

# Chapter 11

## Design and Analysis of a New Configuration of Microwave Power Amplifier

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### **ABSTRACT**

*The chapter has the objective of introducing and explaining the concept of a microwave power amplifier (PA). PA is one of the blocks that has a large effect on the overall performance of communication systems, especially in transmitter systems, and their design is decided by the parameters of the transistor selected. This chapter is divided into three parts, which will be as follows: Part 1 provides background theory relevant to our research. Part 2 describes the matching techniques for PAs. Part 3 utilizes the tools developed in Parts 1 and 2 to analyze and design the proposed microwave power amplifier with a microstrip technology intended for wireless applications.*

### **INTRODUCTION**

Modern radio frequency (RF) and microwave communication systems is a dynamic and exciting field, owing in wide part to the coherence between recent advances in modern electronic device technology and the development in demand for video, voice and data communication capacity that begin in the 1990s and continues through the present (Haynes, 2007). Before to this advancement in communications, microwave technology was the almost chosen domain of the defence industry; the recent and dramatic growth in demand for communication systems for like applications as broadcast video, wireless paging, mobile telephony, and tethered or untethered computer networks has driven the industry to evolve. These

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communication systems are utilized through a large range of environments, including industrial and manufacturing facilities, corporate offices, private homes, as well as infrastructure for municipalities. The variety of applications and operational environments has led, across the accompanying tall production volumes, to enormous progress in cost-efficient manufacturing capabilities of radio frequency and microwave products. This, in turn, has reduced the implementation cost of a host of novel and cost-effective wireless as well as wired microwave and radio frequency services. Automotive collision-avoidance radar, Inexpensive handheld GPS navigational aids, and widely available broadband digital service access are amongst these. Microwave technology is generally adapted for these appear applications in sensing and communications, since the taller operational frequencies allow both wide numbers of independent channels for the large diversity of uses envisioned as well as considerable disposable bandwidth per channel for high-speed communication (Pozar, 2009; Steer, 2009).

In modern microwave communication systems, Amplifiers are a key part of all transmitter systems. The microwave power amplifier (PA) is responsible for the most of the system's power consumption. When the amplifier is operating below 50% DC-DC efficiency, it is more an electrical heater than an oscillator, necessitating high power DC supplies and heat dissipation systems. Heat damage can wreak havoc on satellite and radar communication systems, demanding sophisticated cooling structures to protect not only the PA, but also the surrounding electronics. With wireless communication systems, hand-held battery operated mobile devices suffer the most from the PAs high power consumption, resulting in a decreased battery life and shorter talk time. Reported results on power amplifiers, typically operating above 85%, reliance on precise multi-harmonic impedance terminations on both the input and output terminals at very high levels of device compression, both of which results in highly nonlinear and narrow operating bandwidths (Raab, 2001; Srirattana, Raghavan, Heo, Allen, & Laskar, 2005). PA has been concentrated on specified RF bandwidths of 10% or less. Systems like worldwide interoperability for microwave access (WiMAX) and 4G necessitate wide instantaneous bandwidths, and future systems will likely require even more, not just owing to wider spectral allocations, but the base bandwidth of the signals themselves may well exceed 100 MHz (Choi, Kang, Kim, Park, Jin, & Kim, 2009; Chowdhury, Hull, Degani, Wang, & Niknejad, 2009). In addition, satellite and radar communication systems have yet to benefit from recent improvements in PA output power and efficiency because of their much wider bandwidth requirements with high power gain.

The need for power amplifiers capable of achieving high gain and good impedance matching across a broad range of frequencies has fueled extensive previous research and development of innovative power amplifier architectures. While primarily now an industry-driven field, microwave PA design still has a place in an academic setting as communication systems continue to push the limits of data rates in narrow channels.

In this chapter, basic concepts on power amplifiers will be introduced. A special emphasis on differentiating PAs from conventional small-signal amplifiers will be necessary in order to comprehend the specific requirements for this type of circuit.

Unlike in the small-signal case, the load line is a very important step for power amplifiers. It represents the large signal regime of the transistor. However, the load line does not define exclusively the type of amplifier, because this can be influenced by the dynamic behaviour of the device.

In order to start the description and characterization of microwave power amplifiers, a general configuration of a single-stage microwave amplifier is presented in Figure 1. This conventional circuit is applicable either for small or large-signal amplifiers. It comprises an input matching network, the active device, and the output matching network.

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