ANALOG PREDISTORTION LINEARIZER FOR HIGH POWER RF AMPLIFIER

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ABSTRACT

Analog predistortion linearizer for the high power amplifier of CDMA base station has been developed.
To suppress the spectral regrowth in the adjacent channels effectively, the odd order intermodulation distortions should be cancelled. For the purpose, the predistorter, which can cancel the 3rd and 5th inter-modulation distortions independently, has been employed. The implemented pre-distorter linearized the RF amplifier with average power 45 dBm at 2.37-2.4GHz band. 9dB suppression of spectral regrowth was achieved for CDMA signal over 30MHz bandwidth.

INTRODUCTION

Among the various techniques for linearizing nonlinear RF amplifiers, predistortion method is the low cost solution for the moderate performance improvement [1]. It has the additional advantages of low power consumption and simple circuit configuration over feed-forward [2]. In comparison with feedback technique, the predistortion offers wider bandwidth because it is inherently open loop structure [3].
In general, the high power RF amplifiers for the base stations operate in class AB mode for the enhanced efficiency. As a result, in addition to the 3rd order intermodulation distortion, a significant amount of higher order distortions are generated. The linearization performance of the predistortion depends on how well the nonlinear characteristic of the predistorter follows that of main amplifier. Therefore, we have developed a predistorter with separate control of 3rd and 5th order components for the efficient suppression of the harmonics. Based on predistortion method, we have demonstrated a high quality linear power amplifier.

NONLINEARITY OF MAIN AMPLIFIER

A. Phase measurement of IM components

The amplifier module of CDMA base station uses large size devices and the large size device has large memory effect. To predict the nonlinear behavior of the amplifier, the usual method of measuring the AM/AM and AM/PM characteristic is not appropriate, since the characterization is adequate only for the memoryless systems [4].
For this reason, the behavioral model that describes the two-tone characteristics of the main amplifier is developed. The magnitude transfer functions of intermodulation distortions are easily measured on spectrum analyzer. The method for measuring phase information was presented in [5]. An improved approach is presented in this paper. The measurement setup is shown in Fig. 1.

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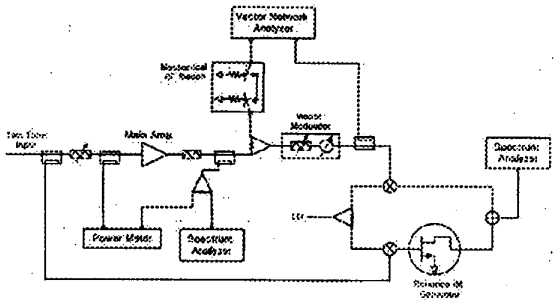


Fig. 1. Measurement setup for two-tone transfer characteristics.

The reference IM generator is operated at a very low frequency, about 750 kHz, and the intermodulation distortions of main amplifier and IM generator are cancelled by adjusting vector modulator. We can measure the relative phase variations of the carrier and inter-modulation distortions as the input power level varied by monitoring the phase change of the vector modulator using vector network analyzer. At a low frequency the reference generator has no AM/PM distortion, and the phases of IM and fundamental components are 0° or 180°. After this offset phases is de-embedded from measured data, the transfer characteristics of intermodulation and fundamental components can be extracted.

B. Results

The average output power of the main amplifier is 45 dBm with 400 W peak power. The final stage is four-way combined 120W LDMOS to handle 450 W of peak power in CDMA signal. The measured fundamental, IM3 and IM5 phases of this main amplifier using the method described previous section are shown in Fig. 2.

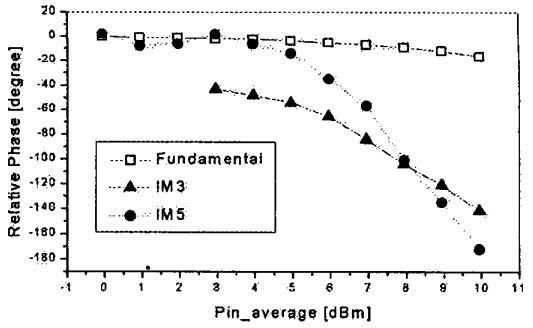
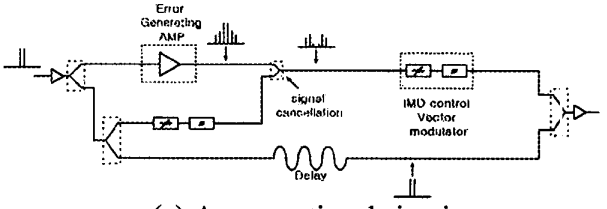
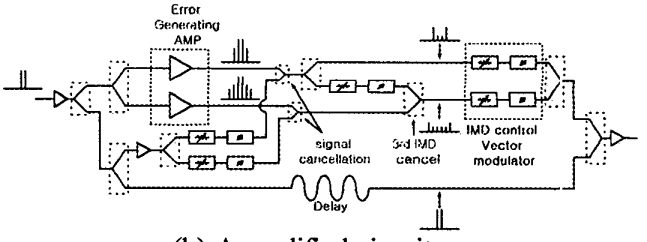


Fig. 2. Input power dependence of the relative phases of fundamental, IM3 and IM5.

