

Contents

List of Authors	xix
1 Modelling of the Manufacturing Processes.....	1
1.1 Manufacturing Systems in Electronics Production	1
1.2 Abstract Manufacturing Systems	4
1.2.1 Principles and Terms	4
1.2.2 Scheduling	15
1.2.3 Static Process Model	19
1.3 Characteristics of Technological Processes.....	29
1.3.1 The Technological Process Term	29
1.3.2 Characteristics	33
1.4 Process Characteristic.....	47
1.4.1 Explanation of the Process Characteristic Term.....	47
1.4.2 Operating Point for Technological Processes.....	50
1.4.3 Adjustment Point and Eccentricity	50
1.4.4 Variation Width of Technological Processes	53
1.4.5 Process Capability	54
1.4.6 Normal-distributed Process Characteristic	54
1.5 Measurement Characteristic	55
1.5.1 Measurement Process – Principles and Terms	55
1.5.2 Measurement and Chance.....	56
1.5.3 Measured Process Characteristic	57
1.5.4 True and Measured Yield	58
References	59
2 Structures, Graphs and Networks.....	61
2.1 Directed Graphs.....	61
2.2 Network Planning.....	64
2.2.1 Principles	64
2.2.2 CPM Network and Equivalent Representations	65
2.2.3 Determining Dates in the Network.....	67
2.2.4 Calculation of Buffer Times in the Network	70
2.2.5 Strategies in Network Planning	70
2.2.6 CPM Cost	72

2.3	Product-flow Graphs	74
2.3.1	Weighting Function for Technological Processes	74
2.3.2	Operator Technological Processes.....	78
2.3.3	Basic Structures of Technological Processes	81
2.3.4	General Structures, Regularities, Relationships	84
2.4	Queue Models.....	89
2.4.1	Demand Flows.....	90
2.4.2	Classification of Queuing Systems.....	96
2.4.3	Loss System M/M/1/0	96
2.4.4	Systems with Queue	102
2.5	Petri Nets	105
2.5.1	Definition.....	105
2.5.2	Example.....	111
2.5.3	Elementary Links in Petri Nets.....	114
2.5.4	Extended Petri Nets	116
	References	117
3	Simulation of Manufacturing Processes.....	119
3.1	Principles of the Simulation Methods	119
3.1.1	Definition of Terms	119
3.1.2	Discrete Event Simulation	120
3.1.3	Uses for the Simulation	123
3.2	Simulation Project	124
3.2.1	Preparation.....	124
3.2.2	Performing the Experiment	127
3.2.3	Evaluation.....	128
3.3	Analysis of the Simulation Results.....	128
3.3.1	Event Trace.....	128
3.3.2	Online Evaluations	130
3.3.3	Characteristic Variables.....	131
3.3.4	Representation Forms	135
3.4	The simcron MODELLER	142
3.4.1	Overview	142
3.4.2	Model Objects	143
3.4.3	Simulation Run.....	151
3.4.4	Report	152
3.5	Simulation Models.....	152
3.5.1	Flow Shop and Operating Curve	152
3.5.2	Cluster in Semiconductor Production.....	155
3.5.3	Quality Processes of Printed-Circuit Board Production	156
3.5.4	Job Shop in Electronics Manufacturing.....	158
3.6	Process-accompanying Simulation.....	161
3.6.1	Template Model.....	162

3.6.2	Integration	163
3.6.3	Comparison of Reality and Simulation	167
3.6.4	Model Adaptation.....	170
	References	171
4	Optimisation of Technological Processes	173
4.1	Calculation of Extreme Values.....	173
4.2	Linear Programming.....	175
4.2.1	Optimisation of Product Volumes – Problem.....	176
4.2.2	Optimisation of Product Volumes – Solution Method	176
4.2.3	Exchange Method and Simplex Algorithm	180
4.3	Dynamic Programming	184
4.3.1	Introduction	184
4.3.2	Example.....	184
4.3.3	Problem Definition for Dynamic Programming.....	186
4.3.4	Bellman Recursion Equation.....	187
4.3.5	Dynamic Programming Strategy	190
4.4	Simulation-based Optimisation	191
4.4.1	Principles.....	191
4.4.2	Optimisation Cycle.....	195
4.4.3	Search Algorithms	198
4.5	Optimisation with Several Goals.....	201
	References	205
5	Quality Assurance	207
5.1	General Goals and Terms	207
5.2	Description of Quality Characteristic Variables.....	209
5.2.1	Quality Characteristic Variables as Random Value	209
5.2.2	Calculation of Probabilities	210
5.3	Discrete Quality Characteristics and their Distributions	212
5.3.1	Discrete Quality Characteristic Variables	212
5.3.2	Discrete Probability Distribution.....	213
5.3.3	Distribution Function	214
5.3.4	Parameters for Discrete Probability Distributions.....	215
5.3.5	Important Discrete Probability Distributions	217
5.3.6	Uses in Module Production	220
5.4	Distribution Functions of Continuous Quality Characteristics.....	222
5.4.1	Continuous Quality Characteristic Variables	222
5.4.2	Density Function	222
5.4.3	Distribution Function	223
5.4.4	Parameters	224
5.4.5	Important Continuous Distributions	225
5.5	Evaluation of Quality Data and Point Estimates	230

