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THE DESIGN OF PREDISTORTION LINEARIZER USING ZERO-IF MIXING OPERATION

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Abstract-We proposed a new predistortion linearizing method using zero-IF mixing operation of a mixer for K-PCS(Korean PCS) band basestation amplifier. When the input signals are applied to the LO port of a mixer without IF signal, we can extract predistortion signals from the nonlinear characteristic of the mixer. When the 2-tone signal of 1852.5MHz and 1857.5MHz are applied, $(C/I)_{3rd}$ improvements are about 30.46dB at the power level of 26dBm/tone. When the CDMA IS-95A signal is applied at the output power of 26.3dBm, ACPR is improved 10.11dB. With the CDMA IS-95 3FA signals, ACPR is improved 8dB.

1. Introduction

When multi-carrier input, such as a digital cellular and satellite communication using CDMA or TDMA method, is applied to power amplifier, it's generalized to use the linear power amplifier that improved intermodulation distortion occurred at common amplifying. A high power amplifier (HPA) is used at the final part of transmitter. Usually, HPA operates near the saturation power region to obtain the maximum level and high efficiency. Especially, CDMA or other multi-channel signals are amplified simultaneously in amplifier, intermodulation distortion as well as amplitude and phase distortion is occurred. To reduce these intermodulation distortion components, linearization is needed for linear amplification and high efficiency[1],[6]. There are various linearizing methods such as feedforward, predistortion, feedback and so forth. In this paper, we proposed a new predistortion method using zero-IF mixing operation of a mixer. Figure 1 shows an operation of a predistortion linearizer that transfer function is reverse of that of HPA. Figure 2 shows an entire block diagram of the proposed predistortion linearizer. Input 2-tone signals (ω_1, ω_2) applied to the proposed linearizer are split into two different paths: main path and predistortion signal generation (PSG) path. Signals applied to PSG path produces intermodulation signals with the nonlinear characteristic of a mixer itself. At the output port of the power combiner, these intermodulation signals constitute predistortion signals with the main path signals[2].

2. Theory of operation

Figure 3 shows a predistortion component generation process. The proposed linearizer uses a nonlinear characteristic of a mixer itself in accordance with the LO signal of the mixer. Nonlinear conductive characteristic of a mixer is based on a microwave diode. Therefore, we can present the diode current polynomial according to the I-V characteristic with the Taylor series like this[3]-[5];

$$I(V) = I_0 + i = I_0 + vG_d + \frac{v^2}{2}G'_d + \frac{v^3}{6}G''_d + \cdots \tag{1}$$

Where G_d=1/R_j is dynamic conductance and R_j is junction resistance of diode. We can eliminate the DC component of the equation (1), because it varies with the input level of the LO port of the mixer. If we only consider the operating signals, equation (1) can be approximated as;

$$i \approx vG_d + \frac{v^3}{6} G_d'' \tag{2}$$

When frequencies of the 2-tone sinusoidal input signal at the LO port of a mixer are ω_1, ω_2 and have the same amplitude, $v=v_o(\cos\omega_1 t+\cos\omega_2 t)$, equation (2) can be represented as equation (3).

$$\begin{aligned} i &= vG_d + \frac{v^3}{6}G_d'' = G_d v_0(\cos\omega_1 t + \cos\omega_2 t) + \frac{G_d''}{6} v_0^3(\cos\omega_1 t + \cos\omega_2 t)^3 \\ &= (G_d v_0 + \frac{G_d''}{4}v_0^3 + \frac{G_d''}{8}v_0^3)\cos\omega_1 t + (G_d v_0 + \frac{G_d''}{4}v_0^3 + \frac{G_d''}{8}v_0^3)\cos\omega_2 t \\ &\quad + \frac{G_d''}{24}v_0^3\cos 3\omega_1 t + \frac{G_d''}{24}v_0^3\cos 3\omega_2 t \\ &\quad + \frac{G_d''}{8}v_0^3\cos(2\omega_1 - \omega_2)t + \frac{G_d''}{8}v_0^3\cos(2\omega_1 + \omega_2)t \\ &\quad + \frac{G_d''}{8}v_0^3\cos(2\omega_2 - \omega_1)t + \frac{G_d''}{8}v_0^3\cos(2\omega_2 + \omega_1)t \end{aligned} \tag{3}$$

