ADVANCED LEAD ACID BATTERIES FOR GRID STORAGE

AS STATIONERY ENERGY SOURCE

Commonwealth

BATTERIES

Reference and applicability

- Large-scale battery banks in utility system
- Complexities of distributed energy system
- Improving Performance
- Battery management, controls and safety
- Battery with DC link capacitor

BATTERIES

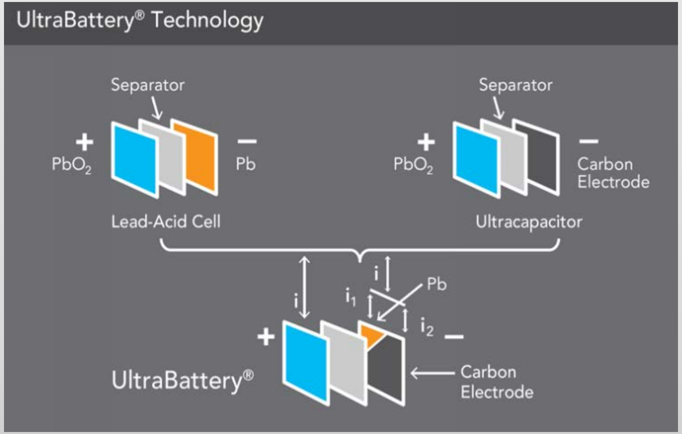
Large scale banks in utility system

- **Advanced Lead Acid**
- Electrodes: Lead oxide, lead and carbon
- Electrolyte: Sulfuric acid

↑ Relatively high energy

- Higher rate partial state-of-charge operation

↓ Short lifespan, need temperature control



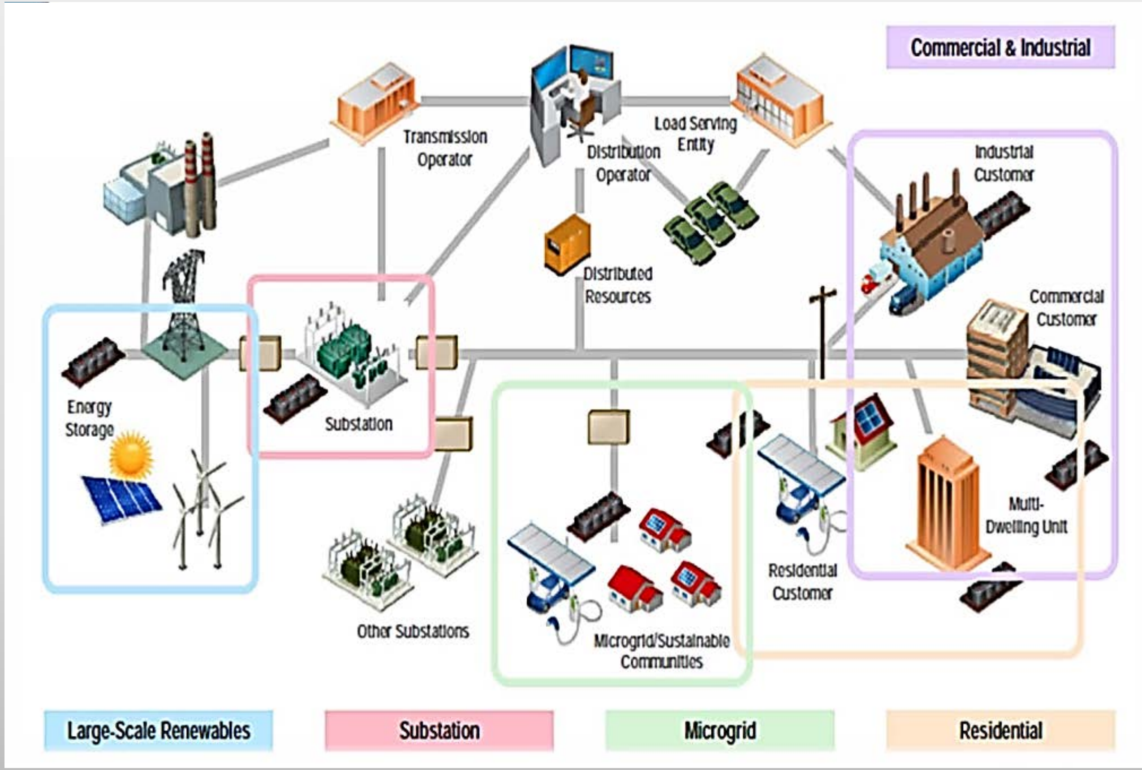
Sketch courtesy: ecoult, http://www.ecoult.com/technology/ultrabattery/

