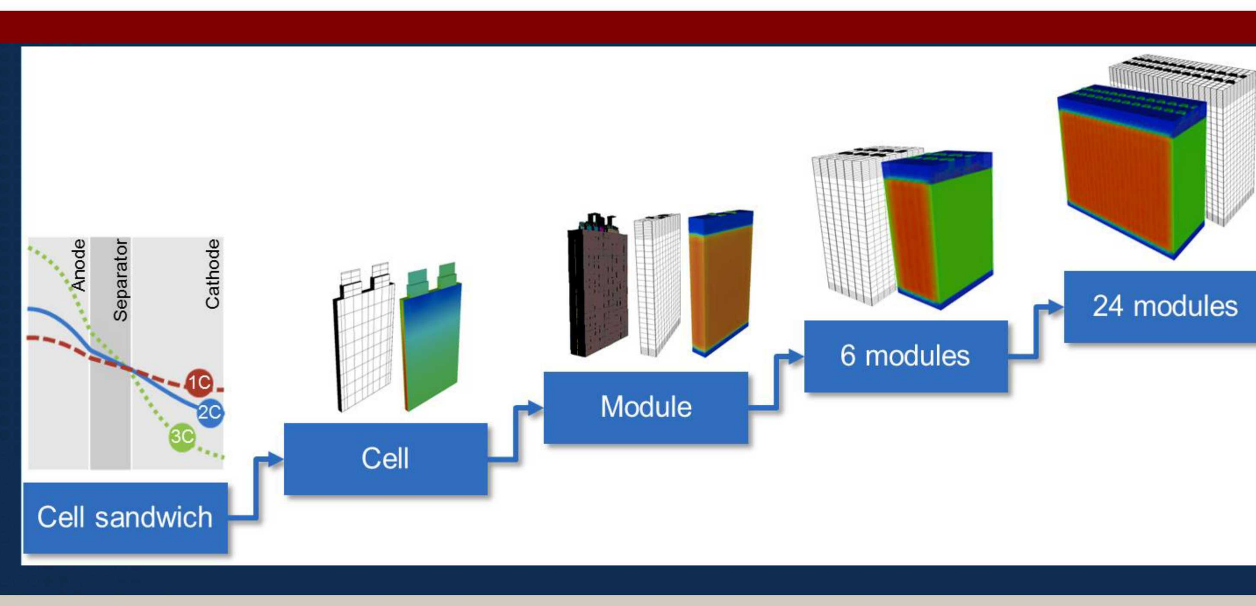


MABC based Distributed power processing for Li-ion batteries

Nataraj Pragallapatti, Satish Ranade
Klipsch School of Electrical Computer Engineering New Mexico State University
Las Cruces, NM

Stan Atcitty, J A Mueller
Sandia National Laboratories
Albuquerque, NM

Project Goal

Investigates processing of energy at the cell level (battery, cell) battery energy storage system by power conditioning circuits

- improved efficiency of the overall stack.
- improved safety and reliability through battery level analytics
- Reliable energy storage can significantly improve the Grid reliability and Resilience.

Accomplishments for Year-1

- Design and analysis of Dual Active Bridge Converter (DABC) based Distributed Power Processing (DPP)
- Complete the prototype of Micro-DABC for the Li-ion battery cell.

Objectives for Year-2

- Design and analysis of Multi Active Bridge Converter (MABC) based DPP
- Voltage droop for co-ordination of multiple parallel sources (i.e. MABC's)
- Develop the prototype of MABC for two Li-ion cells.
- Finite Element Analysis of High Frequency Transformer

Features of MABC-DPPB

- monitoring SOC, temperature of each cell
- independent charge/discharge control of each cell based on cell health
- maximizing bidirectional utilization.
- efficiency improvement [due to zero voltage switching] of MABC at low power level by controlling $T_1, T_2, .., T_n$.
- Safety and Reliability

