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The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION
BARCELONA
17th-20th November 2013

Novel Bidirectional Multiple-Input Multiple-Output Converter for Simultaneous Direct Battery Module Balancing

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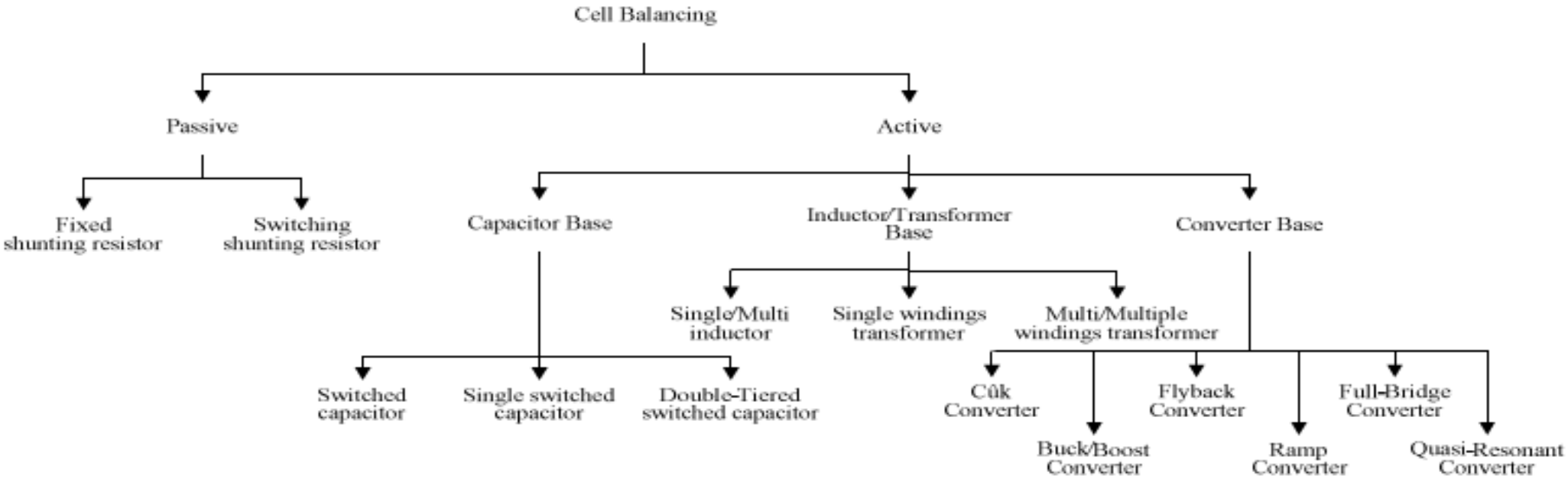
In collaboration with EVAAP EDTA
Supported by European Commission

Outline

1. **Categories for Balancing Topologies**

2. **Direct, Simultaneaous and Bidirectional Balancing**
   a) **Topology**
   b) **Operating Sequence**
   c) **Mathematical description**

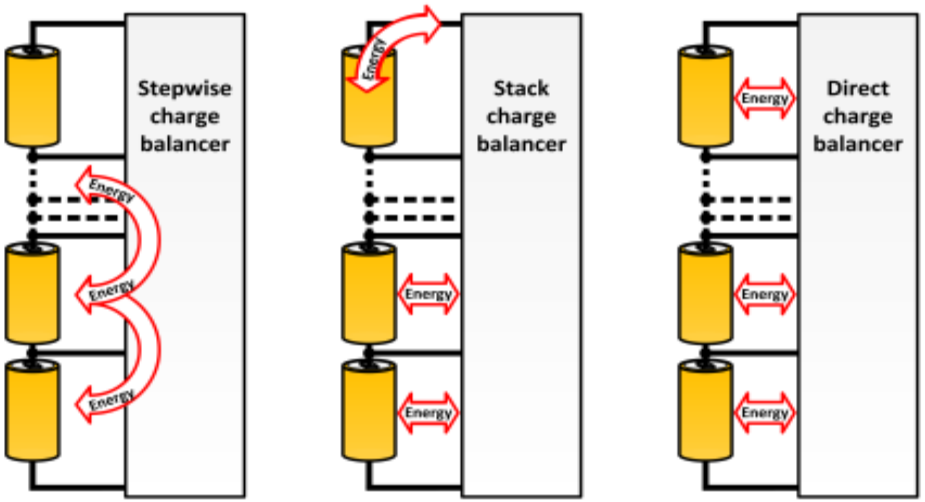
Hardware dependent Categories for Cell Balancing



Source: M. Daowd, VPPC, 2011

Hardware independent Categories

Balancing Path	Concurrence	Direction
Stepwise	Sequential	Unidirectional
Stack	**Simultaneous**	**Bidirectional**
Direct		



