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Scope of the Conference

3. High-power Devices and Techniques

Abstract

In this paper, a new predistorter controlling modified individual order intermodulation distortion signals is proposed. The proposed predistorter generates and controls the predistorted third and high order IM signals independently. Using predistorted signals, intermodulation distortion signals of power amplifier are suppressed effectively. The predistortion linearizer has been manufactured to operate in Korean PCS base-station transmitting band (1840~1870MHz). The test results show that IMD_3 and IMD_5 of power amplifier are improved more than 40dB and 23dB for CW two-tone signals, respectively. The predistorter improves the adjacent channel power ratio (ACPR) more than 10dB for CDMA (IS-95) 2FA signals.

A Design of Predistortion Linearizer Controlling Modified Individual Order IM Signals

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In this paper, a new predistorter controlling modified individual order intermodulation distortion signals is proposed. The proposed predistorter generates and controls the predistorted third and high order IM signals independently. Using predistorted signals, intermodulation distortion signals of power amplifier are suppressed effectively. The predistortion linearizer has been manufactured to operate in Korean PCS base-station transmitting band (1840~1870MHz). The test results show that IMD_3 and IMD_5 of power amplifier are improved more than 40dB and 23dB for CW two-tone signals, respectively. The predistorter improves the adjacent channel power ratio (ACPR) more than 10dB for CDMA (IS-95) 2FA signals.

1. Introduction

In the past, the voice transmission is main issue in communications. However, the more data, the better quality, anywhere communication requirement evolves from voice communication to complex data and mobile communication. Because of this circumstance, more complex modulation/demodulation schemes, and broadband channel bandwidth are required for modern mobile communication systems. In general, a complex modulation/demodulation schemes require linear transmitter/receiver. But in power amplifier design, high efficiency is another issue besides of high linearity.

When signals are amplified in the power amplifier, unwanted harmonics and intermodulation(IM) distortion signals in addition to amplified signals are generated simultaneously by nonlinear characteristics of power amplifier. These IM signals increase bit error rate of data and adjacent channel interferences, and decrease the efficiency of power amplifier. Predistortion is a linearization technique that lays a circuit having inverse distortion characteristic in front of the power amplifier. Because of inverse distortion characteristic, predistortion linearizer can reduce IM signals of power amplifier [1]. Also, when the third and the high order IM products can be generated and controlled independently in predistorter, IM products of power amplifier can be reduced more effectively[2]. But this method has a problem of signal interference in small size circuit board and difficulty of implementation. In this paper, for reducing of power amplifier nonlinearity, we are proposed new predistorter controlling modified individual order IM signals. It is that generated the third IM by using main signal and the high order IM product by using main and third IM signals. This method has a merit that is easy implementation and little interference problem than the conventional method.

2. Theory

We assume that the nonlinearity of the amplifier can be expressed in terms of a power series as like equation (1).

$$v_o = k_1 v_i + k_2 v_i^2 + k_3 v_i^3 + k_4 v_i^4 + \cdots\cdots \qquad (1)$$

where v_i is input and v_o is output signal voltage.

If input signals consist of two, equal-amplitude, signals as

$$v_i = A[\cos(\omega_1 t)+\cos(\omega_2 t)] \qquad (2)$$

then we can take DC, intermodulation distortion components($\omega_1 \pm \omega_2$, $2\omega_1 - \omega_2$, $2\omega_2 - \omega_1$, $\cdots$) and harmonic components($2\omega_1$, $2\omega_2$, $3\omega_1$, $3\omega_2$) besides amplified input signals at the output port. So, we are designed predistortion signal generators for compensating nonlinearity characteristics of power amplifier, where Fig. 1 shows a block diagram of the third order intermodulation signal generator (IMG_3). The bias voltage of MSA-0386 BJT is controlled for generating the third IM signal as large as possible.

Fig. 2 shows a block diagram of the high order intermodulation signals generator (IMG_h) that generates the high order intermodulation signals by using IMG_3 output signals that consist of main and third order intermodulation signal as input signals. Also, IMG_h consists of a 3dB hybrid coupler, anti-paralleled Schottky diodes for high order intermodulation signal generation and a resistor and a capacitor for controlling input signal amplitude and phase[3].

We designed the predistortion power amplifier controlling modified individual order IM signals as like Fig. 3. It consists of an automatic level controller (ALC) circuit, IMG_3, 3rd IM control block, IMG_h, high order IM control block and high power amplifier (HPA). Input signals are divided into the power amplifier path and ALC path by coupler. Since power amplifier operates for wide dynamic power range, ALC generates constant signal level for effective predistortion signal generation. If input signal level varied, the optimum IM generating matching condition of IMG_3 and IMG_h are also varied. So, even though input signal level is change, ALC circuit maintains constant power level for the effective the third and the high order IM generation. The IM control block consist of a variable attenuator and a variable phase shifter, which is used to control magnitude and phase of the third and the high order IM. To match those of intermodulation distortion signals of power amplifier for dynamic output power range, adaptive control of magnitude and phase of the third and the high order IM is necessary[4]-[6].