Diagram of Distributed Power Processing Configuration

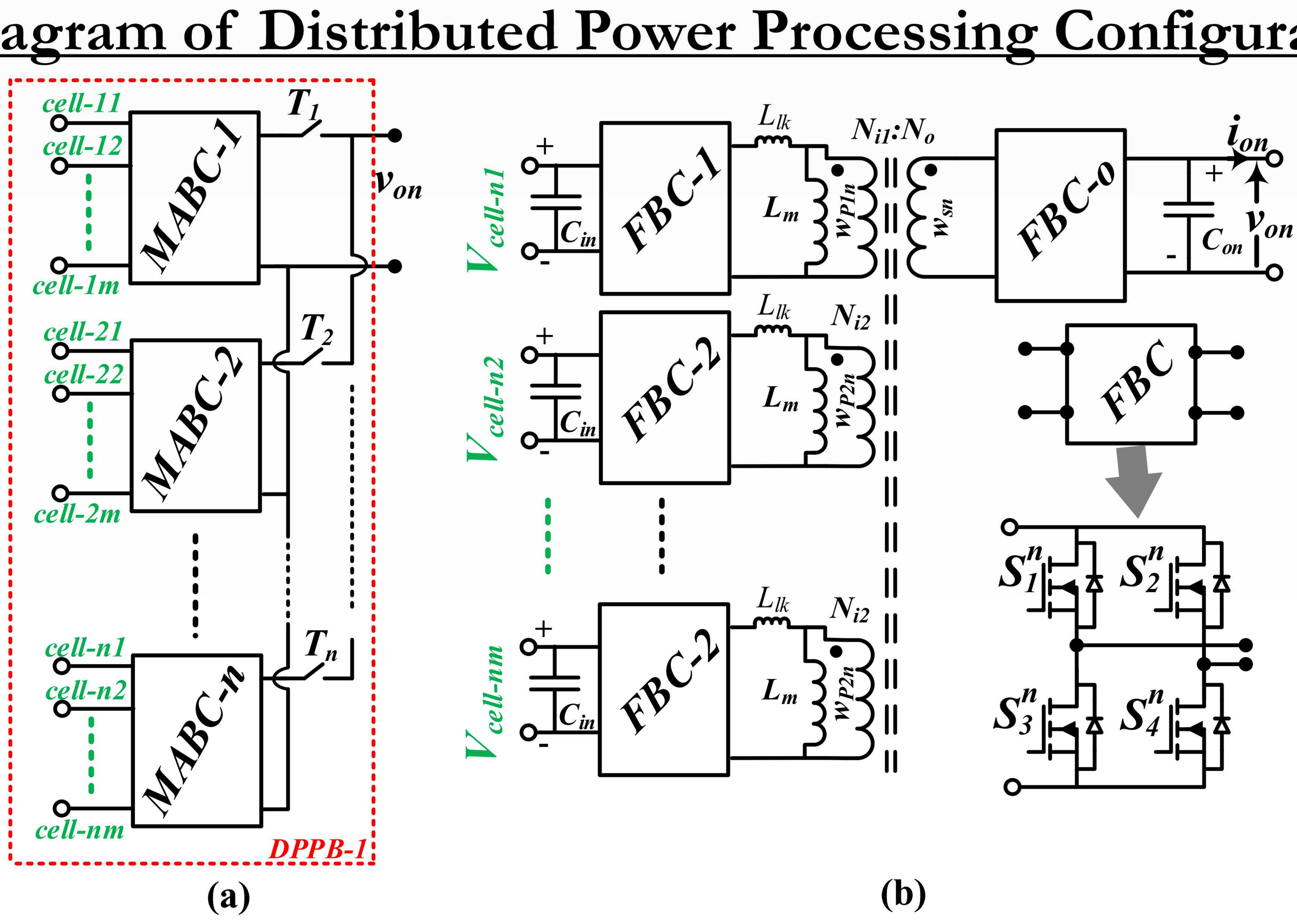


Fig. (a) Distributed Power Processing structure based BESS (DPP-BESS); (b) Multi Active Bridge Converter (MABC)

Control strategy of MABC

- (a) To ensure the uniform current sharing of the parallel MABCs, virtual resistances (R_d) are assumed in series with the output of each MABC. $V_{on\_ref} = V_{ref} - i_{on} R_d$
- (b) Voltage regulation issue can be mitigated by using the secondary voltage controller, i.e., adding the voltage compensation to primary voltage of the controller. $\delta V_o = \left(K_p + \frac{K_i}{s}\right)(V_{o_{ref}} - v_o)$
- (c) Equal SOC regulation of all cells in each MABC to improve the life time.