5.5.1	Obtaining a Sample	230
5.5.2	Calculation of Statistical Measured Values	233
5.5.3	Random Sample and Sample Functions	235
5.5.4	Distributions and Parameters of Sample Functions.....	236
5.5.5	Point Estimates for Quality Characteristic Variables	238
5.6	Statistic Test and Interval Estimate for Quality Characteristics ...	241
5.6.1	General Problem Definition.....	241
5.6.2	Testing the Continuous Quality Characteristic Values.....	242
5.6.3	Comparing Continuous Quality Characteristic Values.....	246
5.6.4	Test Procedure for Discrete Quality Characteristic Values.	251
5.6.5	Testing of Distributions	252
5.6.6	Confidence Estimates	254
5.7	Quality–Control Charts	257
5.7.1	Introduction	257
5.7.2	Process Types	258
5.7.3	Shewhart Quality–Control Charts	260
5.7.4	Control Charts	265
5.7.5	Operations Characteristics of Quality–Control Charts	271
5.7.6	Estimating Process Parameters Using a Preliminary Run ...	274
5.8	Quality Capability of Processes.....	278
5.8.1	Process Capability	278
5.8.2	Machine Capability	281
5.9	Acceptance Sample Test.....	282
5.9.1	Introduction	282
5.9.2	Single Sampling Plans.....	284
5.9.3	Determination of Single Sampling Plans.....	289
5.9.4	Double and Multiple Sampling Plans.....	290
5.9.5	Sequential Plans.....	293
5.9.6	Sample Test for the Number of Defects per Unit.....	295
5.9.7	Variable Sampling Plans	295
5.9.8	Sampling Systems	298
	References.....	301
6	Process Cost Optimisation	303
6.1	Process Chains in Electronics Manufacturing.....	303
6.1.1	Principal Technologies of Electronics Production	303
6.1.2	Quality Assurance in Modern Electronics Production	307
6.2	Quality Cost Optimisation to Reduce Process Costs.....	310
6.2.1	Goal of Quality Cost Optimisation.....	310
6.2.2	Yield y and Defect Rate p	311
6.2.3	Basic Quality Cost Model and Quality Distribution.....	313
6.2.4	Extensions to the Basic Quality Cost Model	321
6.2.5	Features of the Inspection Process.....	328

6.2.6	Cost Model for the Sampling Test.....	331
6.3	Effects of Process Optimisation	337
6.4	Dynamic Programming to Solve Complex Process Chains	340
	References	346
7	Design of Experiments and Regression Analyses	349
7.1	General Goals	349
7.2	Regression Analysis	350
7.2.1	Problem Specification	350
7.2.2	Simple Linear Regression.....	352
7.2.3	Dual Linear Regression	358
7.2.4	Restrictions for Performing Regressions.....	359
7.3	Variance Analysis.....	360
7.4	Design of Experiments	363
7.4.1	Complete Factorial Test Designing	363
7.4.2	Reduced Test Designs	367
7.4.3	Test Designs with Repetitions	371
7.4.4	Test Designs for Nonlinear Relationships	371
7.4.5	Special Response Variables.....	373
7.4.6	Practical Recommendations for Designing Tests.....	374
7.4.7	Investigation of a Wave Soldering Bath.....	377
	References	387
8	Reliability of Products and Processes	389
8.1	Reliability Characteristics and Models.....	389
8.2	Terms and Reliability Characteristics	389
8.3	Lifetime Distributions	393
8.3.1	Exponential Distribution	393
8.3.2	Weibull Distribution.....	393
8.3.3	Use of Lifetime Distributions.....	395
8.4	Reliability Tests.....	396
8.4.1	Graphical Evaluations of Reliability Data.....	396
8.4.2	Computed Evaluations of the Results.....	398
8.5	Markov Chains	402
8.5.1	Technological Process with Two States	402
8.5.2	Two Technological Processes	406
8.5.3	Technological Processes with More than Two States	407
8.5.4	Markov Chains with Infinitely Many States.....	408
8.6	Multidimensional Process and Test Characteristics	409
8.6.1	Two-dimensional Process Characteristic.....	409
8.6.2	Process Equation	411
8.6.3	Two-dimensional Process Operator	412
8.6.4	Chain Structure of Two Technological Processes.....	412

8.6.5 Measured Process Characteristic	414
8.6.6 Measured Process Equation.....	415
8.7 Reliability of Technological Processes.....	416
8.7.1 Process Defect Rate for Several Quality Characteristics.....	416
8.7.2 Operating Point Drift.....	418
8.7.3 Momentary Yield.....	420
8.7.4 Test Blurring.....	422
References	428
9 Assembly Accuracy Theory	429
9.1 Introduction	429
9.2 Positioning Tasks for the Solder Paste Application	430
9.2.1 Machine Accuracy (Positioning Accuracy).....	430
9.2.2 Assembly Accuracy.....	434
9.3 Positioning Actions for Component Placing	436
9.4 Improvement of the Assembly Accuracy	441
9.5 Assembly Accuracy as Quality Characteristic Variables	442
9.5.1 Introduction	442
9.5.2 Placement of Components with Peripheral Leads	444
9.5.3 Placement of Area-array Components.....	447
9.5.4 Positioning Accuracy as Random Variable	452
9.5.5 Defect Rate for Placement.....	455
9.6 Machine and Process Capability.....	461
References	463
Appendix – Tables.....	465
Index.....	473