ECE 532 Writing Assignment – Spring 2015

Novel Monolithic Doherty Power Amplifier Topologies in GaN

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***Abstract* – This paper explores novel Doherty Power Amplifier topologies, which increase efficiency, gain and bandwidth. In order to increase bandwidth a reconfigurable matching network is proposed. A class F amplifier substitutes the traditional class AB amplifier in order to increase efficiency and a auxiliary amplifier is added in the peaking branch to increase gain.**

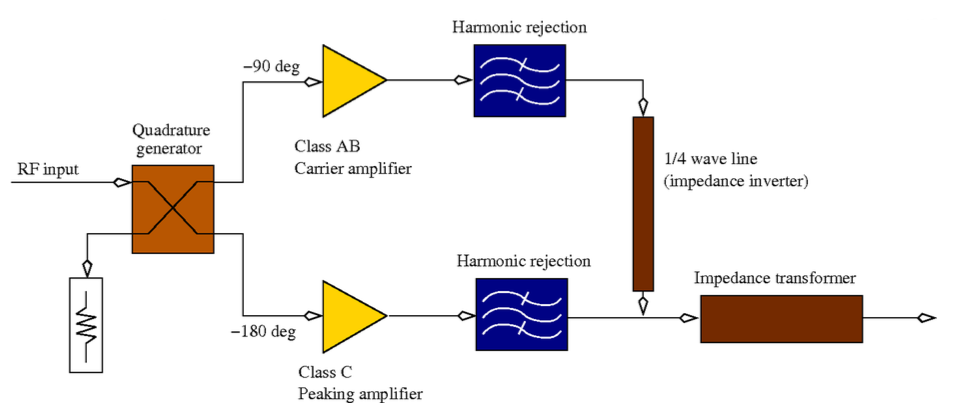
I. Introduction

Since the advent of wireless communication RF power amplifiers have played a crucial role. RF power amplifiers were initially used in AM/FM radio transmitters. These Transmitters would transmit upwards of 500KW and were not very efficient. I class AB amplifier has an efficiency of about 33%. Clearly this is unacceptable in today’s standards. Today mobile communications demand high efficiency and high bandwidth. The Doherty Power Amplifier (DPA) has shown improved efficiency and is now gaining attention. In this paper various novel topologies are explored. These topologies aim to increase efficiency, bandwidth and gain.

This paper is organized as follows. Section II explores the DPA and some of its disadvantages. Section III explores novel DPA topologies that increase efficiency and bandwidth.

II. The Doherty Amplifier

A DPA is composed of two amplifier branches as shown in Figure 1.

**Figure 1 Basic schematic of Doherty amplifier [5]**

The “carrier” branch is implemnted with a class AB amplifier and the “peaking” branch is a class C amplifier. The Idea behind this topology is to increase efficiency by summing both amplifier outputs. When the carrier amplifier begins to saturate or enters compression the peaking amplifier is turned on hence making up for lost output power.

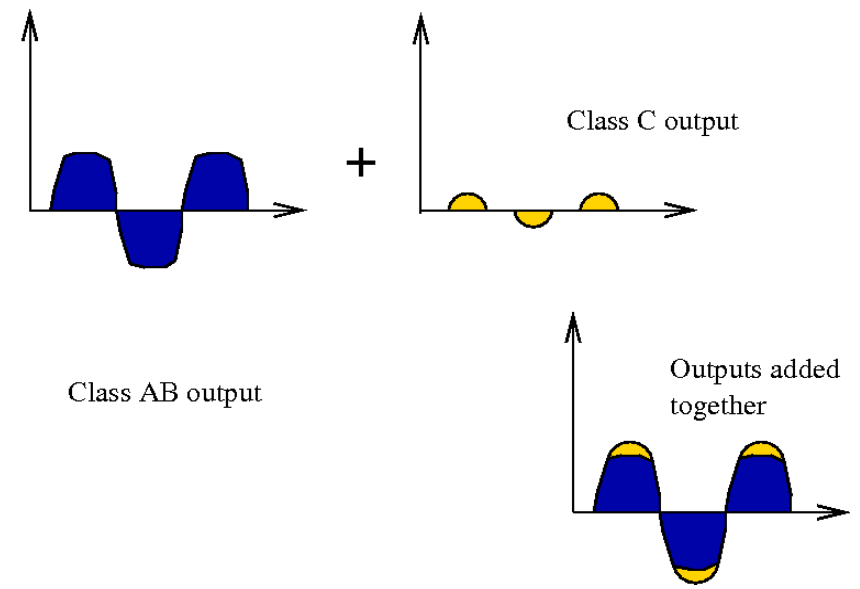


Figure 2 Doherty amplifier theory of operation [5]

Figure 2 shown a diagram of the theory of operation of the amplifier, as shown the peaking amplifier “tops off” or add the peak of the waveform when the carrier amplifier is saturated. As seen in Figure 1 a power splitter and a λ/4 transformer are necessary, these elements hinder the performance of the DPA. First, the power splitter lowers the gain of the carrier amplifier by 3dB. Second, both of these structures are optimized for a single operating frequency hence reducing operating bandwidth.

III. Doherty Amplifier Topologies

In order to increase efficiency, gain, and bandwidth various novel topologies are suggested. Each of the following topologies aims to increase one of these factors.

