Design and Application of Battery Systems

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(Primary and Secondary Cells)

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The widespread use of primary (non-rechargeable) and secondary (rechargeable) batteries has resulted in a proliferation of battery designs, and the demand for higher performance energy storage. Recent advances in battery chemistry, such as metal hydride and Lithium ion cells, have increased the options available to the designer of energy storage systems. This diverse selection of battery technologies, coupled with improvements in manufacturing technology, power management, charging and control techniques, has increased the options available to the designer of energy storage systems. This seminar is intended to give the student a basic understanding of battery system design and application. The seminar covers two aspects of system design: battery chemistry and application design. The topics covered in the battery chemistry section include: chemical-energy storage theory, primary and secondary cell types, commercially available products, failure mechanisms, and safety considerations. Application design topics include system design requirements, maintenance, advanced charging techniques, performance optimization, support circuit design, fault condition handling, supervisory controls, and future trends in battery powered systems. Practical design examples are used to illustrate the concepts covered in the seminar.

After completing the seminar, the student will be able to specify the requirements for battery systems, select appropriate batteries, and design an integrated system from commercially available components.

Pre-requisites: Basic inorganic chemistry, basic semiconductor electronic circuits and systems.

Ken Arnold is President of HiTech Equipment Corporation, where he supervises the design and development of battery powered systems such as security systems, pagers, and communications devices employing primary and secondary energy storage systems. Mr. Arnold is an instructor of Electrical and Computer Engineering courses at the University of California at San Diego, Extended Studies, where he has instructed eight different courses since 1982. Mr. Arnold is also a member of several curriculum development committees at UCSD. Mr. Arnold is author of the text "Embedded System Design," as well as numerous papers. He is also listed in "Who's Who in California."

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PART I -- Battery Design and Characteristics

5 Examples of Commercially Available Batteries

- Applications
- Manufacturers
- Comparative Performance
  - Capacity
  - Density
  - Life
  - Cost
- Example Battery Designs

6 Wear-out & Failure Mechanisms

- Operating Lifetime
  - Deep Discharge
  - High Temperature Charging
  - Over Charging
- Failure Modes
  - Cell Reversal
  - Shorted electrodes
  - Recovery
  - Venting
  - Overcharge
  - Over Temperature
- High Temperature Charging Effects
- Charge "Memory"

7 Safety Aspects

- Storage
- Operating
  - Discharge
  - Charge
- Venting
- Hazardous Materials
- Disposal
- Recycling

PART II -- Battery Operated System Design and Application

1 Systems Design

- Specifying the Storage System Requirements
- Battery Technology Selection
- Design Considerations
- Supervisory Circuits
- Applications
- Examples

2 Simple Charging Circuits

- Constant Voltage
- Constant Current
- Isolation from Charging Source

3 Maintenance and Charging

- Operating Temperature Effects
- Charging Temperature Effects
- Parametric Variations
  - Manufacturing Variations
  - Operating Life Variations

4 Charge and Discharge Cycles

- Discharge Rate vs. Capacity Interaction
- Temperature Effects on Cell Capacity
- Normal Charge
- Trickle Charging
- High Charge Rate

5 Theoretical vs. Practical Performance

- Output Voltage
- Capacity
  - Energy Capacity (energy/mass)
  - Volumetric Efficiency (energy/volume)
- Peak Output Current Limitations
- Maximum Charging Current Limitations

6 Power Conversion Circuits

- Voltage Conversion
- Voltage Inverters
- Power Source & Load Switching