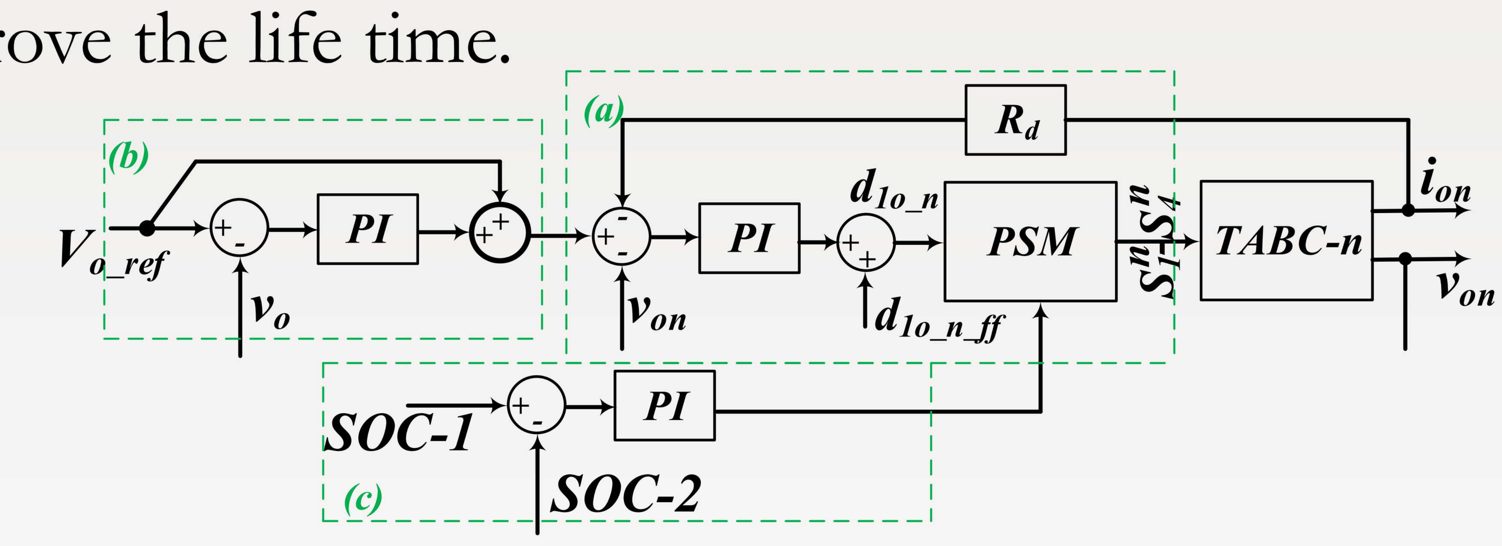
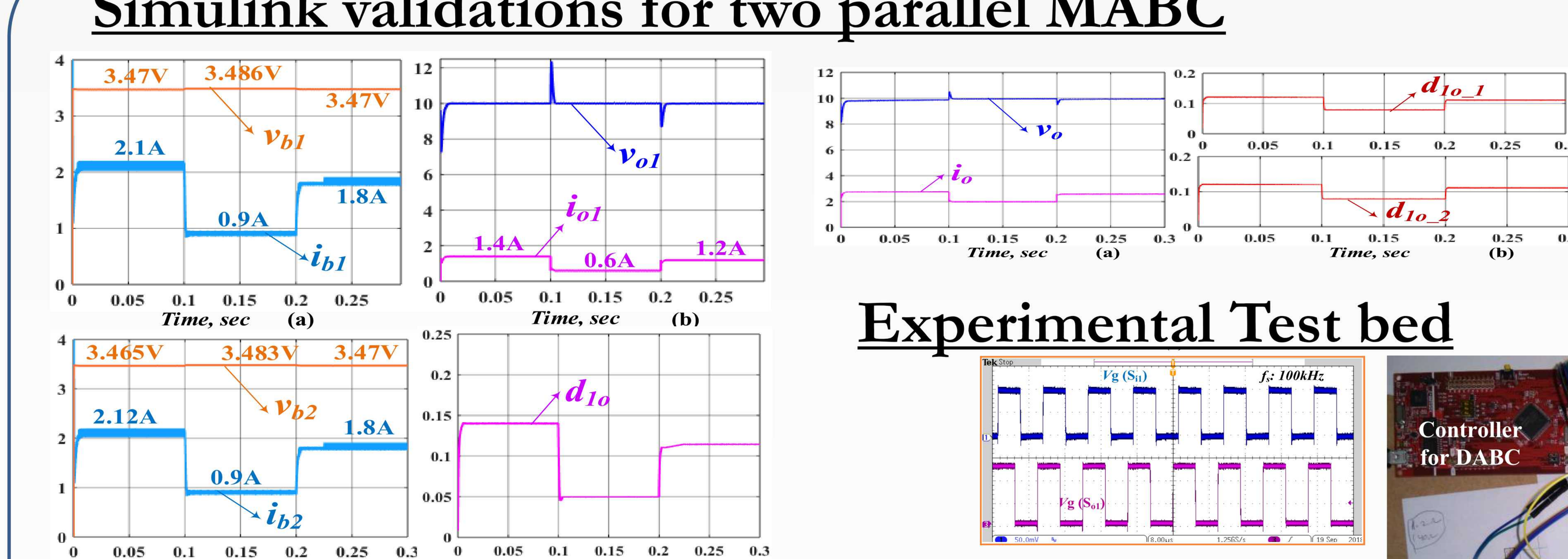