CHALLENGES

Complexities of distributed energy system

- Battery banks stabilize intermittent power sources
- Stationary storage to adjust load profile
- Provides voltage support and frequency regulation
- Supports small microgrid power systems
- Behind meter residential energy storage

ENERGY STORAGE HAS POTENTIAL APPLICATIONS ACROSS THE ENTIRE ELECTRICITY ENTERPRISE VALUE CHAIN

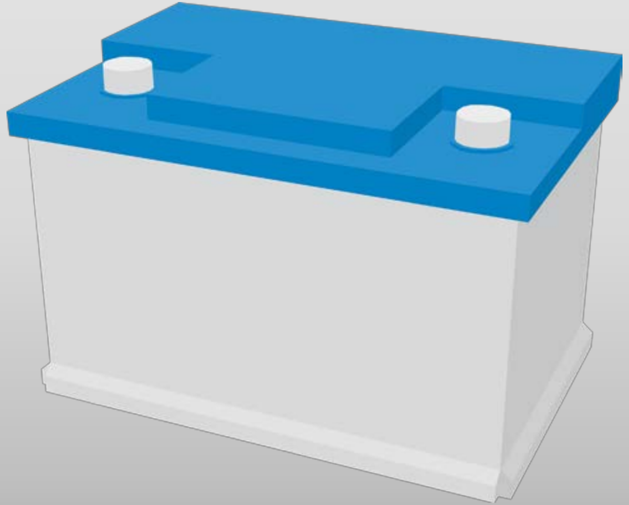


Source: EPRI

OPPORTUNITIES

Improving performance – Advanced lead acid batteries

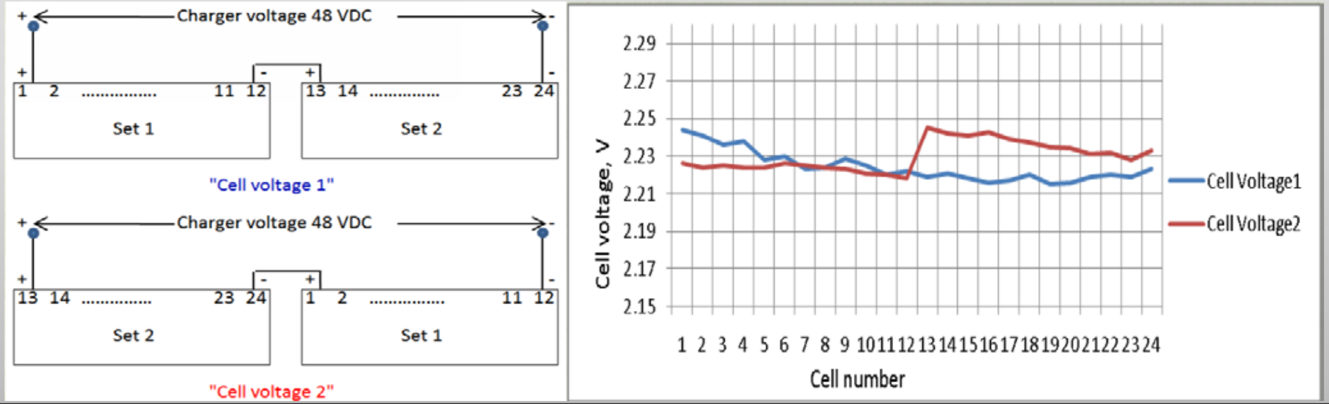
- Many cells in series/parallel combination
- Long usage causes stratification of electrolyte
- Deposit of lead sulfate: Cell degradation



OPPORTUNITIES

Improving performance – Advanced lead acid batteries

- Charging 2 series connected banks
- Each bank – 12 cells/2 v each
- Bank position switched: Cell voltage improved



