

FRET 36

FRONTIERS IN ELECTRONIC TESTING

Gloria Huertas Sánchez
Diego Vázquez García de la Vega
Adoración Rueda Rueda
José Luis Huertas Díaz

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

Preface	xiii
1. OSCILLATION-BASED TEST METHODOLOGY	1
1.1 Linking Oscillation with Testing	1
1.1.1 Point of origin: Early OBT	1
1.1.2 Evolution of the OBT concept	6
1.1.3 Critical analysis of the OBT concept	8
1.2 The OBT Oscillator	10
1.2.1 Direct approach: classical linear oscillator	11
1.2.2 Second approach: oscillator using non-linear methods	24
1.2.3 Proposed approach: amplitude controlled by limitation	31
1.3 The OBT Concept Revisited: Proposal for Robust OBT	38
1.3.1 The oscillator	38
1.3.2 General circuit modifications	39
1.3.3 Start-up problem	41
1.3.4 Requiring more test information	41
1.3.5 Characterizing the test oscillator	42
1.3.6 Characterizing the test interpretation	43
1.3.7 The test process	44
1.4 Summarizing the New OBT Concept	46
2. MATHEMATICAL REVIEW OF NON-LINEAR OSCILLATORS	49
2.1 Framework	50
2.2 The Describing Function Method	51
2.2.1 A General Describing-Function for Piecewise-linear Elements	55
2.2.2 On the use of the DF method in oscillators	58
2.2.3 Convergent Equilibrium: Steady Oscillation Mode	61

2.3	Applying the DF Approach	63
2.3.1	Determining the oscillation parameters	63
2.3.2	Describing-Function limitations	67
2.4	Error Bound Calculation for the DF Approach	75
2.4.1	First proposed method	75
2.4.1.1	Example #1: Oscillator with bandpass functions of different Q	77
2.4.1.2	Example #2: (Example of Fig. 2.19)	82
2.4.2	A graphical method for a particular type of nonlinearities	84
2.4.2.1	Proposed Strategy	84
2.4.2.2	Example #3: Non oscillatory solution	90
2.4.2.3	Example #4: Existence of an oscillatory solution	92
2.5	Summary	94
3.	OBT METHODOLOGY FOR DISCRETE-TIME FILTERS	97
3.1	Feasible OBT Strategy in Discrete-time Filters	97
3.1.1	Oscillation solutions for a generic filter	99
3.1.2	Oscillation solutions for the biquadratic case	105
3.1.2.1	Type a: Delay-free loop oscillator (n=0)	107
3.1.2.2	Type b: Single-delay loop oscillator (n=1)	108
3.1.2.3	Type c: Two-delay loop oscillator (n=2)	109
3.1.3	A simple Non-Linear Block	110
3.1.4	Oscillation Conditions	111
3.2	Application to a Particular Biquad Structure	117
3.2.1	Properties of the FL-Biquad	119
3.2.1.1	The E- and F-circuits	119
3.2.1.2	Pole placement	120
3.2.1.3	Zero Placement	122
3.2.1.4	Design Equations	125
3.2.2	Applying the OBT technique to the FL-biquad	125
3.2.2.1	Regions of interest in the plane b_0, b_1	131
3.2.2.2	OBT routine	136
3.3	A Generic OBT Oscillator	137
3.3.1	Conclusions extracted by the simplified results	139
3.3.2	Conclusions extracted by the no-simplified results	141
3.3.3	Selected Generic Oscillator: Case BP10	142
3.3.4	Guidelines to implement a generic OBT scheme	142
3.3.4.1	Conclusions related to K, b_0 and b_1	142
3.3.4.2	Conclusions related to the zero placement formulas (I,J,G,H)	143

3.3.4.3 Applying the generic OBT scheme	151
3.3.4.4 Designing the oscillator	153
3.4 Summary	155
4. OBT METHODOLOGY FOR DISCRETE-TIME $\Sigma\Delta$ MODULATORS	157
4.1 OBT Concept in Low-pass Discrete-time $\Sigma\Delta$ Modulators	158
4.1.1 Basic approach: forcing oscillations using local extra feedback loops	158
4.1.2 Practical OBT scheme in low-pass 2nd-order $\Sigma\Delta$ modulators	165
4.1.3 Fault Analysis	167
4.1.4 Fault Detection	168
4.1.5 Extension to High-order Architectures	171
4.2 OBT Concept in Bandpass Discrete-time $\Sigma\Delta$ Modulators	174
4.2.1 Background	174
4.2.2 Basic OBT approach: forcing oscillations around the notch frequency	176
4.2.3 Practical OBT scheme: downsizing the oscillation frequency	181
4.2.4 Structural Test and Fault Analysis	184
4.2.5 Fault Detection	187
4.2.6 Extension to Higher order structures	191
4.3 Practical OBT Scheme for any Type of Modulators	192
4.3.1 Theoretical Normalized Oscillation Parameters	194
4.3.2 Fault Coverage considerations	200
4.4 Summary	202
5. OBT IMPLEMENTATION IN DISCRETE-TIME FILTERS	205
5.1 A Specific Circuit	205
5.2 Some Practical Examples	209
5.3 Fault Coverage Considerations	214
5.4 Oscillator Modelling Accuracy	217
5.5 DTMF Biquad Validation	219
5.1 Fault coverage considerations	223
5.2 Test Quality	223
5.6 Summary	231

6. PRACTICAL REGARDS FOR OBT-OBIST IMPLEMENTATION	233
6.1 Demonstrator Macrocell	235
6.2 Applying the OBT-OBIST Methodology to the DTMF Macrocell	240
6.2.1 Biquad-Level Test	242
6.2.2 System-Level Test	244
6.2.3 A modified System Architecture	250
6.2.4 An alternative implementation	253
6.2.5 Cells adaptation for OBIST implementation	257
6.2.6 Start-up problem	265
6.2.7 The DTMF integrated prototype	269
6.3 On-chip Evaluation of the OBT Output Signals	272
6.3.1 Using a Frequency Measurement Counter	272
6.3.2 Using a Peak Detector to determine the amplitude	274
6.3.3 Using a low-accuracy $\Sigma\Delta$ modulator	275
6.4 Electrical Simulation Results in the OBIST Mode	282
6.5 Digital Processing Part of the DTMF	284
6.5.1 Digital Detection algorithm	284
6.5.2 Steering logic	285
6.5.3 Simple Frequency Measurement Counter Block	285
6.6 DTMF/OBIST Operation Modes Description	287
6.6.1 OBIST Mode description	290
6.6.2 Test Strategy Comparison	292
6.7 Summary	294
7. OBT-OBIST SILICON VALIDATION	297
7.1 Introduction	297
7.2 First Experimental Demonstrator	298
7.2.1 Programmable biquad and fault programming	299
7.2.2 Experimental results	300
7.2.3 On-chip evaluation	324
7.3 Second Circuit Demonstrator: DTMF Receiver	327
7.3.1 Floor-Planning and Chip	328
7.3.2 DTMF Operation Modes	329
7.4 Summary	358

<i>Contents</i>	xi
Appendix 2.A	359
Appendix 5.A	375
Appendix 5.B	399
Appendix 5.C	411
Appendix 6.A	415
Appendix 7.A	419
References	439

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 enormous 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 application. 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 ($\Sigma\Delta$) modulators. The goal of this Chapter is to establish conclusions defining a general OBT procedure for generic discrete-time $\Sigma\Delta$ 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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