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FRONTIERS IN ELECTRONIC TESTING

Gloria Huertas Sánchez
Diego Vázquez García de la Vega
Adoración Rueda Rueda
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Oscillation-Based Test in Mixed-Signal Circuits

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A Pablete,

que fue testigo del final de este libro “desde dentro”.

To Pablete,

who has been witness to the finishing of this book “from within”.

Contents

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Preface

Driven by the need of reducing the defective circuits to a minimum, present-day fabrication technologies require design techniques been complemented by effective test procedures. In the case of digital ICs, there are many procedures to cope with test problems in an effective manner. However, analog integrated circuits or the analog part of a mixed-signal integrated circuit bring enormeous difficulties when dealing with the problem of how to test them adequately.

Analog circuits are difficult to test because there is a wide variety of analog building blocks, their specifications are very broad, and there is a strong dependency of circuit parameters on component variations. For mixed-signal ICs, where analog circuits must coexist with digital components, testing difficulties increase substantially because the access to both analog and digital blocks is severely restricted. The consequences are a reduced fault coverage, a higher test application time and a longer test development time.

In mixed-signal IC´s, the most difficult components to test are the analog cores, since analog test is based on checking functional specifications, what can be conflicting when test time has to be kept small, the number of available pins is reduced and full access to input/output core terminals can not be granted. Furthermore, functional test techniques greatly differ depending on the involved analog components and/or their application field, turning almost impossible to define a general (functional) test methodology applicable to any analog block.

Experience forged from the test of digital circuits encourages researchers to try structural or fault-driven test methods for analog components and explore Built-In Self-Test (BIST) alternatives as well. This has to be done in a manner that increases accessibility to provide core isolation and test resources access, but it might have a high cost in terms of area overhead, power wasting, performance degradation and/or noise and parasitic penalties. But neither moving from functional to structural testing nor incorporating BIST are trivial issues in what analog circuitry is concerned, and are still far from a wide acceptance by the designer community. This acceptance will depend on several factors like compatibility with functional test approaches, test efficiency, test confidentiality and additional design effort.

Among the emerging structural test solutions, the so-called Oscillation-Based Test (OBT) technique is very appealing. It is conceptually simple, does not demand strong circuit modifications during testing and can handle BIST (called in this case OBIST) without the penalty of dedicated, additional on-chip signal generation hardware. In broad terms, when OBT is employed no external test stimuli are required, some few simple measurements are used, and can be combined with a multiplexing scheme to probe internal nodes, thus complying with some of the factors above.

The purpose of this book is to provide the reader with a deep understanding of OBT and OBIST. The basic concepts underlying OBT/OBIST are presented, as well as the principles for applying this test methodology to complex integrated circuits. Detailed examples and practical implementation details are provided throughout the book in order to help the interested engineer to evaluate whether this technique may or may not be used for a particular appliaction. Our aim is to provide the reader with an overview of the lights and shadows this test technique offers nowadays.

Chapter 1 focuses attention on a mixed-signal structural testing methodology called Oscillation-Based Test (OBT). The state-of-the-art is reviewed, given an overview of the past, the present and the future expectations of this test method. The goal of this Chapter is to define the basics of a new improved OBT concept and overcome some of its main limitations.

Chapter 2 describes a simple, practical and intuitive mathematical approach to model the oscillators required in the OBT strategy: the Describing-Function (DF) technique. The aim of this Chapter is to provide an acceptable theoretical OBT solution which allows us to accurately predict the oscillation parameters.

Chapter 3 discusses a systematic way to apply the OBT approach to discrete-time filters. A particular discrete-time filter structure (the Fleischer and

Laker (FL) biquad) is studied in detail. The objective of this Chapter is to extrapolate the obtained conclusions in order to establish general guidelines for employing OBT to generic discrete-time filter structures.

Chapter 4 discusses a systematic way of applying the OBT approach to discrete-time Sigma-Delta (ΣΔ) modulators. The goal of this Chapter is to establish conclusions defining a general OBT procedure for generic discrete-time ΣΔ modulators.

Chapter 5 reviews the OBT implementation in some practical discrete-time filter examples. A generic biquadratic filter is studied using both, symbolic expressions and specific numerical data. The aim of this Chapter is to extract conclusions on the establishment of the test parameters, the validation of the oscillator model, the fault coverage, the test quality, etc.

Chapter 6 presents some practical considerations for the application of the Oscillation-Based Built-In-Self-Test (OBIST) to a Dual-Tone Multi-Frequency (DTMF) embedded macrocell. The objective of this Chapter is to describe an example of the integration of the OBT-OBIST technique into the frame of analog-core-based design of complex mixed-signal ICs.

Chapter 7 reports experimental results extracted by two circuit demonstrators in which the OBT/OBIST approach has been implemented. The aim of this Chapter is to experimentally validate the OBT/OBIST methodology in mixed-signal ICs.

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