OPPORTUNITIES

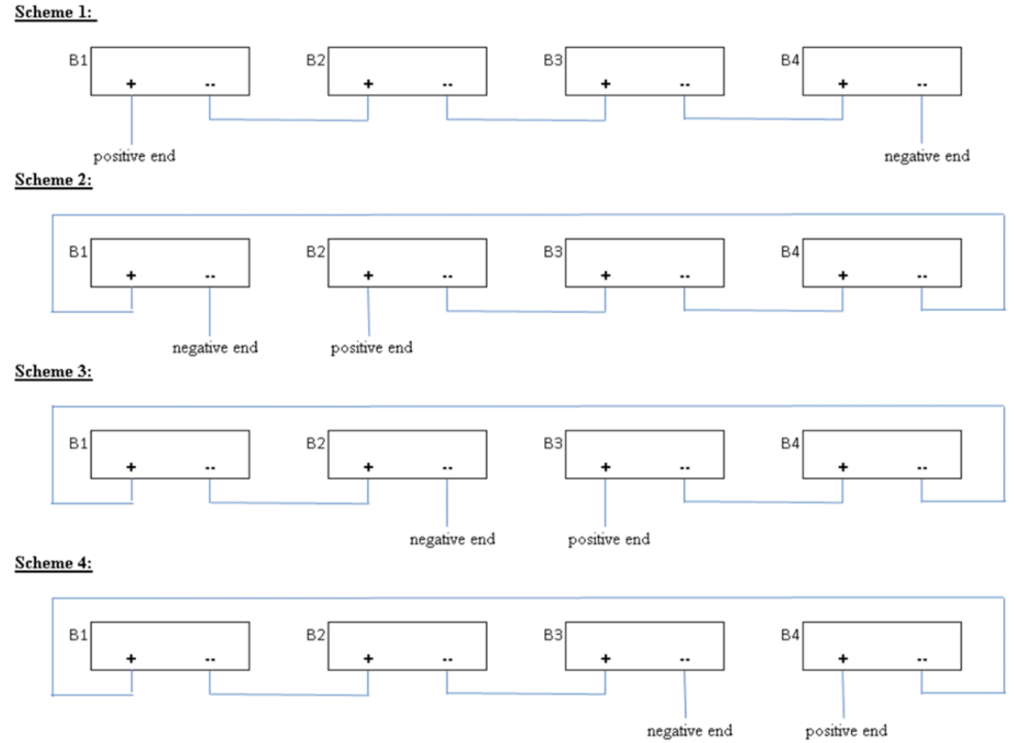
Improving performance – Advanced lead acid batteries

- Cell switching scheme
- Measure and find lowest voltage cell
- Set corresponding switch and reset others

IF V_{B1} = MIN{V_{B1}, V_{B2}, V_{B3}, V_{B4}} THEN SET S_{W1} = 1, RESET S_{W2}, S_{W3}, S_{W4} = 0;
ELSE_IF V_{B2} = MIN{V_{B1}, V_{B2}, V_{B3}, V_{B4}} THEN SET S_{W2} = 1, RESET S_{W1}, S_{W3}, S_{W4} = 0;
ELSE_IF V_{B3} = MIN{V_{B1}, V_{B2}, V_{B3}, V_{B4}} THEN SET S_{W3} = 1, RESET S_{W1}, S_{W2}, S_{W4} = 0;
ELSE_IF V_{B4} = MIN{V_{B1}, V_{B2}, V_{B3}, V_{B4}} THEN SET S_{W4} = 1, RESET S_{W1}, S_{W2}, S_{W3} = 0;
END_IF ;

