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Study of Various Compensation Models for Transmitter Leakage in Carrier Aggregation Applications

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Abstract: ***Communication is one of the important aspects of human life. With increasing demands of high data rates, carrier aggregation technique will be widely employed in wireless cellular communication. So to support carrier aggregation, it requires multi band transmitters. Due to non-linear characteristics of radio frequency amplifiers, the distortion normally added into the transmitted signal after amplification. The distortion signal not only presented at transmitted bands but also at the intermodulation bands. Finally fall into the received bands leads to huge quality degradation in signals. In order to overcome the transmitter problems there is various techniques proposed. In this paper various compensation models for transmitter leakage in carrier aggregation applications are studied.***

Index Terms: transmitter leakage, carrier aggregation, DPD, FPGA, receiver.

I. INTRODUCTION

Today increasing with the population mobile subscriptions also increased. Due to large number of mobile subscriptions the Mobile data traffic is also increased. So this mobile data traffic far exceeds the voice traffic in future. Due to present data traffic, mobile operators are struggling to face the mobile traffic challenges the current technologies. The number of LTE aggregated carriers will be increased in future. So carrier aggregation plays good role in wireless communications technology. The main problem is mobile operators have fragmented frequency spectrum in multiple frequency bands and regions. So in order to meet the user high data demand, it needs more capacity and high data speeds.

One of the best solutions for this problem and mobile data traffic is carrier aggregation (CA) [10]. Carrier aggregation is the technique which is used to combine the different multiple component carriers (CC) along the same or different frequency bands in spectrum. So to support carrier aggregation, it requires multi band transmitters. Due to non-linear characteristics of radio frequency amplifiers the distortion normally added into the transmitted signal after amplification. The distortion signal not only presented at transmitted bands but also at the intermodulation bands. Finally fall into the received bands as shown in below figure 1. It leads to huge quality degradation in signals. In order to overcome the transmitter problems there is various methods proposed. Due to low cost and good quality, digital pre distortion (DPD) is the best method used in transmitters to remove the sideband distortion.

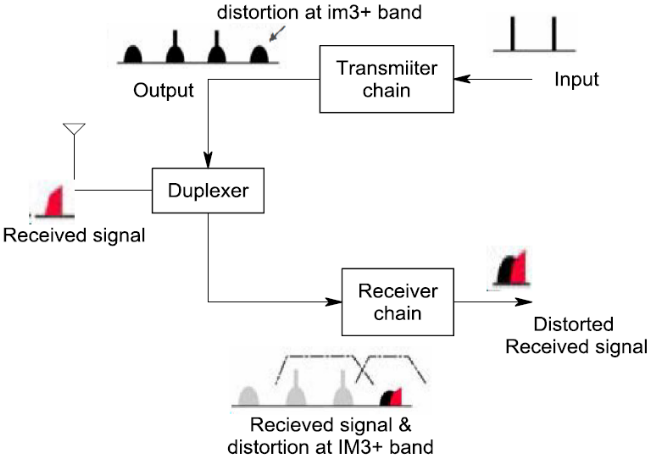

Figure1: Transmitter Leakage

II. COMPENSATION METHODS

Various compensation schemes have been proposed either in transmitter or in receiver to solve the leakage and distortion problems

A.Full-Bandwidth DPD Method

C. Yu proposed a Full bandwidth DPD method to effectively suppress the side band signal by treating the multi band signal including the sideband signal as a single signal [1]. In this proposed approach, it requires three behavioral models in the system: a PA model (the forward model), a DPD model (the inverse model) and a nonlinearity injection model. The model selection depends on the system requirement. In this work, he employs the band-limited second-order DDR-Volterra [1] model for both the forward and the inverse models. The proposed structure can be shown in below Figure 2.

In this structure, the model generation module is divided into two parts, including target model and inverse model. The model extraction module also includes two parts: inverse model extraction and target model extraction. Before the system starts, the input and output data from the PA without DPD must be captured and a target model is then constructed.

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For linearization level control, a nonlinearity injection model needs to be selected. For linearization band control, the forward PA model must be extracted and the filtering functions must be selected.

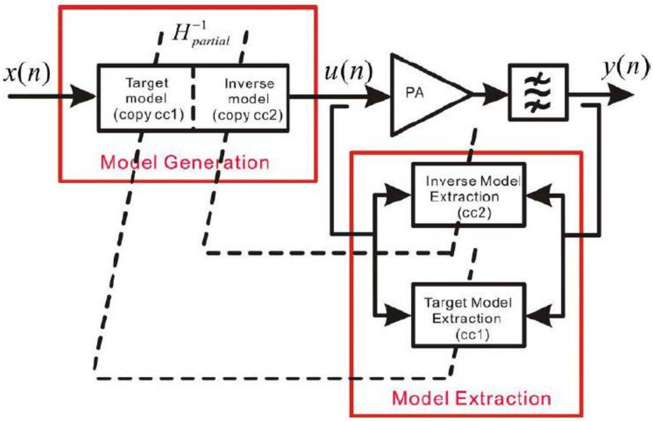

Figure 2: full bandwidth DPD structure

B. Frequency Selective DPD Method

P. Roblin and J. Kims proposed a frequency selective DPD method to effectively cancel the sideband separately [2] [3]. This can be achieved by deploying a large signal network analyzer (LSNA) to extract the device under test (DUT) information. They proposed a architecture for frequency selective digital pre distortion for two and three band power amplifier (PA) shown in below figure 3. The algorithm used accounts for differential memory effects up to fifth order for bands that can be arbitrarily spaced.