3. Experimental Result

In order to show validity of the proposed predistorter, the power amplifier (STA1800-37 of Sewon Teletch Inc.,) for base station or a repeater of Korean Personal Communication Service (KPCS) is used. The gain and 1dB compression point are 50dB and 37dBm, respectively. The delay circuit is compensated by a coaxial delay line, which is about 12ns in this experiment. Fig. 4 shows IMG_3 characteristics in case of CW 2-tone input signals, where input signal frequencies are 1854MHz and 1855MHz with frequency spacing 1MHz. Also, Fig. 5 shows IMG_3 characteristics in case of CDMA 1FA input signal at 1855MHz.

Fig. 6 compares carrier to intermodulation distortion (C/I) ratio of HPA with and without the proposed predistortion circuit in case of CW 2-tone, where the output power is 37.7dBm/tone. The improvements of IMD_3 and IMD_5 are 42.87dB and 23.95dB, respectively.

Fig. 7 compares adjacent power ratio(ACPR) of HPA with and without the proposed predistortion circuit, where the output power is 33.0dBm/FA and test frequencies are 1853.77MHz, 1856.23MHz, respectively. The improvements of ACPR are 10.60dB, 9.2dB, and 9.40dB at f_o±885KHz, f_o±1.25MHz, f_o±2.25MHz, respectively. The test signal generator is ESG4433B of Agilent Technologies. This equipment was observed at center frequency something like the carrier leakage.

4. Conclusion

In this paper, a new predistorter controlling modified individual order intermodulation distortion signals is proposed. The proposed predistorter generator generates and controls predistorted the third and the high order IM component signals independently. Using above predistorted signals, intermodulation distortion signals of power amplifier suppressed effectively. The suggested predistorter linearizer has been implemented to operate in 1840~1870MHz. The test results show that IMD_3 and IMD_5 of power amplifier are reduced more than 40dB and 20dB for CW two-tone signals, respectively. The predistorter improves the adjacent channel power ratio (ACPR) more than 10dB for CDMA (IS-95) 2FA signals.

5. Reference

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[5] Tri T. Ha, *Solid-State Microwave Amplifier Design*, John Wiley, 1981.

[6] Steve C. Cripps, *RF Power Amplifiers for Wireless Communications*, Artech House, 1999.

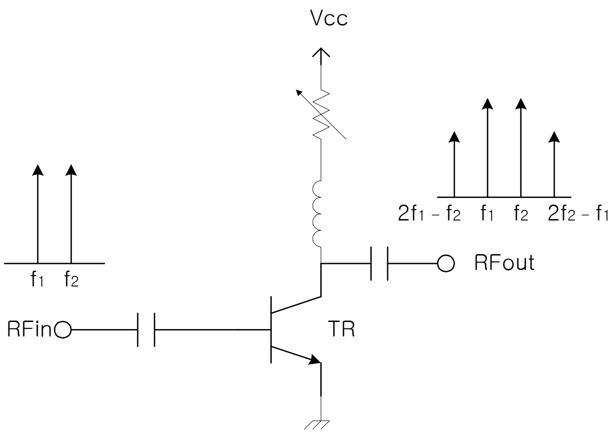


Fig. 1. The block diagram of the third intermodulation signal generator

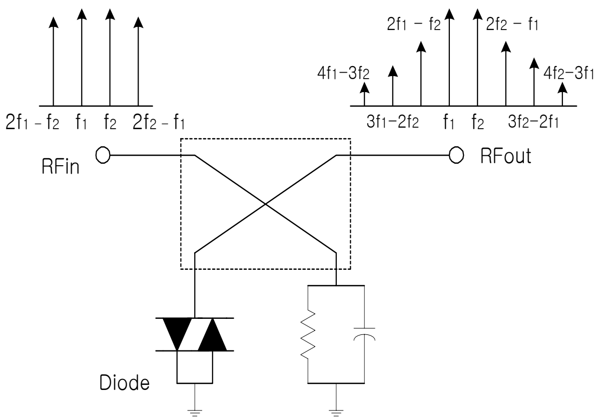


Fig. 2. The block diagram of the high order intermodulation signal generator.

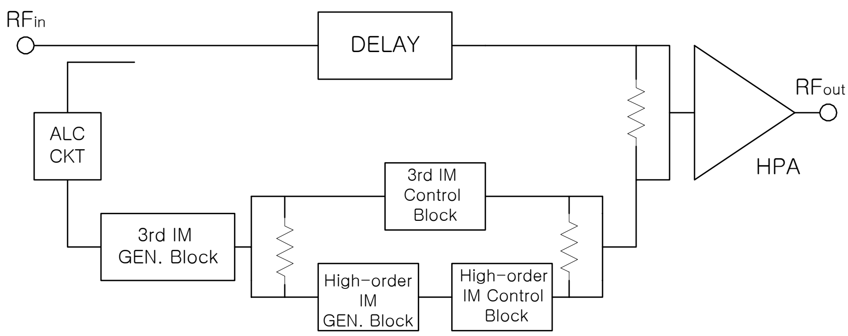


Fig. 3. The block diagram of modified individual order IM controlling predistortion power amplifier.