IMPROVEMENT

Switching schemes

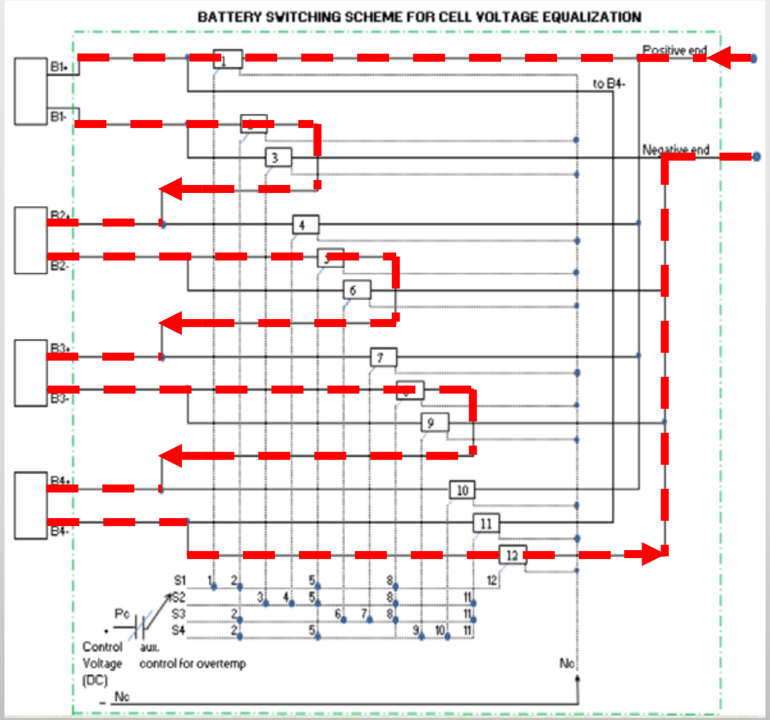


IMPROVEMENT

Battery management, controls and safety

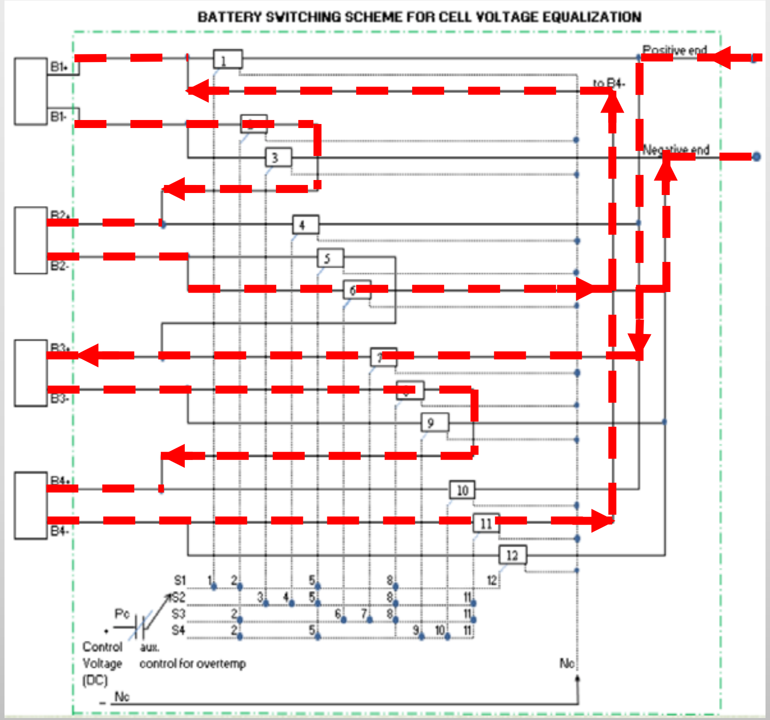
If Cell B1 is at lowest voltage, S1 is connected.

Current flow



IMPROVEMENT

Battery management, controls and safety

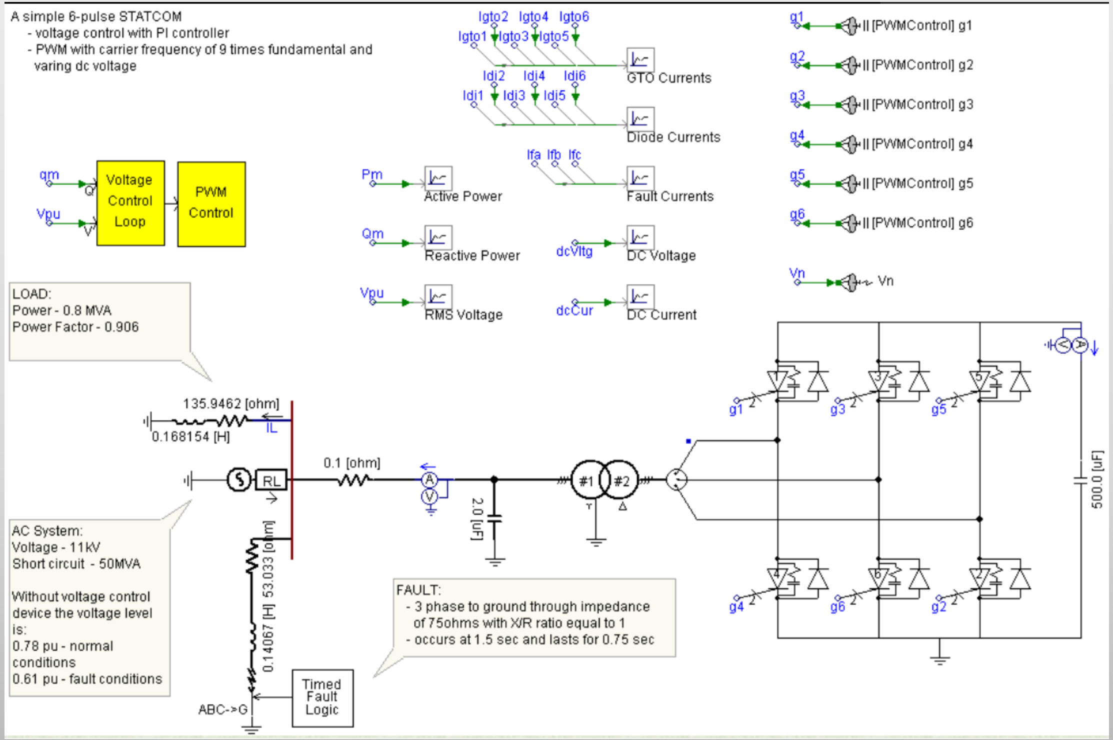


If Cell B3 is at lowest voltage, S3 is connected.

