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ADVANCED PACKAGING SOLUTION FOR RF SYSTEMS

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Abstract

Today, the System-in-Package approach offers a new dimension to system integration, far beyond mere dense micro-packaging of existing System on Chip solutions. Not only does SiP offer the capability to integrate almost any kind of companion passive component with a given active circuit, but it also enables flexible combinations of analogue circuits and RF functions with digital integrated circuits. The SiP approach is a key driver for the miniaturization trend for portable devices (Smart-phones, Tablet PCs, Smart Bluetooth Devices,..), particularly with respect to the growing number of RF functions that need to be integrated.

To date the SiP solution has been successfully applied in the RF system domain. There has been a strong market push for mobile communication devices , where the size, performance and cost are always critical .

This tutorial focuses on diverse aspects of Advanced Packaging Techniques for RF systems.

A range of currently available technological options is reviewed including organic laminates, ceramic multi-layer (LTCC), Intergrated Passive devices on silicon and glass and embedded passives/actives within the substrate.

For each technological option an indication of the tradeoffs between technical performance, size, cost and time to market is given.

Furthermore a review of specific design methodologies is also given.

Table of Contents of the tutorial

Introduction

SIP (System In package) has shown a huge growth in interest, since it brings significant advantages. These allow module designers to propose turn-key solutions in a relatively short time. So far RF systems is one of the most significant domains where SIP solutions have been applied successfully. This has been pushed by the market of mobile communication devices, where the size, performance and cost are constantly critical.

RF SiP Technological Options

The SIP concept consists of making a unique miniaturized package in which several chips have been integrated to produce a module with a specific function. Due to the progress observed in terms of RF design tool accuracy, high quality material availability and packaging techniques today it is possible to achieve a communication module for Bluetooth, WiFi or GPS where the surface is in the order of tens of mm2 with height not exceeding 1.5mm.

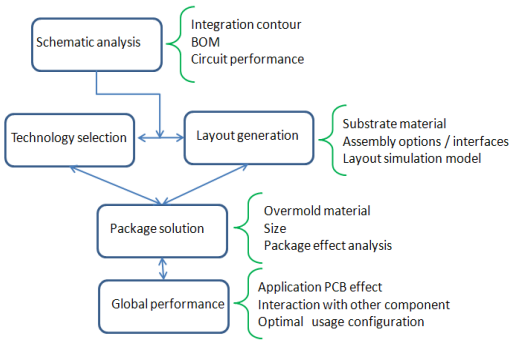
RF SiP can be realized using a multitude of technologies; for each technology a range of suppliers offer different materials, physical dispositions and properties, that require any design to be matched to the particular supplier. In this tutorial the following technologies are considered: Organic multi-layer laminate with small SMTs, Ceramic multi-layer substrates (LTCC), Integrated Passive Devices (using thin film on silicon or glass), organic laminates with embedded passives/actives and a combination of the above.

The integration level was increased over the years to be able to put inside the SIP not only active radio

chips but also antenna, and the proposed SIP called AIP (Antenna in Package) acts as autonomous module where the user doesn't have to manage the problematic of RF matching with an external antenna.

RF SiP Design Methodology

The integration of RF devices is particularly delicate, it requires a good knowledge of electromagnetic behavior of chip and its interaction with environment (i.e. PCB , over molding , shield, metal casing …) hence during the design it is essential to go through the steps as summarized in the flow chart below :



The detailed design methodology developed at Insight SiP has already been described in previous communications[i,ii]. The methodology is summarized in Figure 2.

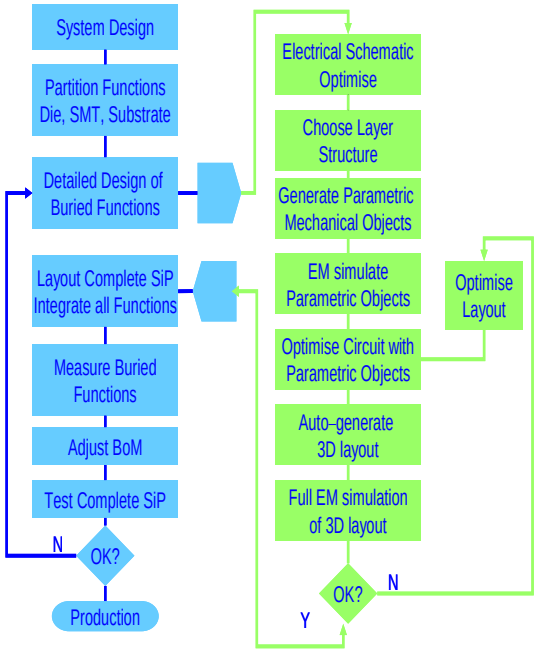


Figure 2 Insight SiP Design Methodology

The method uses a combination of circuit and electromagnetic simulation tools to create a design progressively from basic schematic representation to a complete 3D electromagnetic representation of the layout. Manufacture is only carried out on a design for which the completed layout has been fully simulated; 2.5D or 3D electromagnetic simulations are used for the passive integration (laminate, LTCC, IPD) and harmonic balance or Spice modelling for the active circuits.

RF SiP to RF AiP

The integration level has been gradually increased over the years to be able to put inside the SIP not only active radio chips but also antenna. This concept, also known as AIP (Antenna in Package) facilitates the use of an RF module that no longer needs any external RF matching since the only external RF connection is by radiation.

Examples

A series of module examples are presented in the tutorial. These include:

- Smart Bluetooth Module
- GPS Module
- 2G/3G Module
- Multi-chip module
- Antenna Tuning Module

About the Authors

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Etc.....

[i] Optimal design methodology for RF SiP from project inception to volume manufacturing, C Barratt, IMS2007 Workshop WSE System in

Package Technologies for Cost, Size and Performance, Hawaii, June 2007.

[ii] RF System in Package, design methodology and practical examples of highly integrated systems, C Barratt, IEEE Packaging Conference Como, Jan 2007.