From equation (3), we can see the 3rd order intermodulation signals ($2\omega_1$-ω_2, $2\omega_2$-ω_1) in addition to the 3rd harmonic frequency components ($3\omega_1$, $2\omega_1$+ω_2, ω_1+$2\omega_2$, $3\omega_2$) at the output port of the mixer.

The conductance value of diode is changed according to LO power level. For signal having amplitude modulation characteristic, automatic level controller (ALC) that makes the constant output level even though input signal has a dynamic range needs to be located in front of microwave diode (Figure 2). The LO signal level is changed to optimum value according to nonlinear characteristics of HPA.

3. Measured results

We used MHL19338 of Motorola as HPA to measure the improvements of the proposed linearizer. Gain and P_{1dB} of the fabricated amplifier are 30dB and 35dBm, respectively. Figure 4 shows a comparison of the output spectrum of an HPA with and without the proposed predistortion linearizer. The centre frequency is 1855MHz in K-PCS band, and 2-tone spacing is 5MHz. $(C/I)_{3rd}$ at the output power of 26dBm/tone with and without the predistortion linearizer are 63.78dBc and 34.355dBc, respectively. Therefore, we got about 30.46dB improvement. Figure 5 shows an output spectrum of amplifier with and without the predistortion linearizer at the output power of 26.3dBm when CDMA IS-95 1FA signal is applied. ACPR improvements at the frequency offset of 885KHz, 1.25MHz and 2.25MHz are 10.11dB, 6.39dB, -6.31dB, respectively. Figure 6 shows an output spectrum of amplifier in case of CDMA IS-95 3FA signal at the same output power level. At the frequency offset of 2.5MHz and 3.5MHz, ACPR improvements are 8dB and 5.73dB, respectively. Figure 7 represents an output spectrum of amplifier at the output power of 26.5dBm when the separated CDMA IS-95 3FA signal is applied. At the frequency offset 4.75MHz and 1.25MHz, ACPR improvements are 8.24dBc, 5.1dBc, respectively. Finally, figure 8 shows ACPR improvements at the frequency offset of 885KHz and 1.25MHz for the output power range of 20~29dBm.

Conclusion

A new predistortion technique using zero-IF mixing operation of a mixer for K-PCS (Korean PCS) band base station amplifier is proposed. A proposed linearizer using nonlinear characteristics of diode is implemented and it has a very compact circuit configuration because of zero-IF mixing operation. We implemented reflection type attenuator and phase-shifter to obtain excellent reflection coefficient and to adjust magnitude and phase of each path.

To validate the proposed predistortion linearizer, a two-tone linearization test and CDMA IS-95A linearization test are performed at the K-PCS band of 1.855GHz. The results show that significant cancellations are achieved for the IM_3 component. The CDMA IS-95A signal test show that ACPR characteristic is improved by more than 10.11dB at an average channel output power of 26.3dBm. With the CDMA IS-95 3FA signals, ACPR is improved 8dB.

The preditortion linearizer we proposed is suitable for the base station. Moreover, the proposed method is simple but shows excellent linearization results.

Reference

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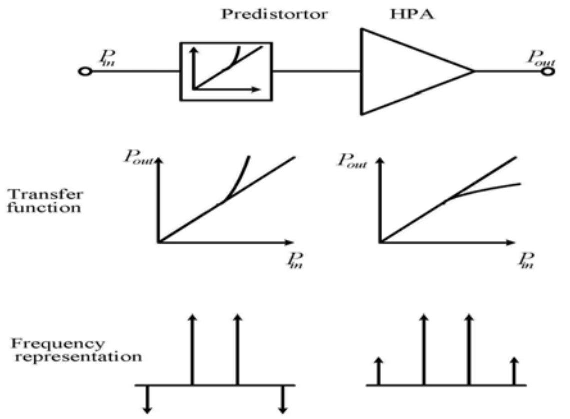


Fig. 1 Operates block diagram of predistortion linearizer.

