

Chapter 14

Integrated Circuit Emission Model Extraction with a Fuzzy Logic System

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ABSTRACT

This paper describes a novel technique for multiple parameter extraction of the S12X TEM cell model using a fuzzy logic system (FLS). The FLS is utilized to capture the circuit information and to extract the circuit parameters based on experiential knowledge. The proposed extraction technique uses both linguistic information (i.e., human-like knowledge and experience) and numerical data of measurement to construct the fuzzy macromodel. The simulation results confirm the validity and estimation performance of the equivalent circuit by the advocated design methodology.

INTRODUCTION

Nowadays, the electromagnetic compatibility (EMC) analysis of integrated circuit (IC) design has become an important issue due to the rapid increasing of electromagnetic interference (EMI) and the tendency of adopting tremendous technologies such as higher operating frequency, higher dissipation and lower supply voltage (Bendhiaet al., 2005). On the other hand, the progress in the

macromodeling technology (Leontaris & Billings, 1987) extends its applications to provide representations of various kinds of ICs under measurement. It has also been integrated with more intelligent algorithms, such as fuzzy neural networks (FNNs), vector fitting (VF) and so on (Mutnury, 2005). However, the primary purpose of macromodeling is to search for a mathematical model that approximately describes input-output mapping in terms of equations. Furthermore, both

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IC vendors and designers need to extract the accurate parameters of the models.

According to its inventor, Zadeh, fuzzy logic systems (FLSs) were particularly developed as a methodology for numerical processing and other inaccurate models which have no other ways to solve this difficulty (Zadeh, 1965; Lin et al. 2007a, 2007b). Undoubtedly, fuzzy logic systems have been applied successfully in many engineering territories. Applications, such as control engines, fault tolerance, parallelism, have exhibited that fuzzy systems can produce better performance than conventional techniques. In the field of circuit design, the major benefit of an FLS is that it provides mathematical strength to the emulation of certain circuit behavior which can be substituted by simple “IF-THEN” relations instead of complicated descriptions. Then, the circuit model can infer measurement information properly by using linguistic attributes associated with human-like cognition and adoptive capacity.

According to Lin et al. (2008), an FLS was able to model high frequency effects of parasitic elements of a circuit by extracting values of symmetric parasitic capacitors. For the consideration of multiple components, organizing fuzzy sets, deciding the shape of membership functions (MFs) are required to improve the fitting performance due to the correlation among each element of models. The fuzzy set theory provides interconnection between logic and intuition by acquiring the quantitative and appropriate experiential knowledge. It forms a series of reasonable regulations or connections by means of a fuzzy inference engine (FIE) that combine fuzzy IF-THEN rules into a mapping from fuzzy sets. After aggregating the results from these fuzzy IF-THEN rules, the fuzzy defuzzifier converts the aggregation result into a crisp quantity for further processing. A suitable modeling methodology is required to increase the information of measurement through the modeler’s judgment. To this purpose, we propose an effective approach with software assistance, which has been developed to help building an integrated

circuit emission model (ICEM) (IC-EMC, 2006), by using SPICE transient simulation.

The main objective of this paper is to demonstrate the extraction capability of a single model to predict the electromagnetic emission of a digital circuit by using a FLS. The remainder of this paper is organized as follows. First we describe the model of the test chip. Next we present the framework of the FLS. Then the extracting procedure of modeling circuits with the FLS is proposed. Experimental results of the extracting procedure are given in and we conclude the findings of this study.

MODELING OF THE CIRCUIT UNDER TEST

This paper works on the model of a commercial component, which is named S12X 16-bit microcontroller and has been widely embedded in automotive electronic systems. Various conducted and radiated emission measurements were performed and a single ICEM model was proposed to predict the emission spectrum level (Labussiere et al., 2008). Radiated measurements were done in a gigahertz transverse electromagnetic (GTEM) cell designed to extend the frequency range of measurement (typically up to 18 GHz) higher than a TEM cell in the frequency domain due to its match termination and tapered structure (IC-EMC, 2002). The protocol for IC emission measurement in the GTEM cell is shown in Figure 1. For each program running in the microcontroller and the different orientations of the test board in the cell, we select the maximum radiated spectrum as the desired data. Frequency of interest is limited to be up to 2GHz.

From these measurements and the basic physical information about the circuit (technology, power supply pin number, size of the die and so on), the SPICE model shown in Figure 2 was proposed to predict the emission level of the test chip (Labussiere et al., 2008). The model of S12X

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