MMIC Based Phased Array Radar T/R Modules

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***Abstract*- In order to lower the cost of basic MMIC components and modules for commercial and civilian phased array applications dramatic cost reductions when compared to the present military must be realized. These cost reductions can only be achieved by employing highly integrated RFICs which are produced on high volume process lines for low cost using GaAs MMICs and Silicon based technologies where appropriate, exploiting high volume plastic packaging technologies for both low cost and high performance, and employing commercial printed circuit board and module manufacturing technologies. The viability of these approaches is already being demonstrated on a number of phased array radar projects ranging from L-Band to X-Band. Results for an ongoing S-Band Phased Array effort are the basis for this work. In this project, M/A-COM Technology Solutions' high performance pHEMT MMIC processes to produce highly integrated Tx and Rx ICs are being employed. Logic control is realized in standard low cost CMOS technology. These ICs are packaged in industry standard PQFN packages. The packaged ICs are then surface mounted to realize the T/R Module.**

I. INTRODUCTION

Phased array radar systems have been in use for literally decades in mission critical military applications where the speed of capturing necessary information spanning from horizon to horizon is paramount. As the existing radar infrastructure for commercial and civilian air traffic control, weather surveillance, marine, and active antennas in general continue to age, the main obstacle to the widespread adoption of phased array technology for these applications has been and continues to be cost.

The RF content has been identified as a major cost driver of Phased Array Radar systems. This includes the RF semiconductors, passive components and ultimately the modules which are used as the basic building blocks of the system. It is often sited that the Gallium Arsenide (GaAs) based MMIC content of a Phased Array system can represent as much as 60% -80% of the Transmit/Receive Module cost. Yet, this same fundamental MMIC technology is supporting commercial applications such as cellular telephony which has some of the most aggressive sell price requirements in the electronics industry.

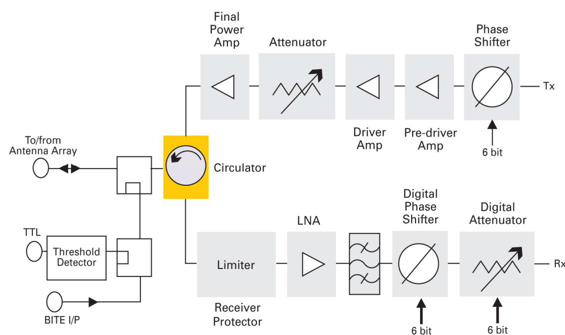

Figure 1 Basic RF Transmit/Receive Module block diagram

Applying commercial practices at the component and module level allows opportunities for cost reduction, while maintaining the required high performance can be realized. In commercial applications, cost reduction is routinely achieved through functional integration at the Integrated Circuit (IC) level. Aggressive integration and size reduction at the die level leads to increased functionality per square millimeter of semiconductor and ultimately lower cost per function.

The choice of packaging technology can be a critical expense driver at both the component and module level. Typically, hermetic, ceramic/metal-based packing is utilized in the military market for perceived reliability and performance reasons. This manufacturing approach is often extended to the module level utilizing complex multi-level ceramic substrates and hermetic enclosures. In the commercial space, non-hermetic, epoxy over-molded packages are the norm for component packaging. At the module level, printed circuit board technology dominates.

Increased integration can result in improved assembly yield through decreased part count and relaxed assembly requirements. The choice of packaging can lead to either more flexibility in manufacturing approach at the next level of assembly or dramatically restricted options.

Plastic IC packaging and printed circuit board technology has been shown to be highly robust and reliable. Under many operating conditions, standard epoxy over-molded packages have been found to exhibit equivalent or superior reliability as compared to hermetically sealed parts [1],[2]. Components and modules based on plastic packaging and printed circuit board technologies are routinely used in critical applications as diverse as automotive safety to defense ship-board radar.

A generic block diagram for a Phased Array T/R Module is presented in Figure 1. The transmit chain (Tx) consists of

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