1. Reconfigurable Matching Networks

For proper operation of the DPA the inputs of the carrier and peaking amplifiers must be 90° out of phase. 90° phase shift is realized with a λ/4 transformer ether in micro strip or lumped element depending on the operating frequency. It is obvious that this presents a challenge if large bandwidth is desired. To solve this problem reconfigurable input and output matching networks (IMN/OMN) are proposed. Figure 3 shows a schematic of a reconfigurable DPA.

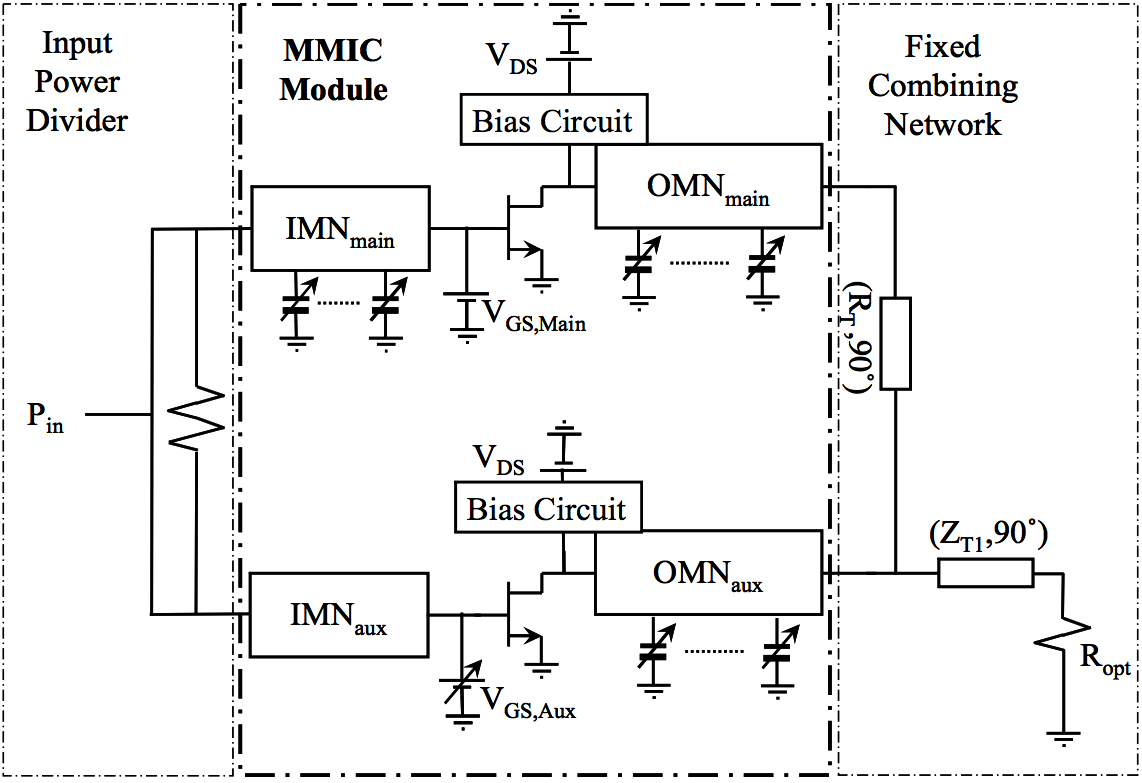


Figure 3 Schematic of Reconfigurable DPA [1]

To achieve reconfigurable matching networks microelectromechanical systems (MEMS) are used. MEMS devices are preferred due to their ultra-linearity, low losses, and easy of integration in current MMIC processes [1]. A reconfigurable matching network can present the optimum impedances to both input and output of the transistor for the best gain and efficiency at various operating frequencies. As shown in [1] such topology yielded high power gains and efficiency at 1.7, 2.14 and 2.6 GHz using the same amplifier with reconfigurable matching networks.

1. Class F amplifier in Carrier branch

In some cases, a class F amplifier can be used as an alternative to for the main class AB amplifier. The purpose of using a class F amplifier is to increase the overall efficiency of the amplifier. A class F amplifier is similar to a class B, however the output is harmonically terminated, and it is single ended, rather than a push pull. As shown in Figure 4 there are several filters on the output that tune out the higher order harmonics that distort the signal and cause energy from the power source to be put into frequencies that are not in the spectrum of interest.

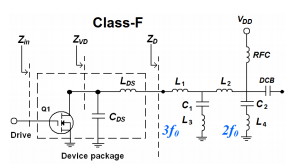


Figure 4 Class F Amplifier [3]

Distortion in the signal can come from various places, however in the class B bias condition (no bias) the main sources of the distortion comes from the input waveform also needing to bias the transistor, and from the transistor not conducting during the negative cycle of the wave. These distortions show up as higher order harmonics, which are then tuned out via the harmonic termination. Theoretically, a class F amplifier can reach 100% efficiency however realized designs have shown efficiencies near 60% to 75%.

1. Raymonds section

IV. Conclusion

In this paper we explored some novel topologies of the Doherty power amplifier. These topologies take upon the original design and make modifications to improve efficiency, gain and bandwidth. It was observed that by adding reconfigurable matching networks the bandwidth of the amplifier is greatly increased. In order to increase efficiency a class F amplifier substitutes the traditional class AB amplifier and takes advantage of the distortion products. In order to increase gain an auxiliary amplifier is added to the peaking branch.

References

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