Computational Analysis of Shielding Problems for System in Package Using VEMC System

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***Abstract*—This paper presents modelling, simulation and optimization of a radio frequency integrated circuit (RFIC)/system-in-package (SiP) for its shielding performance using a self-developed virtual electromagnetic compatibility (VEMC) system. The system is designed and proved for computational electromagnetics needs in high performance distributed and parallel computation and visualization. Optimal shielding effectiveness is to be found in relation with different combination of shield thickness, material conductivity and permeability, and frequency.**

***Index Terms*—Electromagnetic compatibility, integrated circuit, electromagnetic radiation, electromagnetic shielding, computational electromagnetics.**

I. INTRODUCTION

System-in-Package (SiP) is becoming a growing trend for the semiconductor industry, which encloses one or more integrated circuits (ICs) in a single package. It allows multiple components to be designed and configured under various technologies. According to the previous research [1], electromagnetic compatibility (EMC) challenges of ICs are turning significant due to the complicated internal structure. This paper addresses modelling, simulation and optimization of electromagnetic shielding configuration of a quad-flat no-leads (QFN) packaged radio frequency integrated circuit (RFIC)/SiP. Computation is completed by a self-developed virtual electromagnetic compatibility (VEMC) system.

II. VEMC SYSTEM

The VEMC system is aimed to provide multiple users a remote integrated EMC computation platform with high performance computation and visualization capability, specialized for electromagnetic modelling, simulation and optimization. According to the structure of VEMC prototype system (as shown in Fig. 1), each system is managed by a cloud controller (CLC). It is a central administration unit which is responsible for the management of system information, licenses of modelling and simulation software, status of all connecting nodes, user information and its access authority (AA). In the system, the CLC is connected with database server and web service manager. The database server stores web graphical user interface (GUI) and pre-defined model library. The web service manager is connected by a group of configurable nodes and one storage pool. The nodes are scalable for high performance (HP) nodes or high availability (HA) nodes using virtualization technology. The HP nodes are high performance computers which are capable of distribute and parallel computing. The HA nodes are normal desktops which are used for graphic display and general simulation. The storage pool provides storage of relative simulation software image.

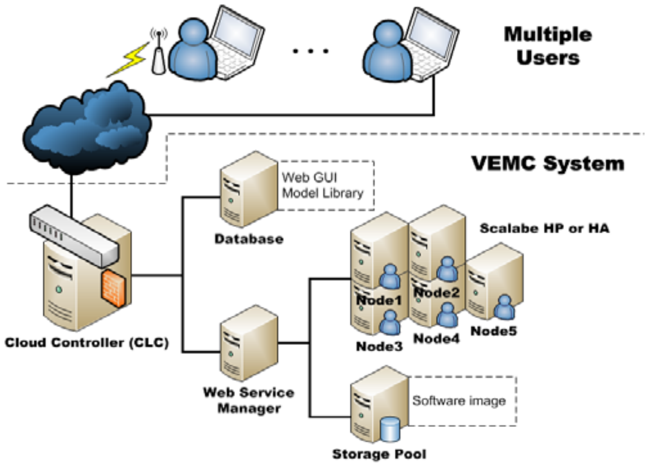

Fig. 1 Hardware structure of VEMC prototype system

III. SIMULATION AND OPTIMIZATION

A. Modelling

The selected RFIC consists of one microcontroller unit (MCU) die and one RF die using SiP technology, as shown in Fig. 2. The MCU is working at 1GHz and the RF circuit is working at 2.4GHz. The chip is packaged in a QFN package with 64 pins. The size of the QFN package is 9.6mm (length) x 9.6mm (width) x 0.75mm (height). The internal connections between die and lead frame are bond wires.

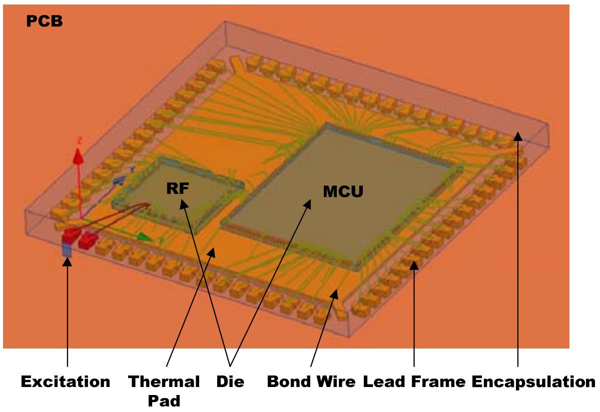

Fig. 2 Simulation model of RFIC/SiP

B. *Simulation and Results*

Simulation is conducted under an excitation with the frequency swept from 0 to 50GHz. The reflection coefficient plot, as shows in Fig. 3, indicates that there are several resonant frequencies, for example, 27.9GHz with -23.0219dB and 33.5GHz with -18.3094dB. Fig. 4 gives a near-field E-field at 27.9GHz. Energy is concentrated around the pad of die which is connecting with the excitation via bond wire. The near-field H-field distributes similar to the E-field which is not shown limited by the paper lengthens. More excitations and simulation results will be added in the full paper.

