The Novel Programmable RF Predistortion Linearizer

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***Abstract* — A novel programmable RF predistortion linearizer is developed in this paper. The key concept of this novel circuit is the distortion compensation performance can be easily optimized at different input power and different operation frequency by controlling the BJT transistor bias V_b and varactor voltage V_{vac}. There are 9 dBc improvement in IM_3 and 6 dBc improvement in ACPR in the prototype for the novel programmable RF predistortion linearizer for IS-95 application.**

I. INTRODUCTION

Linearization of power amplifier has become an important issue, with the advent of linear modulation methods in the mobile communication. The majority of linearization schemes described to date have either been intrinsically narrow band in nature (Cartesian Loop) or have only been applied over relatively small percentage bandwidths (Feedforward). Another shortage for above linearization techniques is complicate implementation, so that it is difficult for them in handset application. RF predistortion is conceptually the simplest form of linearizer for a RF power amplifier. It simply involves the creation of a distortion characteristic that is precisely complementary to the distortion characteristic of the RF power amplifier and cascading the two in order to ensure that the resulting system has little distortion. The fundamental advantages of RF predistortion are its ability to linearize the entire bandwidth of an amplifier or system simultaneously, high efficiency, simple implementation, small size and low cost. So that it is therefore ideal for use in wideband carrier systems, such as handset / basestation in wireless communications, satellite communications and digital microwave systems. Compared with traditional diode or GaAs FET RF predistortion linearizers[1],[2],[3],[4],[5], [6], the most important benefit for this novel programmable RF predistortion linearizer is easy to optimize the distortion compensation at different input power and different operation frequency and save the controlling parameters (BJT transistor bias V_b and varactor voltage V_{vac}) into the micro-processor. So that we can get the best linearization performance at different working condition (input power and operation frequency) based on setting the proper controlling parameters from the micro-processor.

II. CIRCUIT DESCRIPTION

The novel programmable RF predistortion linearizer utilizes the non-linearity of the BJT transistor to achieve the positive amplitude and negative phase deviation. This phenomenon is expected to compensate the AM-AM and AM-PM distortion of power amplifiers that provide negative amplitude and positive phase deviation when the RF input power increases.

We select the BJT transistor as the device for the novel programmable RF predistortion linearizer because it has low insertion loss, easy tuning and good performance at the operation frequency for wireless communications. As we know, any power amplifier has different distortion performance at different input power and different operation frequency. The traditional RF diode linearizer and GaAs FET RF linearizer are optimized the predistortion performance at the fixed input power and single operation frequency, then balance the design at the marginal operation frequency and input power dynamic range. So that we can't get the optimization performance for the RF predistortion linearizer at whole input power dynamic range and whole operation frequency band.

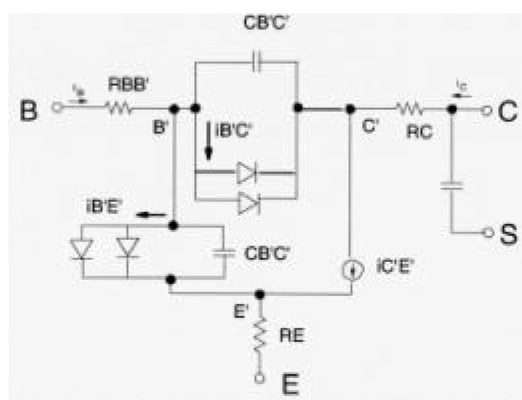

Fig.1: The BJT Gummel-Poon Large Signal Schematic Circuit

The BJT Gummel-Poon large signal schematic is shown in Fig.1. In the case that the BJT's operating point changes from the linear region to saturation region, the equivalent

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impedance of diode iB'E' increases. As a result, the BJT would show increasing gain and negative phase characteristics. Fig.2 is the schematic circuit for the novel programmable RF predistortion linearizer. Based on the MDS simulation results, we find the inductor L_e is very critical for the gain and phase compensation curve slope. If the value of L_e is set not properly, phase deviation will be changed from negative to positive. Because the inductor value is fixed, so that the varactor has the benefit to change the equivalent impedance at the emitter of the BJT transistor to exactly compensate the negative gain and positive phase deviation from RF power amplifiers. The resistor R_e has two functions in this circuit: (1) improving the stability of the BJT RF predistortion linearizer; (2) more easier to tune the gain and phase compensation curve slope with BJT transistor bias V_b together. Another important MDS simulation result shows us that increasing the BJT transistor bias V_b slightly as the input power increase is an effective method of improving the gain compression. A novel circuit of the programmable RF predistortion linearizer is developed for IS-95 application. The key concept of this novel circuit is to optimize the linearization performance by changing the BJT transistor bias V_b and varactor controlling voltage V_{vac} (change the capacitance at the emitter of the BJT transistor) to make sure that the best distortion compensation results at different input power and different operation frequency.