The simulation and experimental studies are performed using various signal sets; two- and three-band multi tone signals with various tone spacing, band separation, and complementary cumulative distribution function. An improvement of 10 dB over third-order linearization is demonstrated in simulation for more than 20 dB of adjacent channel power ratio reduction. The test signal and the linearization algorithm were implemented on a field-programmable gate array. The linearization algorithm was applied to an RF amplifier at 700–900 MHz. For the two-band case, more than 15 dB on the in-band, 13 dB on the third, and 5 dB on the fifth intermodulation distortion (IMD) cancellation were achieved. For the three-band case, more than 12 dB of IMD cancellation was observed. For largely spaced signal DPD, more than 15 dB of IMD cancellation was achieved. In the three-band case, the linearization of intermodulation byproducts overlapping with the in-band distortion is found to be of critical importance.

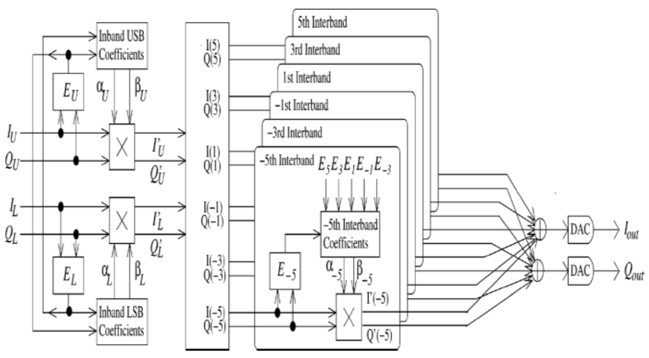

Figure 3: Frequency Selective DPD Architecture

C. Filtering Based sideband distortion model

S.A. Bassom proposed a filtering based sideband distortion modeling technique to inject the anti-phase sideband distortion for suppressing the distortion at transmitter as well as for reducing the complexity [4]. This is the channel-selective multi-cell processing pre distortion technique that compensates for the nonlinearities of multi-carrier transmitters. This technique uses independent processing cells to compensate for the intra-band and inter-band distortions of nonlinear transmitters. This frequency-selective feature of the proposed technique significantly reduces the minimum sampling rate requirements of analog-to digital and D/A converters which are a critical issue for DPD techniques. The block diagram of bassom's multi cell processing DPD is shown in below figure 4.

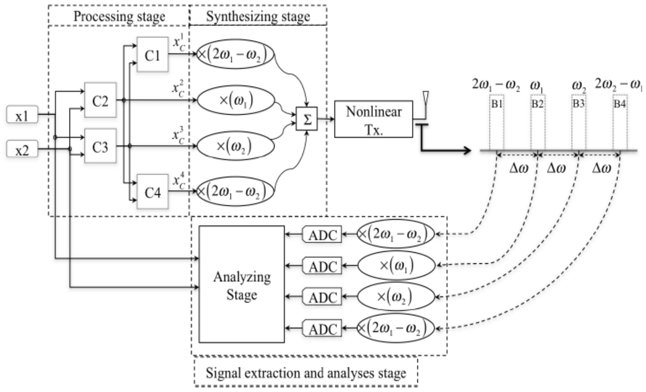

Figure 4: Multi Cell Processing DPD

D. Side Band Compensation Scheme

Z. Fu proposed a side band compensation scheme which based on evaluation and minimizing the power spectral density (PSD) of power amplifiers (PA) output signal around the pre-specified frequency [5]. In this technique, the pre distortion processing is kept as simple as possible, deploying quasi-memory less polynomial models. Efficient mitigation of unwanted emissions around the target frequency is demonstrated via simulations and actual RF measurements, in both single-carrier and dual-carrier waveform scenarios, using memory less and memory-based power amplifiers.

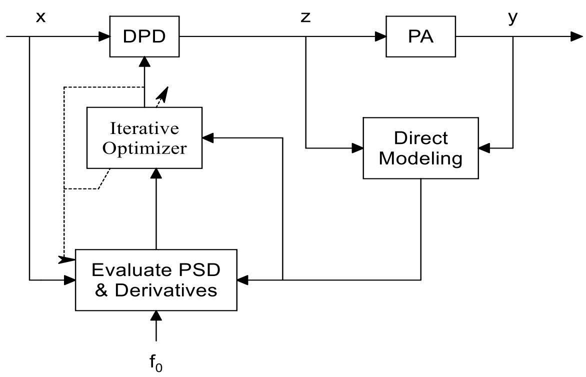

Figure 5: block diagram of Bassom's proposed compensation sheme

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This DPD solution could potentially be employed in many applications like mobile devices utilizing non- contiguous multi- carrier transmission, where the intermodulation spurs may overlap with the device's own receiver band, or could potentially be violating the spurious emission limits.

