

CHAPTER 1

1.0 INTRODUCTION

Solid-state microwave amplifiers play an important role in communication. Usually, signals provided by the transducers are weak; typically, it is in the order of microvolt (μV) or millivolt (mV). It is not easy, and sometimes not possible, to have reliable processing for signals with low levels. For this reason, the need for a signal amplifier arises. In a transceiver circuit, a signal amplifier has different applications, including low noise, high gain, and high power amplifiers.

One of the problems that face the user of portable units is the limited lifetime of the battery, which determines the operating time of the unit, or “talk time.” One solution is to use a battery with longer lifetime, which brings an undesirable increase in the cost and weight of the portable unit. Since it is known that RF power amplifier consumes most of the power consumption within a transmitter, reducing its consumption power will increase the talk time of the unit.

Because of its superior performance over the MOS transistors, Gallium Arsenide (GaAs) transistors have been used extensively to build the RF power amplifiers. GaAs based power Amplifiers have several drawbacks: costly to implement, require high level power supply, and have large size. CMOS power amplifier’s performance is limited because of its low breakdown voltage, low current drive, and lossy substrate. In spite of its limitation, sub-micron CMOS prove to be the best process to implement the PA operating at frequency up to 2 GHz rang.

The focus of this research has been the design of high efficiency RF Power Amplifier. The goal of the project was to study the basics of RF power Amplifiers then try to design an effective PA for use in an RF wireless communications system. To study the practicality of the designed CMOS PA, it was tested to insure its compliance with the European standard for mobile communications (GSM) specifications.

1.1 OUTLINE OF THE THESIS

The intent of the research reported in this thesis is three-fold: to survey a amplifier classifications and definitions, to give an overview of some basic principles used in the analysis and design of the microwave transistor amplifier, and to design high efficiency power amplifiers for possible use in portable cellular telephone units.

Amplifiers are classified according to their circuit configurations and methods of operation into different classes. Chapter 2 surveys and discusses the definitions and circuit operations of the amplifier classes.

Chapter 3 contains a description of the techniques used in small signal amplifier design (small-signal S-parameters technique) and high power amplifier design (Load-pull and large-signal S-parameters techniques).

Chapter 4 discusses design accuracy of the class-A amplifier using large-signal S-parameters.

Chapter 5 presents new broadband class-E configurations. Two L-band class-E amplifiers are presented in section 5.3. One of them is a lumped elements based circuit and the other is a transmission lines based circuit. Both circuits show good performance over wide bandwidth (1.0 GHz). In section 5.4, lumped elements and transmission lines based X-band class-E amplifiers are proposed. Both circuits show good performance over a wide bandwidth (4.8 GHz).

Chapter 6 presents a 900 MHz CMOS RF PA with one-watt output power and a high power added efficiency (68%). This PA can be used in the European standard for mobile communications (GSM) handset transmitter. Moreover, it presents simulation results, and layout issues of the designed PA.

The final chapter summarizes the work and suggests future work.