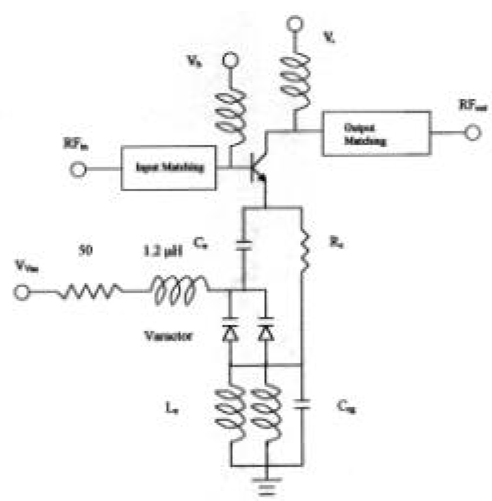
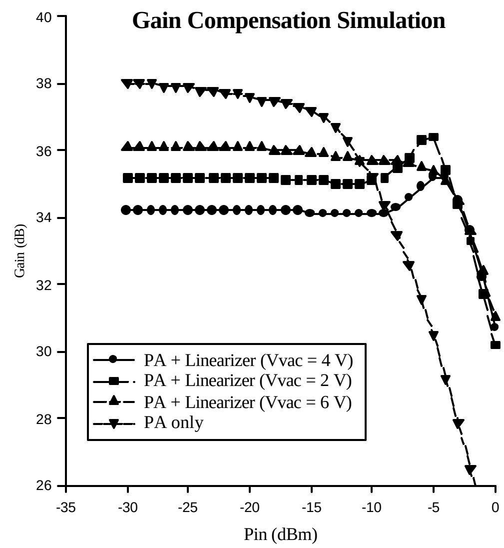


Fig.2: The Novel Programmable RF Predistortion Linearizer Schematic Circuit

Fig.3 is the MDS simulation results for gain compensation and Fig.4 is the MDS simulation results for phase compensation. It is obvious that the compensation curves very with the varactor voltage changing. Fig.4 is MDS simulation results for IM3 comparison. The normal BJT RF predistortion linearizer has 6 dBc improvement in IM3 but the novel programmable RF predistortion linearizer has the much better performance in the whole input power dynamic range, about 20 dBc improvement in IM3. We have also successfully built the prototype for novel programmable RF predistortion linearizer for IS-95 application at 1850 – 1910 MHz as shown in Fig.8. Fig5 is IM3 test result and Fig.6 is ACPR test result. Fig.7 is the spectrum plotting. The test data show us there are 9 dBc improvement in IM3 and 6 dBc improvement in ACPR.