Current flow

IMPROVEMENT

Adding a battery bank to a DC link capacitor

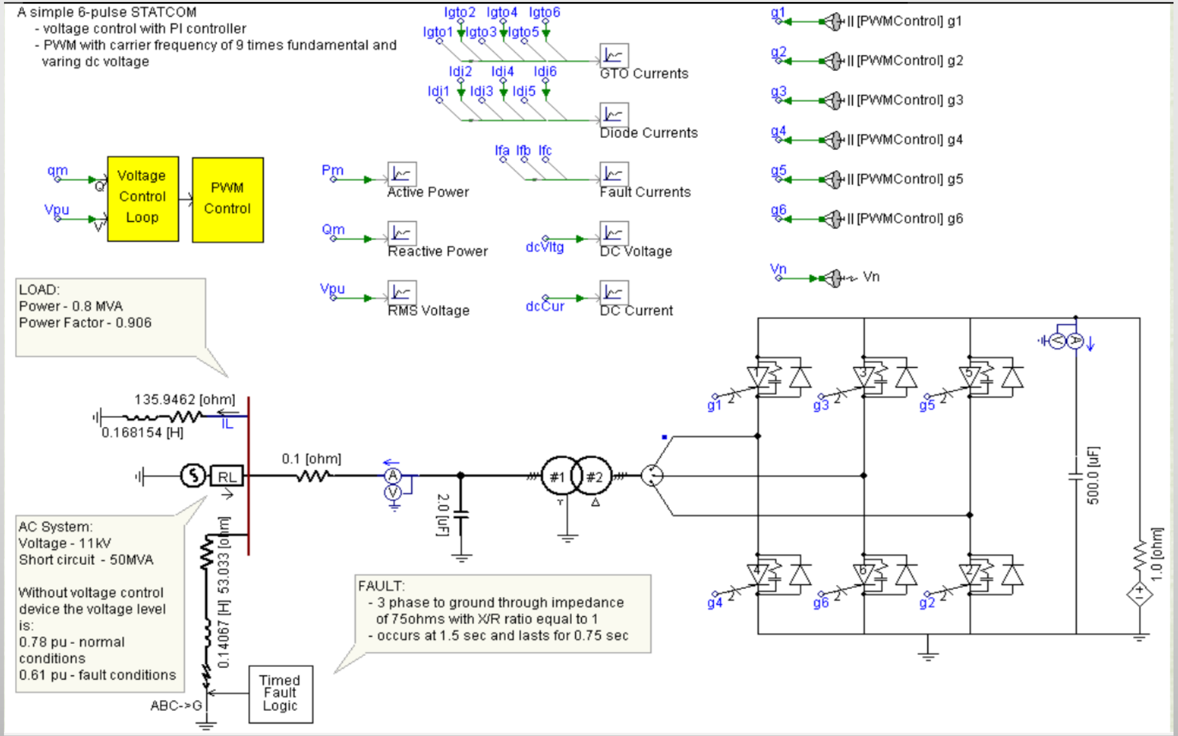


IMPROVEMENT

STATCOM fault response without battery

IMPROVEMENT

Battery bank added to DC link capacitor of STATCOM



IMPROVEMENT

STATCOM fault response with battery

BETTING ON OUR FUTURE…

Key stationary energy storage growth drivers

Increasing renewable penetration and changing electricity mix

- Solar PV added 46 GW in 2016 to 302 GW (+18%)
- Wind added 55 GW in 2016 to 487 GW (+13%)
- US coal plant retirements in 2015: 15 GW to 313 GW (-5%)

Climate and energy storage regulations

- Paris COP21 signed by 195 countries
- Renewable energy goals set by numerous nations
- Renewable Portfolio Standards in most US states
- California's AB2514: 1,325 MW of energy storage by 2020

Needed investments in grid infrastructure

- Grid investment not keeping up with electricity growth rates
- Distributed generation is challenging the historically unidirectional grid system
- Microgrids for energy security
- Smart grid initiatives

Vehicle electrification

- Vehicle and industrial electrification to reduce carbon and other emissions

Battery improvements

- Capital cost reductions
- Power and energy performance increases
- Improvements in battery cycle life

Source: Primus Power

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