

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Motivation . . . . .	1
1.2	Scope . . . . .	3
1.3	Structure . . . . .	5
<b>2</b>	<b>Basics and Terms</b>	<b>7</b>
2.1	Terms and Definitions . . . . .	7
2.2	Verification Technology . . . . .	8
2.2.1	Static Verification . . . . .	9
2.2.2	Dynamic Verification . . . . .	10
2.2.3	Testbench Architecture . . . . .	13
2.2.4	Stimulus Generation . . . . .	14
2.2.5	Acceptance Evaluation . . . . .	15
2.2.6	Test Quality Criteria . . . . .	16
2.3	Verification Languages . . . . .	18
2.3.1	Temporal Logic . . . . .	18
2.3.2	PSL / Sugar . . . . .	19
2.3.3	<i>e</i> -Language . . . . .	20
2.3.4	SystemVerilog . . . . .	21
2.3.5	TTCN . . . . .	23
2.3.6	Classification Tree Method CTM and CTM/ES . . . . .	24
2.4	Electronic Design Development and Verification . . . . .	28
2.4.1	Electronic Design . . . . .	28
2.4.2	Process . . . . .	29
2.4.3	Verification Planning . . . . .	29
<b>3</b>	<b>Mechatronic System Development and Virtual Prototyping</b>	<b>37</b>
3.1	Mechatronic System . . . . .	37
3.2	Solution Patterns and Partial Models . . . . .	38
3.3	Process . . . . .	41
3.4	Virtual Prototyping . . . . .	42
3.5	Shortcomings of Mechatronic System Verification . . . . .	43
<b>4</b>	<b>Verification Plan for Mechatronic Systems</b>	<b>45</b>
4.1	Requirements for Systematic Testing of Mechatronic Systems . . . . .	45
4.2	Concept for Systematic Testing of Mechatronic Systems . . . . .	47
4.3	Systematic Testing Process . . . . .	50
4.4	Architecture of Verification Plan and Testbench . . . . .	52

4.5	Stimulus Patterns for Verification Environment Definition . . . . .	55
4.5.1	Controllability weaknesses of CTM/ES . . . . .	56
4.5.2	Enhanced CTM for Stimulus Patterns . . . . .	59
4.6	Acceptance Criteria for Verification Environment Definition . . . . .	60
4.6.1	Control characteristics for response evaluation . . . . .	62
4.6.2	Enhanced CTM for Acceptance Criteria . . . . .	64
4.7	Test Quality Criteria for Verification Environment Definition . . . . .	65
4.7.1	Characteristics of Functional Coverage . . . . .	65
4.7.2	Enhanced CTM for Functional Coverage . . . . .	68
4.8	Summary: Unified Notation for Systematic Testing Support . . . . .	70
<b>5</b>	<b>Notation of the Verification Plan Definition and Mapping</b>	<b>73</b>
5.1	Functional Stimulus Definition with Constraints . . . . .	74
5.1.1	Mapping CTM/ES Stimulus Patterns to Constraints . . . . .	75
5.1.2	Mapping Enhanced CTM Stimulus Patterns to Constraints . . . . .	80
5.2	Functional Evaluation Definition – Acceptance Criteria . . . . .	82
5.2.1	A new notation for CTM Acceptance Criteria Definition . . . . .	83
5.2.2	Mapping CTM Acceptance Criteria to a Verification Language . . . . .	88
5.3	Functional Evaluation Definition – Functional Coverage . . . . .	92
5.3.1	A new notation for CTM Functional Coverage Definition . . . . .	92
5.3.2	Mapping CTM Functional Coverage to a Verification Language . . . . .	94
<b>6</b>	<b>Application of the Verification Plan</b>	<b>107</b>
6.1	Example System: RailCab Suspension-Tilt Module . . . . .	107
6.2	Model-based Test . . . . .	108
6.2.1	Architecture and Tool Support . . . . .	109
6.2.2	Formalization of Requirements . . . . .	111
6.2.3	Creation of Testbench . . . . .	124
6.2.4	Test Execution . . . . .	126
6.2.5	Result Evaluation . . . . .	128
6.3	Towards Physical Test . . . . .	130
6.4	Summary . . . . .	133
<b>7</b>	<b>Discussion</b>	<b>135</b>
7.1	Outlook . . . . .	137