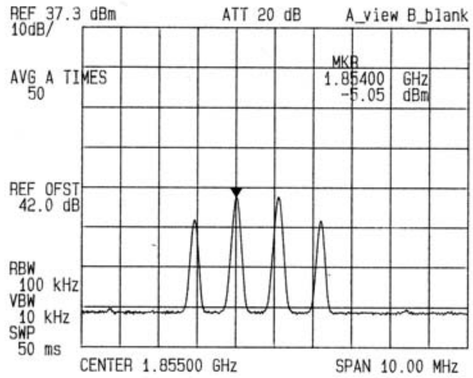


Fig. 4. IMG_3 characteristics for CW 2-tone input signals.

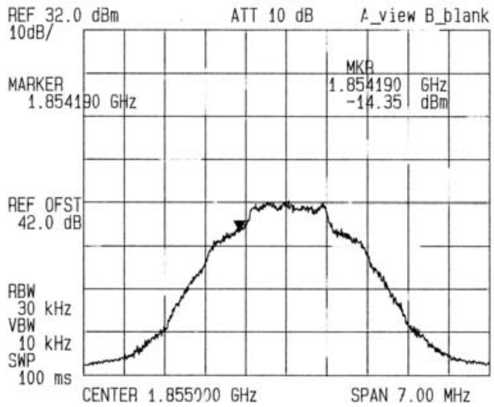
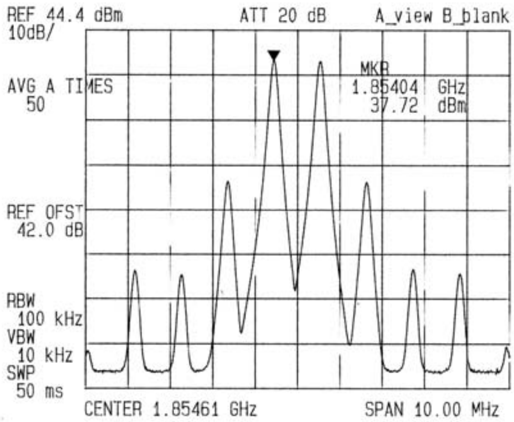
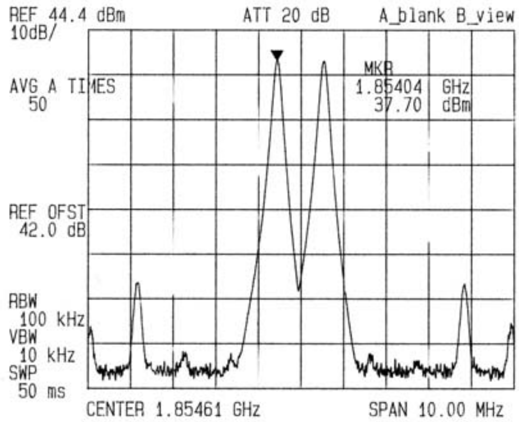


Fig. 5. IMG_3 for CDMA 1FA input signal.

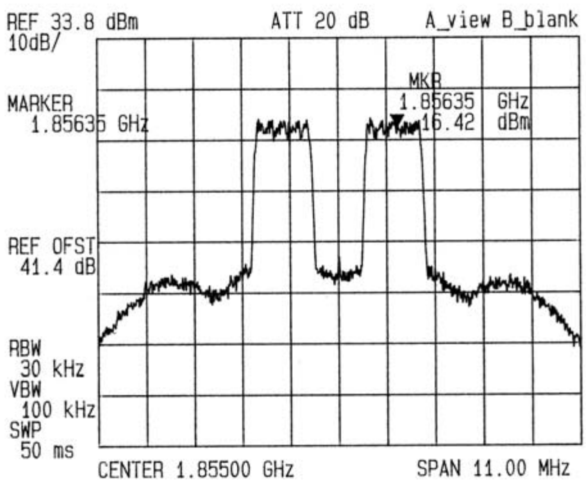


(a)

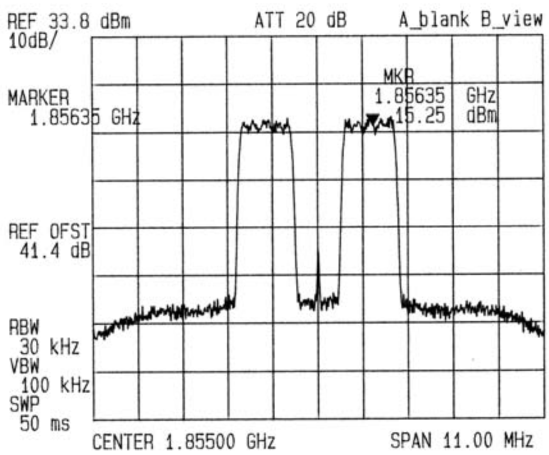


(b)

Fig. 6. (C/I) characteristics of HPA (a) with and (b) without the proposed predistorter (@P_o=37.7dBm/tone) .



(a)



(b)

Fig. 7. ACPR characteristics of HPA (a) with and (b) without the proposed predistorter (@P_o=33.0dBm/FA).