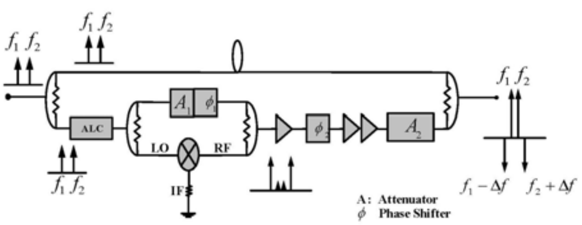


Fig. 2 Block Diagram of Predistortion Linearizer

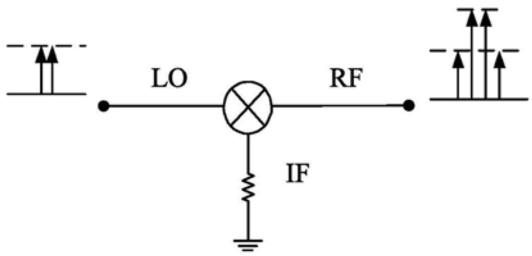
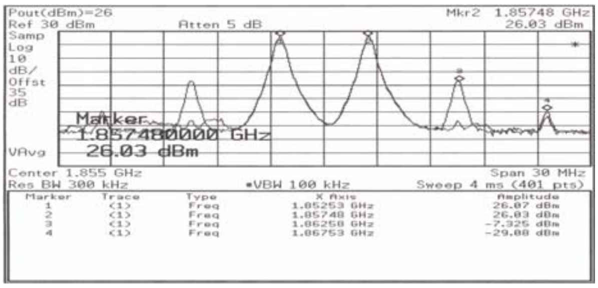
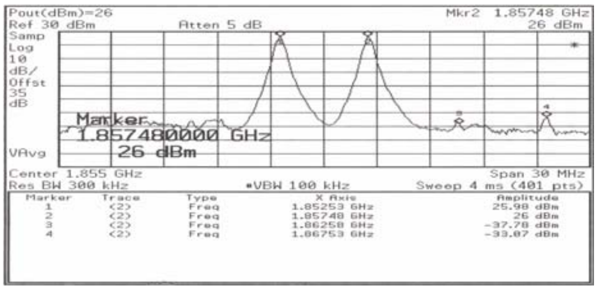


Fig. 3 Generation Process of Nonlinear frequency using zero-IF mixing operation

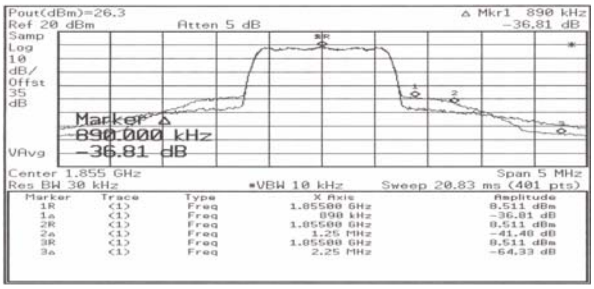


(a) Without

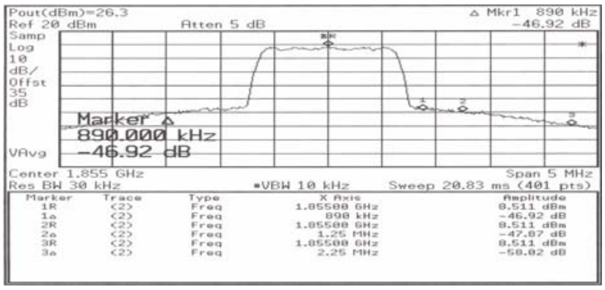


(b) With

Fig. 4 The output spectrum comparison with and without the proposed linearizer in case of 2-tone input signals (@Po=26dBm/tone)

