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An Optimized 2.4GHz RF Power Amplifier Performance for WLAN System

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Abstract. Recently, the design of RF power amplifiers (PAs) for modern wireless systems are faced with a difficult tradeoff for example, cellphone; battery lifetime is largely determined by the power efficiency of the PA and high spectral efficiency which have ability to transmit data at the highest possible rate for a given channel bandwidth. This paper presents the design a multi stage class AB power Amplifier with high power added efficiency (PAE) and acceptable linearity for the WLAN applications. The open-circuited third harmonic control circuit enhances the efficiency of the PA without deteriorating the linearity of class-AB mode of the PA. The voltage and current waveforms are simulated to evaluate the appropriate operation for the modes. The effectiveness of the proposed controller has been verified by comparing proposed method with another methods using simulation study under a variety of conditions. The proposed circuit operation for a WLAN signals delivers a power-added efficiency (PAE) of 37.6% is measured at 31.6-dBm output power while dissipating 34.61 mA from a 1.8V supply. Finally, the proposed PA is show a good and acceptable result for the WLAN system.

1. Introduction

Nowadays, RF Power amplifier efficient are becoming more important as technology advances integration of wireless communication systems requires stringent capabilities in terms of linearity and efficiency. It is difficult to employ these RF linearization techniques as a complete transmitter for a base station due to the complicated circuits and/or insufficient linearization which need to amplify signals efficiently to increase the battery life that typically deliver their highest efficiency at maximum output power in linearity becomes significant [1].

The most common power amplification techniques with inherently more power efficient have been researched to satisfy the requirements [2], [3]. Such techniques are included load modulation technique, switching mode amplifiers [4], envelope elimination and restoration [5], the multi-modes and multiband of operation and envelope tracking [6]. The Doherty Power Amplifier is a promising candidate with advantages of high PAE, low cost and simple construction [7]. Resistive feedback [8] involves good wide band matching and flat gain but suffer from poor noise figure and large power dissipation, it has normally features of wideband but consumes large current because of several distributed amplifiers which is not proper for low power applications. This technique has previously

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been implemented in integrated multi-band multi-standard receivers [9] and LNAs [10] where a matched input is required, but also in multi-band multi-standard transmitters [11] and compact power amplifier drivers [12].

This paper focus on control the shape and overlap of the drain voltage and/or current waveforms for class-AB power amplifier using appropriate gate biasing and harmonic terminations. First, exploit the harmonic contents so the loss in the active device is minimized. Second, bias the amplifier toward class AB/A (AB or A) to improve the linearity. Finally, the simulation result show that proposed PA are significantly improvement the linearity, efficiency and output power can be achieved with proper harmonic terminations and proper biasing voltage.

2. Proposed Circuit Design

For design and simulation purposes a faithful mathematical model which closely describes the actual behaviour of this inherently nonlinear power amplifier is required. Figure 1 shows the schematic circuit diagram of a typical class AB RF power amplifier with linearization network. Some of the key specifications in the design of this PA are its frequency of operation, gain, output power level, and bias voltages are adaptively modified of the input/output impedances. In addition, all the impedances of any RF block are terminated with 50 Ω, especially to aid in the testing of these blocks. Finally, it is easy to see that with the load modulation can be carried out in two stages with different control voltage profiles.

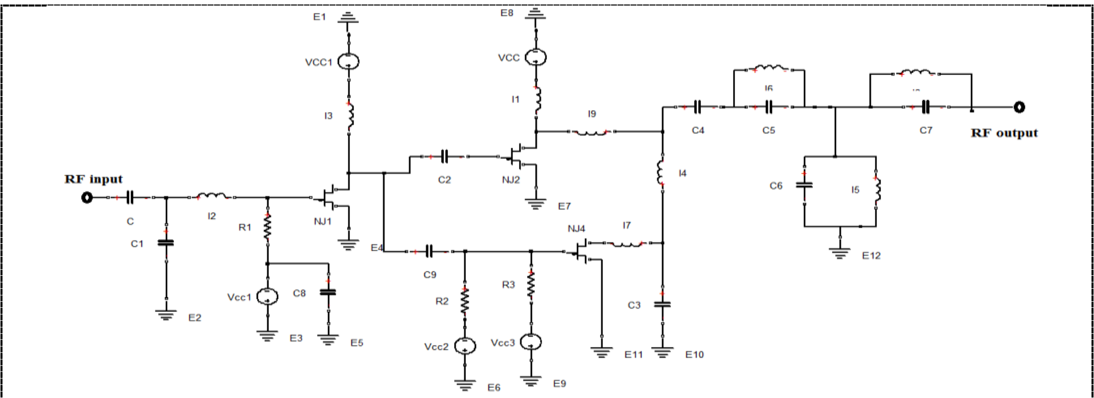

Figure 1. Optimized PA schematic

The maximum output power is determined by the maximum voltage swing at the output since the output impedance is fixed through the 50Ωs. This results in a limited current in the output stage since the single-ended output impedance is set to 50Ω and the supply voltage is 1.8V. A higher output power can be achieved by reducing the output impedance. This will increase the output current, but the influence of wire resistance will then be more significant.

3. Simulation Results

To enable to test the proposed class AB amplifier, closer examination of the voltages and currents of WLAN amplifier is required. Figure 2 shows the voltage and current waveforms at the drain terminal for the class AB output stage of 2-stages WLAN PA.