PREDISTORTION CIRCUIT CONFIGURATION



(a) A conventional circuit



(b) A modified circuit

Fig. 3. (a) A conventional and (b) modified predistortion circuit configuration

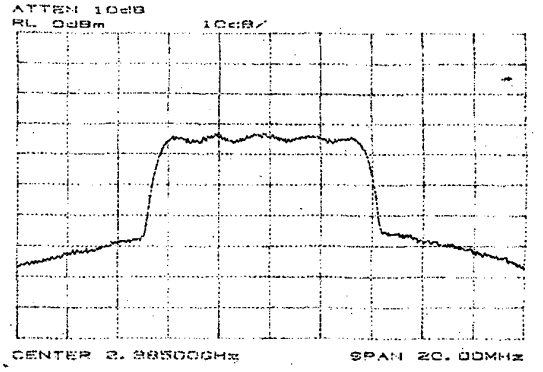
A conventional configuration of predistortion circuit, shown in Fig. 3(a), uses one nonlinear device for generating predistortion signal [6].
The IM components of predistortion circuit should have equal magnitude and out of phase to those of main amplifiers to compensate

nonlinearities. It is very difficult to match the nonlinear characteristics of the predistorter and main amplifier because they are different in the device size and number of stages. Therefore, the amount of cancellation of intermodulation distortion is limited, especially so for the IM5 and higher order distortions. To solve this problem, a modified configuration that can control the magnitude and phase of IM3 and IM5 independently is employed as shown in Fig. 3(b). The error generating amplifier for IM3 is quite linear and only IM3 harmonic is significant. To generate IM5, another error generating amplifier with high nonlinearity is employed. In general IM3 is greater than IM5 level, so IM3 is cancelled out using the IM3 component of IM3 generating amplifier. After that, we can have only IM5 and can control the magnitude and phase of IM5 independently by a vector modulator.

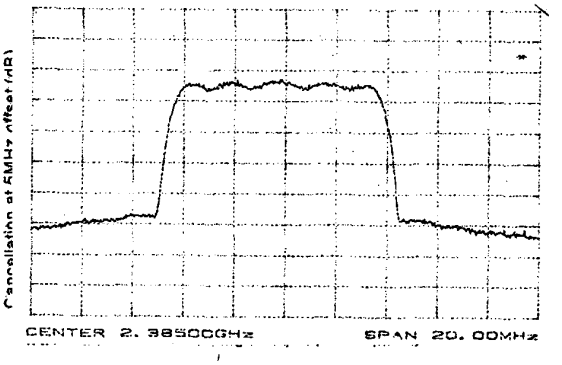
RESULTS

The predistortion circuit of Fig. 3(b) is used to linearize the high power RF amplifier driven into class AB. Fig. 4 illustrates the linearization result. The spectral regrowth of main amplifier at the average output power of 45 dBm is suppressed by about 9 dB at 5 MHz offset from the center frequency. The test CDMA signal is 8 MHz bandwidth with center frequency 2.385 GHz and has about 11 dB peak-to-average ratio.

Fig. 4(c) shows the improvement of spectral regrowth at the center frequencies of 2.375 GHz, 2.385 GHz and 2.395 GHz when the output power is lowered from the average output power of 45 dBm. The spectral regrowth is suppressed for the broad power range. The improvement is smaller for the lower power but the amplifier is more linear at that power. And this amplifier satisfies the linearity characteristics for all power level.



(a) before linearization



(b) after linearization

(c) Suppression with center frequency of CDMA signal varied.

Fig. 4. Spectral regrowth (a) before linearization and (b) after linearization with predistorter and (c) suppression with center frequency of CDMA signal varied.

CONCLUSIONS

The predistortion linearizer which can control 3rd and 5th harmonics separately has been developed and applied to the linearization of the high power RF amplifier with average output power of 45 dBm. The phase variations of the intermodulation terms are accurately measured using new method and the data is employed for the predistortion design. About 9 dB improvement of ACPR was achieved at 5 MHz offset from the center frequency of CDMA signal with 8 MHz bandwidth. This amplifier covers 2.37-2.4 GHz bandwidth.

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