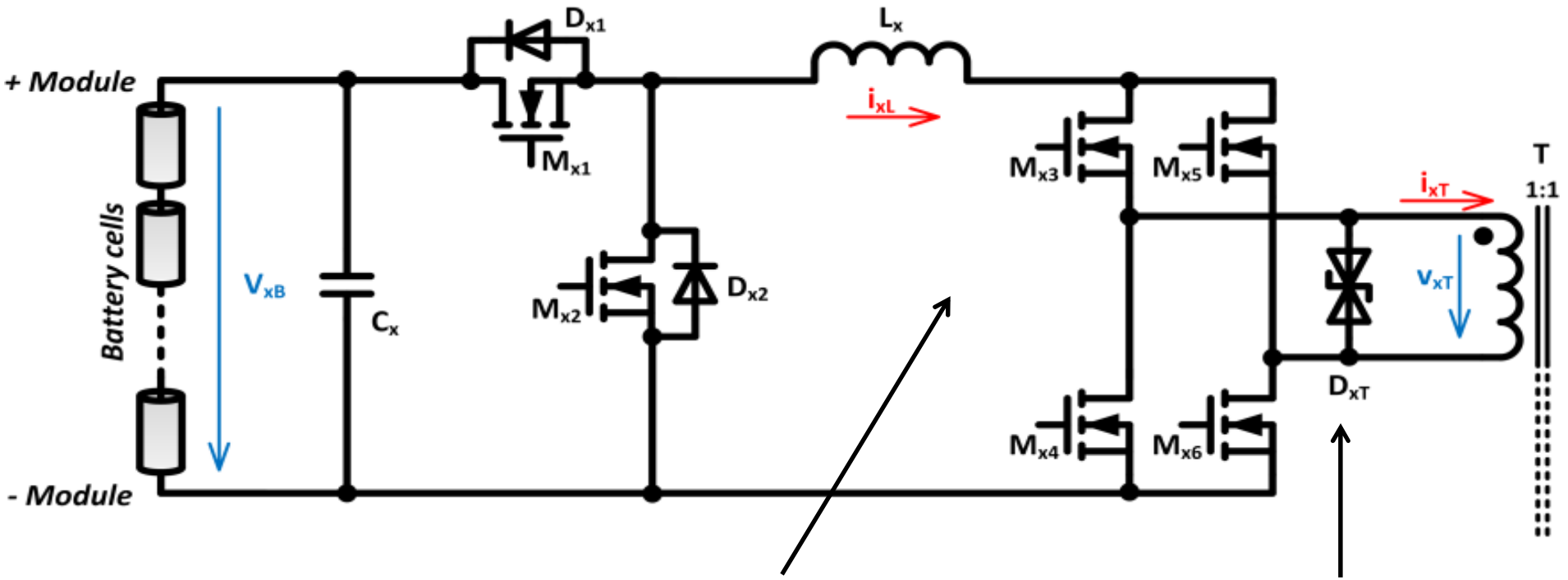
Topology of a single channel

Battery Module

Buck/Boost Converter

Full Bridge

Common Transformer