From figure 2, the propose circuit design achieved a linear power gain of 11.3dB, with an output power of 19.8dBm at 2.4GHz, which provides few dB of margin over the design requirements, and 1-dB output compression at 15.3dBm which is defined as the 9dBm in an input level axis, which means a 0dB back-off level in this work. At that point, the PAE is measured to be 73.4%. Also, the PAE is measured to be 68.3% at 6dB back off, 54.2% at 12dB back off, and 29.9% at 18dB back off, which represents a PAE improvement of 1.58 times, 2.245 times, and 2.986 times respectively, compared to a single-stage class AB design.

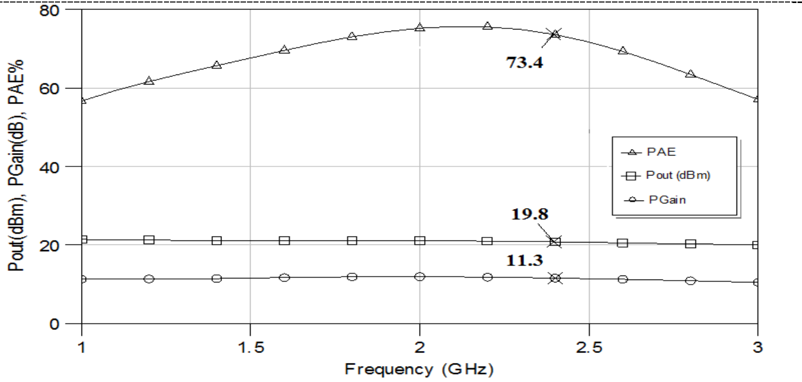

Figure 2. Output power, power gain and PAE

From figure 3, once the auxiliary amplifier is turned ON, the current from the auxiliary amplifier through the inductor partially cancels that coming from the main amplifier, causing the inductor loss to the output power ratio to decrease. Since the loss at the first efficiency peak is significantly higher, it causes the first efficiency peak to be somewhat much lower than the second peak. This concept is the same in between the auxiliary #1 and the auxiliary #2, which causes the second efficiency peak to be somewhat much lower than the third peak and so on.

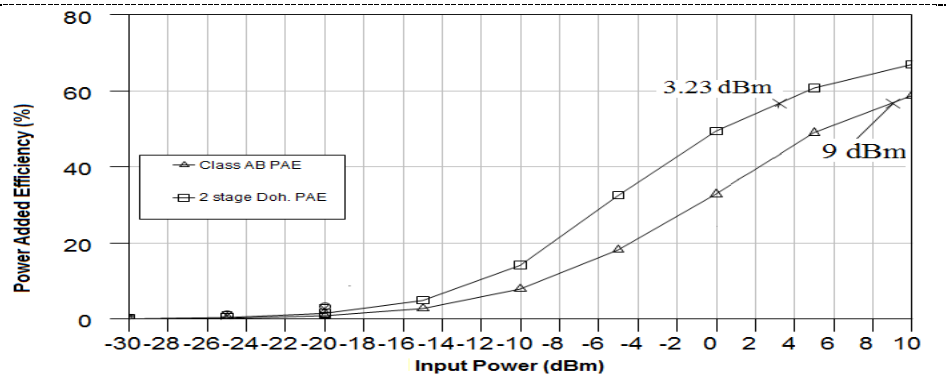

Figure 3. PAE versus input power

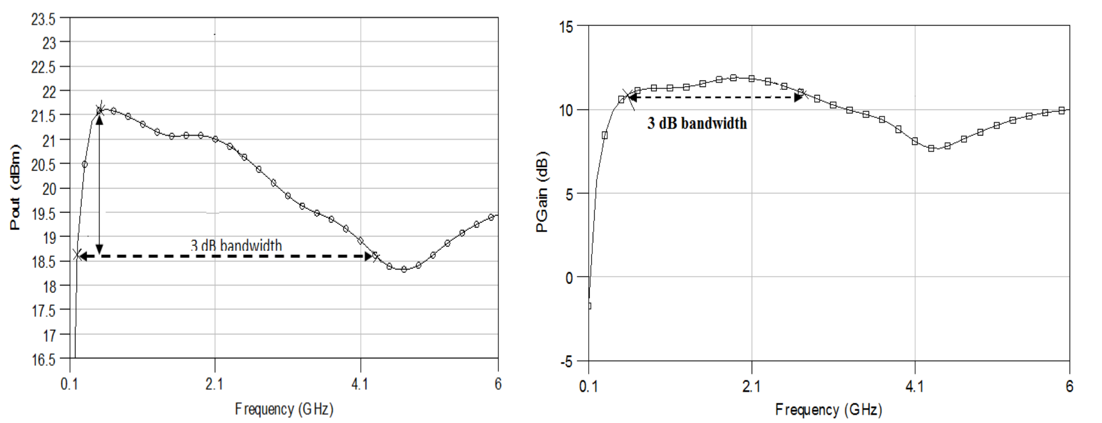

Figure 4. a) Output power versus frequency **b)** Power gain versus frequency

From figure 4a, output stage design the 3-dB bandwidth is measured to be 4.232GHz with about ±2GHz from the center frequency 2.4GHz of WLAN standard as shown. Also there is a flatter gain over a wide frequency range with only ±0.5dB gain variation for 2.13GHz bandwidth as shown in figure 4b.

4. Conclusion

In this paper, Class AB is studied the ideal theoretical solution for the efficiency-linearity tradeoff and have proposed a new concept of a class AB PA 2.4 GHz using multi-stage technique. However, the performance of this amplifier relies heavily on the realization of the harmonic traps and the input biasing voltage. For the third-harmonic resonator to generate a third-harmonic component of voltage, it requires third-harmonic current which does not exist. The simulation result showed that the proposed significantly improved the efficiency over a broad average output power compared to the conventional balanced amplifier.

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