Contents

1 Introduction **1**

1.1 Motivation 1
1.2 Challenges to the Automotive Domain 4
1.3 Scope of the thesis 7
1.3.1 Problem Statement 7
1.3.2 Contribution 8
1.3.3 Outline 10
1.3.4 Publications 12

2 Testing of Embedded Systems **15**

2.1 Embedded Systems 15
2.2 Software Quality 17
2.3 Software Testing 18
2.3.1 Confidence 21
2.3.2 Test Phases 23
2.4 Model Based Testing 25
2.4.1 Black Box Testing 27
2.4.2 White Box Testing 28
2.5 Related Work in the Automotive Domain 31
2.5.1 CTM 31
2.5.2 TPT 33
2.5.3 Conformance and *IOCO* 34
2.5.4 Markov Chain Usage Models 36

3 Time Usage Model **43**

3.1 Definition 45
3.2 Modeling Elements 47
3.3 Timing Dependencies 48

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

3.4 Role in Development Process of Systems 52
3.4.1 Specification 53
3.4.2 Testing 55

4 Requirements and Specification 57
4.1 Requirements Analysis 58
4.2 Specification 62
4.3 Analysis and Formalization of the Requirements Specification . 65
4.3.1 Classic Method: Sequence Based Specification 65
4.3.2 Behavioral Equivalence Enumeration: BEE 69

5 Test Management Indicators 79
5.1 Metrics 79
5.2 Classic Markov Metrics 81
5.2.1 Test Management Indicators 82
5.2.2 Dependability Measures 87
5.2.3 Other Metrics 89
5.3 Time Usage Model Metrics 91
5.3.1 Semi-Markov Process 91
5.3.2 Mapping to Semi-Markov Processes 92
5.3.3 New Metrics 93

6 Strategies for Test Case Generation 99
6.1 Algorithms for Time Usage Models 100
6.1.1 Probabilistic Algorithms 101
6.1.2 Deterministic Algorithms 104

7 Reference Models 105
7.1 Fundamental considerations 106
7.1.1 Execution of Reference Models during Test Execution . 108
7.1.2 Execution of Reference Models during Test Case Generation 108
7.2 Combination of Aspect Models with TUM 110

8 Application 113
8.1 System Design and Specification 114
8.1.1 Model in the Loop Testing 114
8.1.2 Active Safety Presense Basic Project 115
8.1.3 Results 120
8.2 System Integration and Verification 120
8.2.1 EXtended Automation Method (EXAM) 121
8.2.2 Hardware in the Loop Testing 122

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

8.2.3 Design Patterns for Time Usage Model 124
8.2.4 Energy Management Project 126
8.2.5 Results 130
8.3 Conclusions 130

9 Conclusions **133**

10 Outlook **139**

A Acronyms and Abbreviations **143**

List of Figures **145**

List of Tables **147**

Bibliography **149**

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.