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3.6.1 Arrhenius Equation; 3.6.2 Conservation of Energy; 3.7 Side Reactions and Aging; Problems; 4 Discretization Methods; 4.1 Analytical Method; 4.1.1 Electrolyte Diffusion; 4.1.2 Coupled Electrolyte-Solid Diffusion in Pb Electrodes; 4.1.3 Solid-State Diffusion in Li-Ion and Ni-MH Particles; 4.2 Pad Approximation Method; 4.2.1 Solid-State Diffusion in Li-Ion Particles; 4.3 Integral Method Approximation; 4.3.1 Electrolyte Diffusion; 4.3.2 Solid-State Diffusion in Li-Ion and Ni-MH Particles; 4.4 Ritz Method; 4.4.1 Electrolyte Diffusion in a Single Domain; 4.4.2 Electrolyte Diffusion in Coupled Domains; 4.4.3 Coupled Electrolyte-Solid Diffusion in Pb Electrodes; 4.5 Finite-Element Method; 4.5.1 Electrolyte Diffusion; 4.5.2 Coupled Electrolyte-Solid Diffusion in Li-Ion Electrodes; 4.6 Finite-Difference Method; 4.6.1 Electrolyte Diffusion; 4.6.2 Nonlinear Coupled Electrolyte-Solid Diffusion in Pb Electrodes; 4.7 System Identification in the Frequency Domain; 4.7.1 System Model; 4.7.2 Least-Squares Optimization Problem; 4.7.3 Optimization Approach; 4.7.4 Multiple Outputs; 4.7.5 System Identification Toolbox; 4.7.6 Experimental Data; Problems; 5 System Response; 5.1 Time Response; 5.1.1 Constant Charge/Discharge Current; 5.1.2 DST Cycle Response of the Pb-Acid Electrode; 5.2 Frequency Response; 5.2.1 Electrochemical Impedance Spectroscopy; 5.2.2 Discretization Efficiency; 5.3 Model Order Reduction; 5.3.1 Truncation Approach; 5.3.2 Grouping Approach; 5.3.3 Frequency-Response Curve Fitting; 5.3.4 Performance Comparison; Problems; 6 Battery System Models; 6.1 Lead-Acid Battery Model; 6.1.1 Governing Equations; 6.1.2 Discretization using the Ritz Method; 6.1.3 Numerical Convergence; 6.1.4 Simulation Results; 6.2 Lithium-Ion Battery Model; 6.2.1 Conservation of Species; 6.2.2 Conservation of Charge; 6.2.3 Reaction Kinetics; 6.2.4 Cell Voltage; 6.2.5 Linearization; 6.2.6 Impedance Solution; 6.2.7 FEM Electrolyte Diffusion; 6.2.8 Overall System Transfer Function; 6.2.9 Time-Domain Model and Simulation Results

Sommario/riassunto

A complete all-in-one reference on the important interdisciplinary topic of Battery Systems Engineering. Focusing on the interdisciplinary area of battery systems engineering, this book provides the background, models, solution techniques, and systems theory that are necessary for the development of advanced battery management systems. It covers the topic from the perspective of basic electrochemistry as well as systems engineering topics and provides a basis for battery modeling for system engineering of electric and hybrid electric vehicle platforms.

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