The block diagram of pre distortion processing including direct power amplifiers (PA) modeling/ learning, evaluation of PSD derivatives and carrying out iterative DPD parameter optimization has been shown in below Figure 5.

The DPD-based sideband compensation methods work well in general but they require extra bandwidths to transmit the sideband information in multi-band transmitters, which is often not desirable in many applications. Instead of removing the distortion in transmitter, some other compensation schemes are realized in Receiver.

E. Dual Basis Envelope-Dependent Sideband Distortion Model

Chao Yu and Anding Zhu proposed a novel dual-basis envelope-dependent sideband distortion model to characterize the transmitter leakage in the receiver band in concurrent dual-band transceivers [6]. It is constructed by first generating a non-linear basis function that maps the inputs to the target frequency band where the distortion is to be cancelled, and then weighing it with envelop-dependent nonlinearities. Chao Yu's proposed model for leakage compensation is shown in below figure 6.

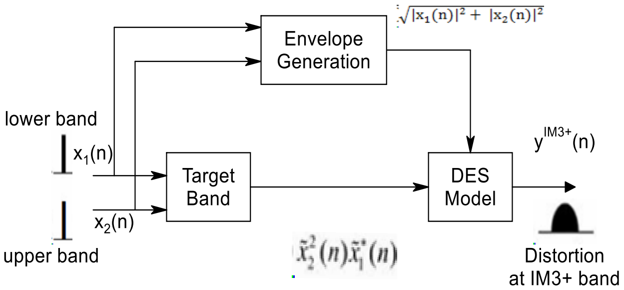

Figure 6: Distortion Model

F. Generalized Dual- Basis Envelope Dependent Sideband Distortion Model for Three Carrier Carrieir Aggregation

Chao Yu and Wenhui Cao proposed a generalized dual-basis envelope-dependent sideband (GDES) distortion model [7] structure is proposed to compensate the distortion induced by transmitter leakage in concurrent multi-band transceivers with non-contiguous carrier aggregation.

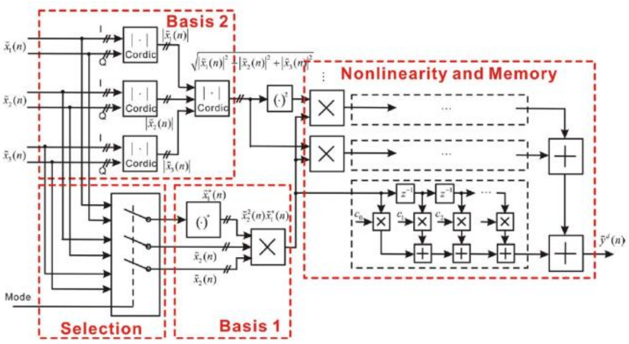

Figure 7: Dual-Based Envelop Dependent Sideband Distortion Modle

This model has a generalized structure that is constructed via first generating a nonlinear basis function that maps the inputs to the target frequency band where the distortion is to be cancelled, and then multiplying with a second basis function that generates envelope-dependent nonlinearities. By combining these two bases, the model keeps in a relatively compact form as shown in below figure 7. This model is implemented by using FPGA. Transmitter leakage suppression is shown in below figure 8.

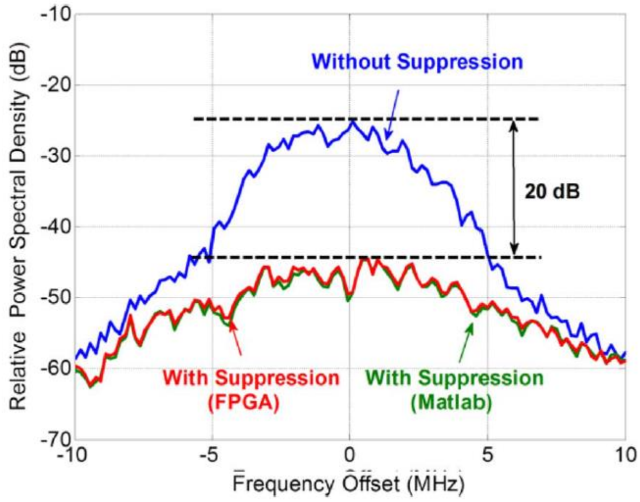

Figure 8: Transmitter Leakage Suppression

This model consumes less number of LUTs and slice registers, so complexity of system is reduced.

III. CONCLUSION

With the demand of data speed, carrier aggregation has a great play role in high data communication systems. There is a transmission leakage problem in carrier aggregation. As per discussed about all above techniques to suppress the transmission leakage in communication system applications like carrier aggregation applications. Each method proposed in the literature has a drawback and these effects need to be considered for real performance measurement. For distortion due to transmitter leakage, reduction in communication systems, different individual and combined techniques are used. Depending upon the performance, complexity and applications of system we can use appropriate method.

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