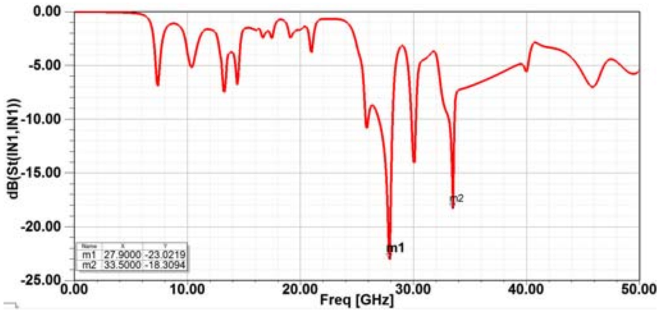

Fig. 3 Reflection coefficients of the simulation model from 0 to 50GHz

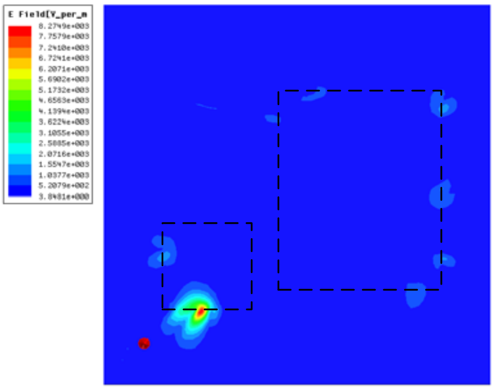

Fig. 4 Near-field E-field plot of the simulation model at 27.9GHz

C. *Shielding and Optimization*

To achieve good shielding effect, metal of high conductivity is needed for high frequency electrical field shielding and metal of high relative permeability is needed for low frequency magnetic wave rejection. The thickness of metal will also affect the shielding effect. In order to quantify the shielding capability, shielding effectiveness (SE) is defined [3] as the ratio of the incident transverse field (E_i) to the transmitted transverse field (E_t), or the incident power (P_i) to the transmitted power (P_t), in decibels. The expression can be written as:

$$\mathrm{SE(dB)} = 20\log_{10}\left|\frac{E_i}{E_t}\right| = 10\log\left(\frac{P_i}{P_t}\right)$$

The program given in Fig. 5 will perform optimization of SE using a plane wave model by an improved version of non-dominated sorting genetic algorithm (NSGA), NSGA-II [4]. Full results and analysis will be presented in the full paper.

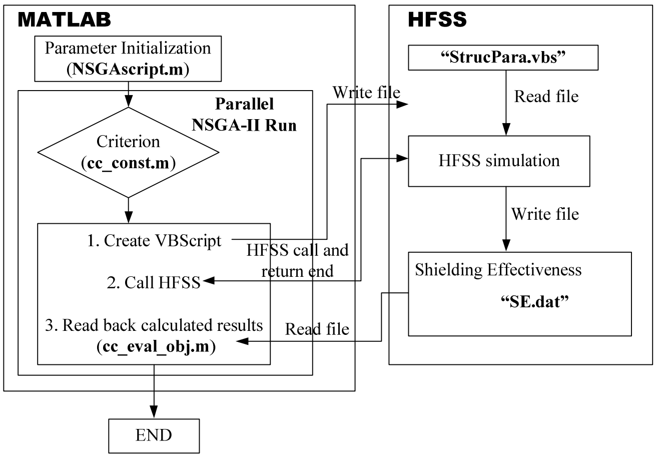

Fig. 5 Optimization program interaction between Matlab and HFSS

IV. CONCLUSION

In this paper, an electromagnetic study was presented on a RFIC/SiP. Modelling, simulation and optimization was performed by a self-developed VEMC system. Optimization of shielding effectiveness was found under different combination of shield thickness, material conductivity and permeability, and frequency.

ACKNOWLEDGMENT

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