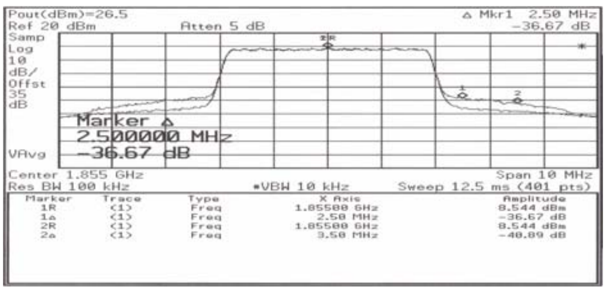


(a) Without

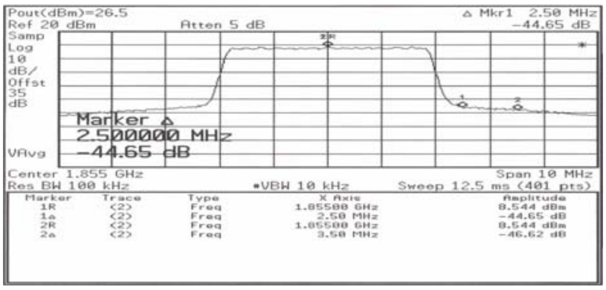


(b) With

Fig. 5 The output spectrum comparison with and without the proposed linearizer in case of CDMA 1FA signal (@Po=26.3dBm)

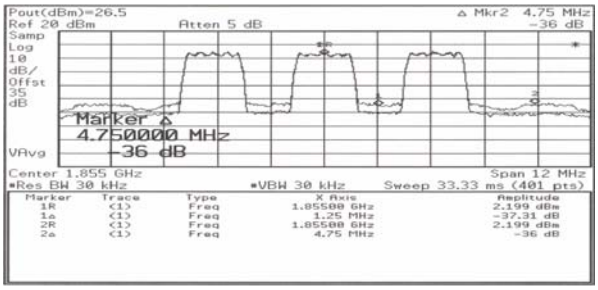


(a) Without

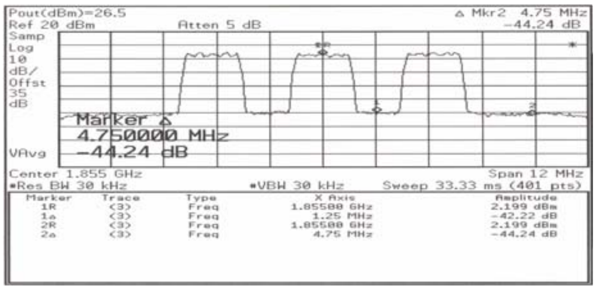


(b) With

Fig. 6 The output spectrum comparison with and without the proposed linearizer in case of CDMA 3FA signals (@Po=26.3dBm)



(a) Without



(b) With

Fig. 7 The output spectrum comparison with and without the proposed linearizer in case of the separate CDMA 3FA signals (@Po=26.3dBm)

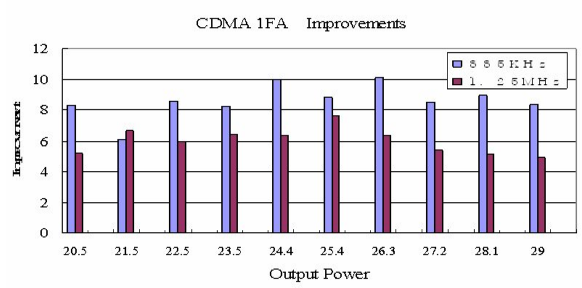


Fig. 8 ACPR improvements at the frequency offset of 885KHz and 1.25MHz (@Po=20~29dBm.