. Fig. 3(a) shows the simulation result and CDMA 1FA envelope generated from the proposed harmonic generator is shown in Fig. 3(b).

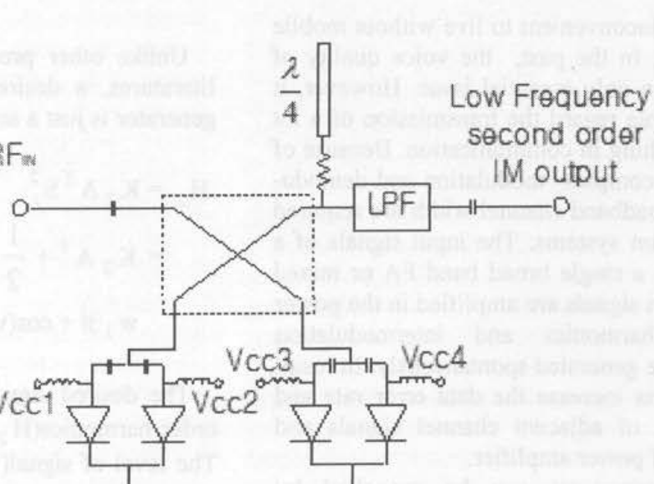

Fig. 2 A detailed circuit of the harmonic generator

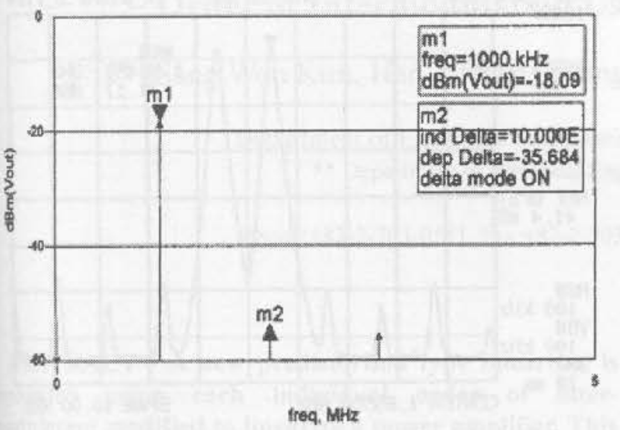

Fig. 3(a) A simulation result after voltage controlling

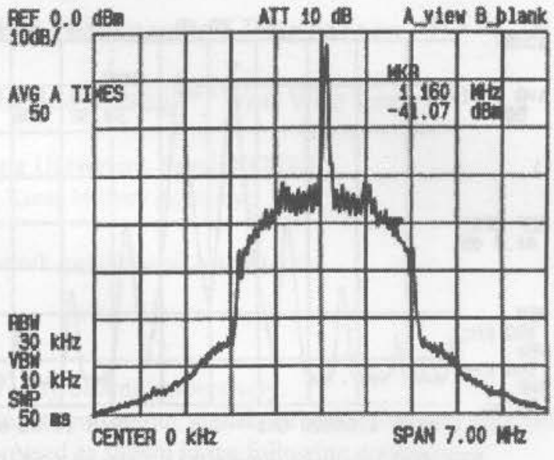

Fig. 3(b) CDMA 1FA envelope

3. The results of experiment

To verify the performance of the proposed predistorter, the power amplifier(STA1800-37, 5Watts) ,developed for a base station or a repeater of Personal Communication Service(PCS) in Korea, is used. The Schottky diodes are used for harmonic generator and also,the RF matching circuit is inserted in the output port of the harmonic generator to generate low frequency intermodulation signals. In the CW(two tone)test, the IM3 component is cancelled more than 20dB and IM5 component about 10dB. Additionally the cancellation of the IM components are improved in the broad bandwidth and the wide dynamic range of the power amplifier. In the CDMA test, the spectral regrowth is improved more than 10dB at the 1FA and multi FA signals.

4 Conclusions

In this paper, a simple and efficient harmonic generator is suggested. The proposed harmonic generator easily controls the amplitude and phase of the IM components simultaneously because the vector modulator consists of I and Q components, and its performance reduce the effort of retunning the attenuators and the phase shifters.

In the result, the IM components are canceled individually and the performance is maintained for a wide dynamic range and the spectral regrowth of the wide CDMA multi FA signals is improved about 10dB. *Also, an adaptive linearizer may be applied to* class-A or class-AB power amplifier using this predistortion method.

