Table of Contents

1 Simulation and Graphical System Models	1
1.1 Setting the Stage	1 4
1.2 Networks for Eligneering 1.3 Mixed Introductory Topics	6
2 Bondgraphs as Networks for Power and Signal Exchange	9
2.1 Word Bondgraphs and Main Bondgraph Variables	9 11
2.3 Computation Marks, Power and Causality	19
2.4 Simulation from Blockdiagrams and Bondgraphs	27
2.5 Nonlinearities and Block-Bondgraphs	30
2.6 Multiport Bondgraph Elements	39
3 Simulation and Design of Mechanical Engineering Systems	41
3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters	41 41
3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference	41 41 41
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving 	41 41 41
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 	41 41 41 41 44 50
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 	41 41 41 44 50 54
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 	41 41 41 44 50 54
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 	41 41 41 44 50 54
3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies	41 41 41 50 54 57
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 4 Simulation of Fluid Power Systems and Hydrostatic Drives 4.1 Hydrostatic Power in Fluid Flow 	41 41 41 44 50 54 57
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 4 Simulation of Fluid Power Systems and Hydrostatic Drives 4.1 Hydrostatic Power in Fluid Flow 4.2 Valve Controlled Actuators and Servomotors 	41 41 41 50 54 57 57 64
 3 Simulation and Design of Mechanical Engineering Systems 3.1 Opening of the Application Chapters 3.2 Mechanical Systems with Ground Reference 3.3 Systematic Writing of Mechanical Bondgraphs with Moving Reference Points 3.4 Slip, Clutches and Electric Induction Motors 3.5 Transmissions and Efficiencies 4 Simulation of Fluid Power Systems and Hydrostatic Drives 4.1 Hydrostatic Power in Fluid Flow 4.2 Valve Controlled Actuators and Servomotors 4.3 Circuits and Hydrostatic Transmissions 4 Special Components and Devices 	41 41 41 50 54 57 57 64 68 71





Ť

s Z

•	
5 Electrical Circuits, Drives and Components	80
5.1 Electric Circuits and Components	80
5.2 Electric Motors	82
5.3 Capacitors, Inductors, Actuators and Real Transformers	89
6 Computational Overview, Practical Procedures and Problems	95
6.1 Programs for Simulation from a Bondgraph	95
6.2 Linear Control Theory, Eigenvalues and Calculating Step	96
6.3 Stability Preview and Steady State Bondgraphs	99
6.4 Eigenvalue Estimation and Dynacheck	103
6.5 Causality Problems and Algebraic Loops	108
6.6 Compact Parameters and Paracheck	115
6.7 Causal Loops and Inspectional Analysis	119
	117
7 Applications to Thermodynamics, Chemistry and Biology	123
7.1 Meet and Love Entrony	123
7.2 Convection Matter Flow and Solar Energy	128
7.3 Networks in Chemistry and Physics	135
	155
8 Selected Questions	139
8.1 Multibonds, Robotics and Circuit Theorems	139
8.2 Bondgraphs for Elements Distributed in Space	144
8.3 Shocks. Collisions and Hysteresis	150
8 4 Analogies Linear Granhs and Portality	155
8 5 The Problem of Alternating Current Bondgraphs	162
5.5 The Problem of Alternating Current Dondgraphs	102
9 Further Worked Examples	165
9 1 Hydraulic Evamples	165
0.2 Thermofluid Examples	17/
	1/4
Appendices	177
A1 Organization of Bondgraph Courses	177
A2 Note on Bondgraph Standards and Graphics	170
A3 Table of the Main Bondgraph Elements	101
	101
Glossary of Frequent Terms in English, French, and German	183
References	185
Subject Index	187