Chapter 8

Design of Medium Power Amplifier Using GaAs PHEMT Technology for Wireless Applications

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ABSTRACT

This paper presents the design of single-stage and two-stage medium power amplifiers (MPAs) using GaAs PHEMT technology for the wireless applications. The single-stage MPA was designed using 0.15 μm GaAs PHEMT technology to be operated at 3.5 GHz whereas the two-stage MPA was designed using 0.5 μm GaAs PHEMT technology to be operated at 5.8 GHz. The MPAs employ a simple RC feedback in order to linearize the stages as well as to improve the circuit stability and to control the gain. In addition, the load-pull technique was used in order to define the optimum load and maximum output power. Therefore, the performance of the proposed amplifier in this paper is discussed in terms of stability, gain, power-added efficiency (PAE), and output power. The simulated data of the proposed MPAs is then compared with the measured data of the fabricated MPAs.

INTRODUCTION

The wireless communications industry has grown rapidly in recent years. In any wireless communication, the transmitter is a one part of this system. As the last stage of amplification in the transmitter chain, the power amplifiers (PAs) are a critical and most challenging component in a transmitter system as shown in Figure 1; where the signal should be at a high level to cross the desired distance.
Since they are designed to drive a large power into a load such as an antenna or a transmission line by the supply circuit, PAs are frequently the most power-hungry Radio Frequency (RF) component, often dominating the power dissipation of an entire transceiver (Razavi, 1998). The PA, which is a critical element in a transmitter system, is expected to provide a suitable output power at a very good gain with high efficiency and linearity so they cannot be approximated as small signal devices. The efficiency considerations lead to various classes of power amplifier such as Class A, B, and AB are linear power amplifiers, whereas Class C, D, and E are nonlinear power amplifiers.

The output power of a PA must be sufficient to get a reliable transmission. High gain reduces the number of stages in an amplifier that are required to deliver the desired output power, hence reduces the size and manufacturing cost. On the other hand, thermal management, battery lifetime and operational costs are improved by high efficiency. In addition, good linearity is necessary for bandwidth efficient modulation (Cripps, 1999). All these requirements make a tradeoff and an optimization is needed for a typical power amplifier design.

This paper will thoroughly discuss the design of a medium power amplifier (MPA) using 0.15 μm and 0.5 μm GaAs PHEMT technology. The Gallium Arsenide (GaAs) Pseudomorphic High Electron Mobility Transistor (PHEMT) has good performances on the frequency range, noise figure, output power, and high efficiency with low distortion (Weitzel, 2003; Huang, Lee, & Chen, 2005; Platzker, & Bouthillete, 1995; Komiak, Wang, & Roger, 1997). Because of its superior performance over the metal oxide semiconductor (MOS) transistors, GaAs transistors have been used extensively to build the Radio Frequency (RF) power amplifiers and play an important role in the wireless communications.

PHEMT power amplifiers are making serious inroads into handset cellular (800 MHz to 2.3 GHz) and Wireless LAN (WLAN) (2.4 GHz to 5.85 GHz) applications (Fujii, Morkner, & Brown, 2004). The IEEE 802.11 WLAN standards have extended the frequency band from 2.4 GHz to 5 GHz bands in order to increase the data transmission rate. The new generation of 802.11a WLAN and HiperLAN/2 standards operating in the 5 GHz spectrum using OFDM modulation are becoming popular due to high speed, greater system capacity and low interference (IEEE Draft Supplement to IEEE Standard 802.11., 1999). Each of these standards requires a power amplifier as the final amplification block of the transmitter and each of them allows a specific maximum output power generated by the power amplifier. Therefore, the application ambit this power amplifier is the key component for researching the advance systems of WLAN and other wireless network systems.

A start-of-the-art power amplifier design has to meet the system requirements for high gain, high efficiency and meet the desired output power while the device and process technology of choice plays a crucial role in realizing a working system. The operating frequency for the proposed MPA in this work

Figure 1. Power amplifiers are used at the output of transmitter (Queen’s Learning Wiki, 2008)