Fig.3: MDS Simulation Results for Gain Compensation



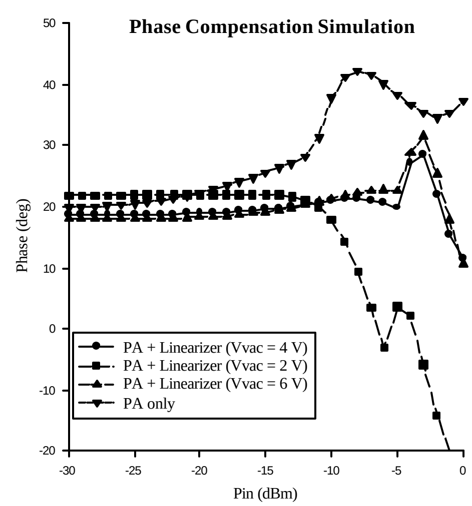


Fig.4: MDS Simulation Results for Phase Compensation

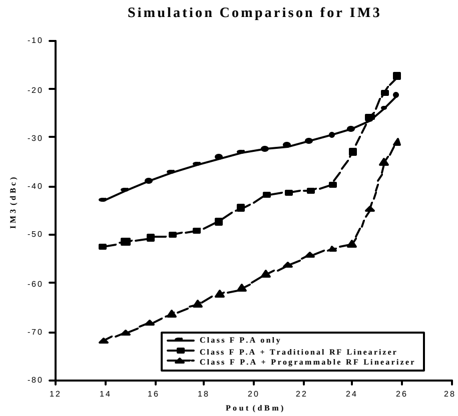


Fig.5: MDS Simulation Results for IM3 Comparison

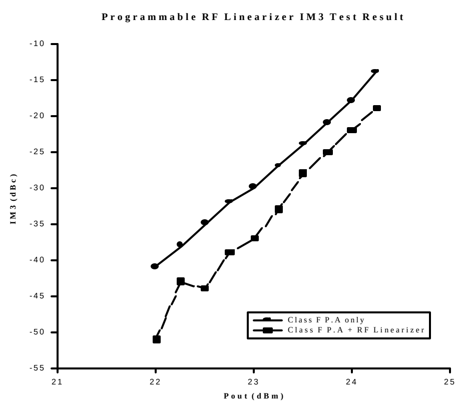


Fig.6: The Test Result (IM_3) Comparison between Normal P.A and P.A with RF Linearizer

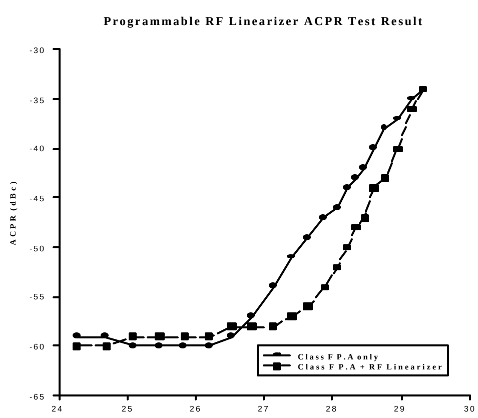


Fig.7: The Test Result (ACPR) Comparison between Normal P.A and P.A with RF Linearizer

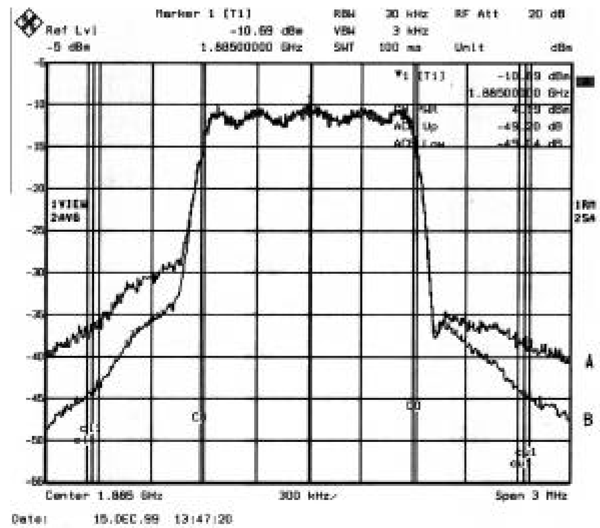


Fig8: The Spectrum (ACPR) Comparison between Normal P.A and P.A with RF Linearizer
A: Class F Power Amplifier only
B: Class F Power Amplifier + RF Predistortion Linearizer

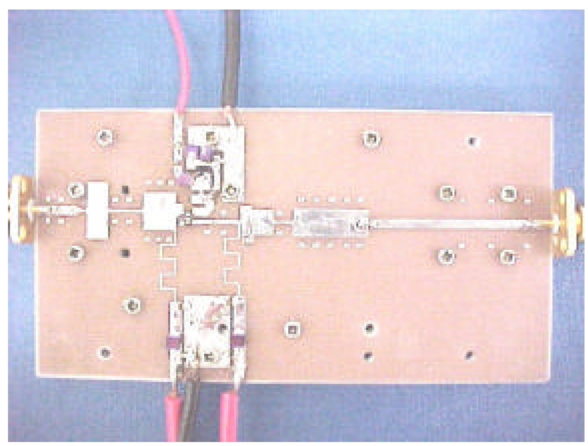


Fig.9: Photo of the Novel Programmable RF Predistortion Linearizer

III. CONCLUSION

A novel programmable RF predistortion linearizer is introduced in this paper. The main advantage of this novel circuit is that the predistortion compensation performance can be easily optimized at different input power and different operation frequency by changing the BJT transistor bias V_b and varactor controlling voltage V_{ac}. The novel programmable RF predistortion linearizer is also easily calibrated and save the controlling parameters into the micro-processor. The test data of the prototype show us there are 9 dBc improvement in IM_3 and 6 dBc improvement in ACPR.

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