References

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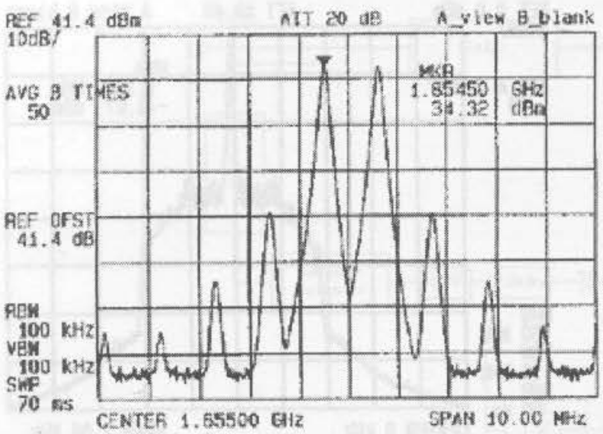

Fig. 4(a) two tone output(PA) @Po=37.32dBm

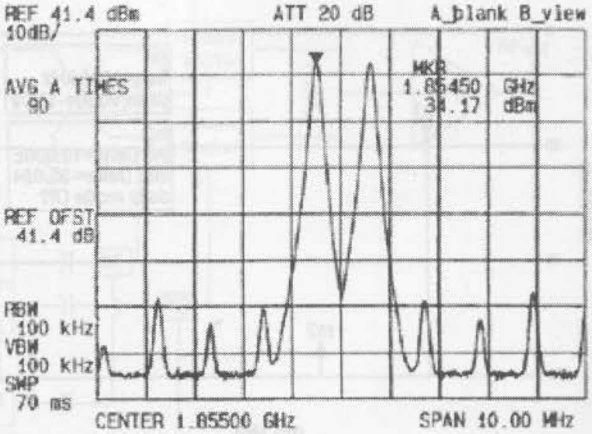

Fig. 4(b) two tone output(LPA) @Po=37.17dBm

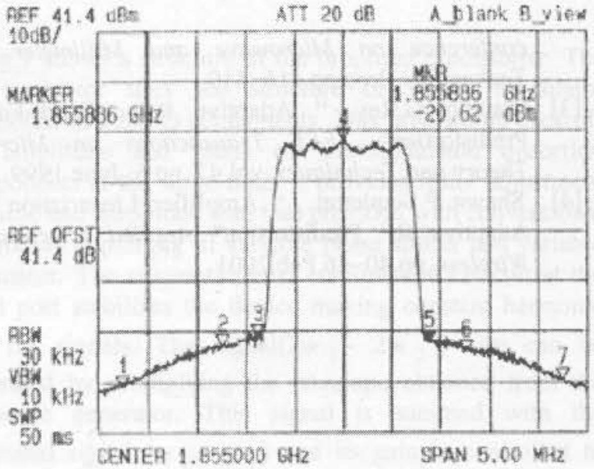

Fig. 5(a) CDMA 1FA output(PA) @Po=35.13dBm

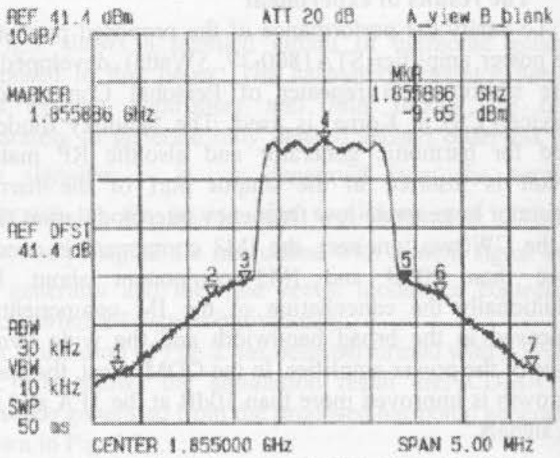

Fig. 5(b) CDMA 1FA output(LPA) @Po=35.13dBm

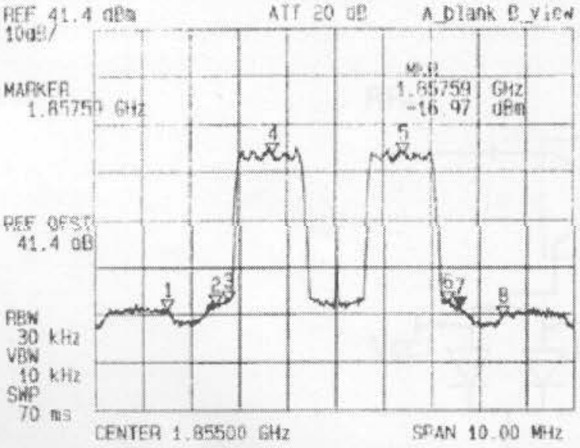

Fig. 6(a) CDMA 2FA output(PA) @Po=34.33dBm

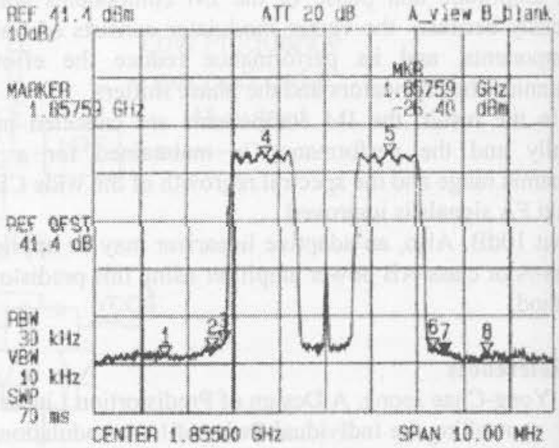

Fig. 6(b) CDMA 2FA output(LPA) @Po=33.83dBm