

Contents

List of variables	vi
1 Preliminaries	1
1.1 Introduction	1
1.2 Fault detection and diagnosis	2
1.3 Optimal input design	10
1.4 Review and original contributions	11
2 Sequential Probability Ratio Test	14
2.1 Introduction	14
2.2 Wald's sequential probability ratio test	15
2.2.1 Definition	15
2.2.2 Behaviour of SPRT and the ASN	17
2.2.3 Baram's distance and convergence principle	22
2.2.4 Influence of initial conditions	23
2.2.5 Application of Wald's SPRT to change detection	26
2.3 The SPRT based on Kalman filters	29
2.3.1 The SPRT based on two Kalman filters	29
2.3.2 The SPRT based on one filter	32
2.4 The multiple model method	33
2.5 The SPRT based on input-output models	35

2.6	Simulation analysis	38
2.6.1	Example 1	38
2.6.2	Example 2	41
2.6.3	Example 3	42
2.7	Conclusions	44
3	Auxiliary Signals for Improving Fault Detection	45
3.1	Introduction	45
3.2	An example	46
3.3	Input design criteria	51
3.3.1	Design constraints	52
3.3.2	Cost function	53
3.4	Off-line auxiliary signal design	55
3.4.1	The derivation of the cost function	55
3.4.2	Influence of modelling error	59
3.4.3	The effect of auxiliary signals on α	62
3.4.4	Examples	63
3.5	On-line design of auxiliary signals	66
3.5.1	The cost function of multistage auxiliary signal design	66
3.5.2	The rolling horizon	70
3.5.3	Consideration of some special cases	75
3.5.4	The resetting mechanism	77
3.5.5	One-stage auxiliary signal design	77
3.6	Simulation results	78
3.6.1	Introduction	78
3.6.2	Comparison of different auxiliary signals	80
3.6.3	Comparison of on-line designs	88
3.7	Comparison between the off-line and on-line designs	91

3.8	Conclusions	91
4	Extension To Multiple Hypothesis Testing	92
4.1	Introduction	92
4.2	SPRT for multiple hypothesis testing	93
4.3	Application to fault detection and diagnosis	97
4.3.1	Resetting	97
4.3.2	The algorithm	101
4.4	Auxiliary signal design for multiple hypothesis testing	105
4.4.1	Off-line design	106
4.4.2	On-line design	109
4.5	Simulation results	111
4.5.1	Introduction	111
4.5.2	Simulation 1	113
4.5.3	Simulation 2	114
4.5.4	Simulation 3	115
4.6	Conclusions	116
5	Modelling and Identification of the Chemical Process	118
5.1	Introduction	118
5.2	Description of the plant	119
5.3	Analysis of the fault dynamics	122
5.4	Model structure selection and experiment design	126
5.4.1	General considerations	126
5.4.2	Model structure selection	128
5.4.3	Experiment design	130
5.5	Parameter estimation and model validation	132
5.5.1	The determination of the model with tank level as output	133

5.5.2	The determination of the model with tank flow input as output	136
5.5.3	The determination of the model with pre-concentrator base level as output	136
5.5.4	The determination of the model with vapour temperature as output	137
5.5.5	Summary of the final models	138
5.6	Conclusions	140
6	Fault Detection and Diagnosis in the Chemical Process	157
6.1	Introduction	157
6.2	SPRT to detect both <i>Type I</i> and <i>Type II</i> faults	158
6.3	Detection of <i>Type II</i> faults	165
6.4	Detection of <i>Type I</i> faults	168
6.5	Decision making mechanism and the FDD scheme behaviour . . .	169
6.5.1	Decision making mechanism	169
6.5.2	FDD scheme behaviour	174
6.6	Other simulations	177
6.7	The application of auxiliary signals	178
6.8	Conclusions	180
7	Conclusions and Further Research	188
	References	189
	Appendix 2.1	198
	Appendix 3.1	200
	Appendix 3.2	202

Appendix 3.3	205
Appendix 3.4	207
Appendix 5.1	209