Reconfigurable Array of Inexpensive Batteries Architecture

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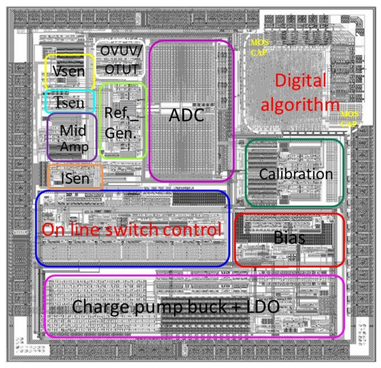
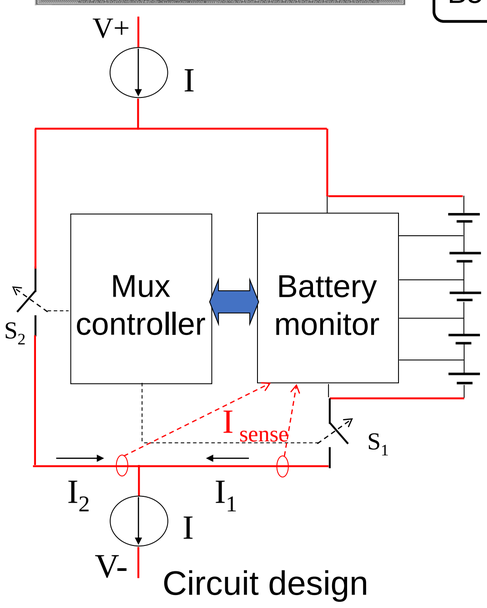
Introduction

- Batteries play a key role in renewable energy storage systems (ESS) and are important for data center energy cost reduction, but they remain expensive despite many innovations over the years.
- RAIBA is designed for ESSs built from retired batteries.

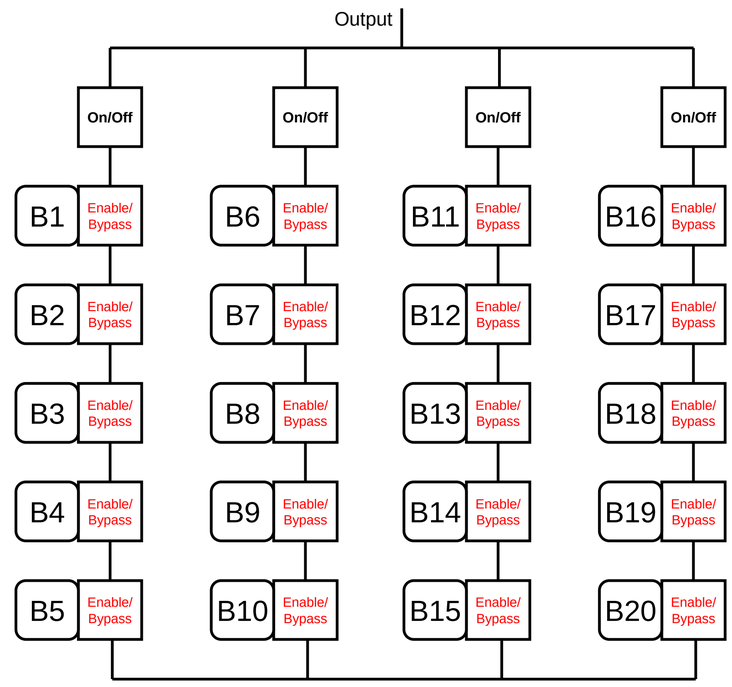
RAIBA

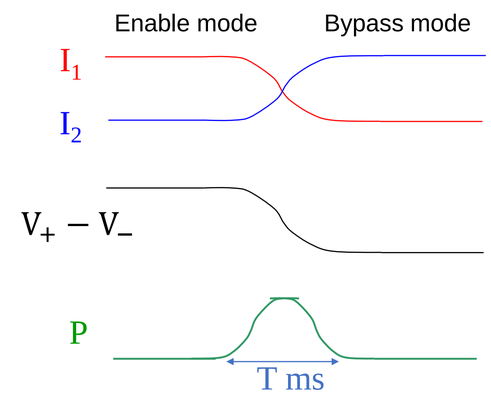
- **Pain points for ESSs using retired batteries**
  - Heterogeneous charging/discharging characteristics
  - Safety of retired batteries
  - Non-battery cost – Batteries 60-70%, PCS 30~40%
- **Dynamically reconfigurable connectivity**
  - Enable/bypass batteries in a column
  - Turn On/off columns of the array
- **Challenges of circuit implementation**
  - Minimize switching energy loss
  - On-line reconfigurability – constant output current
  - Guaranteeing operational safety





Circuit design





Transient electric behavior

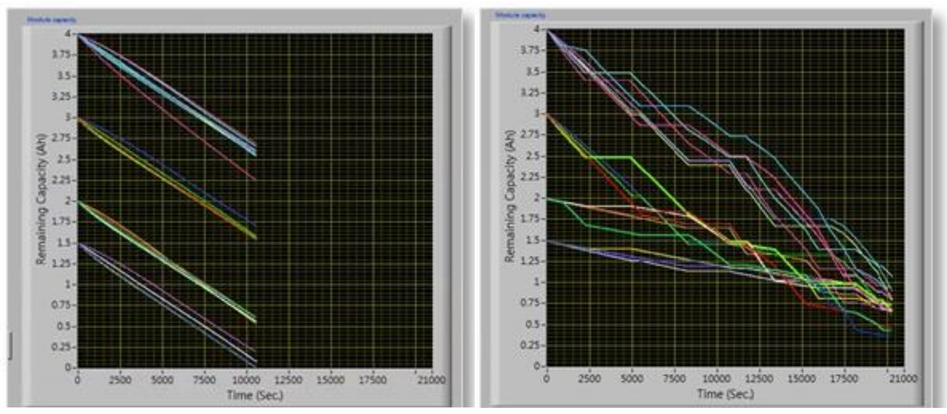
Hardware Support

- **Circuit design**
  - Enable/bypass/disable mode
  - Battery monitor – temperature, V and I
  - Constantly measure and feedback-control
  - Constant output current during switching: $I_1 + I_2 = C$
- **Minimal switching energy loss (15V, 12A)**
  - Bypass – 30μsec, 1.8mJ
  - Enable – 50μsec, 3.0mJ

Software Support

Configuration control algorithm

- Capacity balancing – Equalize residual capacities of batteries
- Utilization efficiency maximization
  - Energy output of each charge and discharge cycle
  - Number of charge/discharge cycles



The RAIBA Prototype

- **5×5** array of battery modules – 2.5KWh
- Battery module – 30Ah
  - An enable/bypass switch
  - **4S2P** 15Ah LiFePO4 cells
- RAIBA controller – ACCA algorithm
- Battery measurement and communication
- Surge protection

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RAIBA