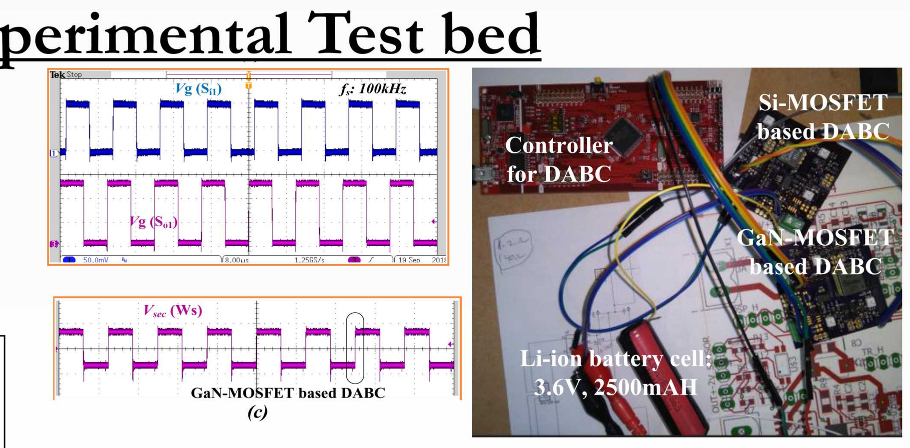
Fig. Local control scheme for the MABC-n.

Simulink validations for two parallel MABC



Spec: f_s:0.1MHz,, V_{in}:3.3V; R_L:50 Ω;PCB:2.1"x2.2"
HFT: Ferrite core, 0.19:1, L_{leak}= 4μH (referred to sec.)
MOSFET: GaN: EPC2040,EPC2014; TMS320F28377S DSP

Experimental Test bed



- Lab prototype validations are underway.

Future work

- Efficiency analysis and optimal power control of MABC
- Health monitoring of DPP based battery
- Complete prototype pack

Recent Publications

[1] Nataraj Pragallapati, Satish J Ranade, and S. Atcitty, "Secondary Voltage and Droop Control Strategy of Parallel Converters based Cell Level BESS", *IEEE International Conference on RTEICT*, 2018.

[2] N. Pragallapati, S. J. Ranade, M. Jacob and S. Atcitty, "Distributed TABC based Bi-Directional Converter for Cell/Sub-Modular Level Battery Energy Storage System," *2019 IEEE Texas Power and Energy Conference (TPEC)*, Texas, 2019.

The authors gratefully acknowledge support for this work from the U.S. Department of Energy, Office of Electricity, ES program and Dr. Imre Gyuk.