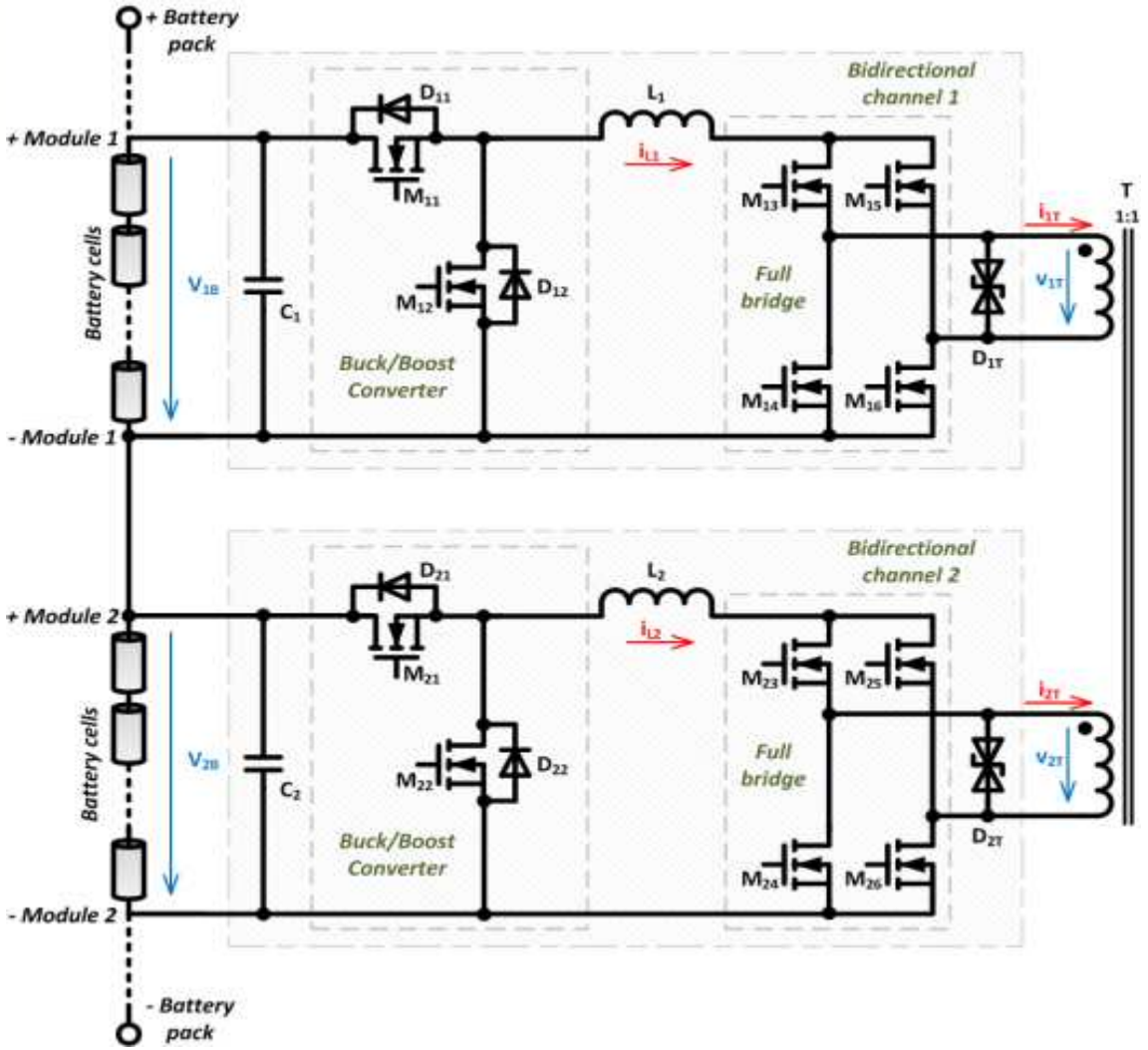
No Capacitor

Clamping Diode

Topology of a 2 channel balancer

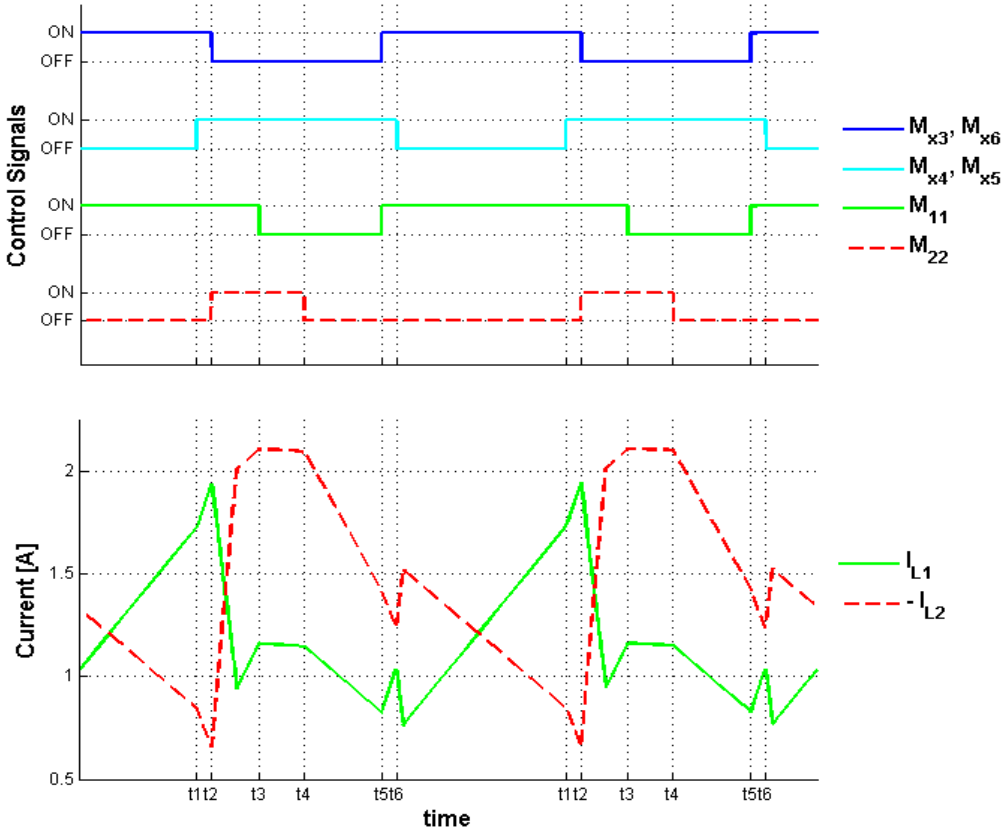
Battery module 1

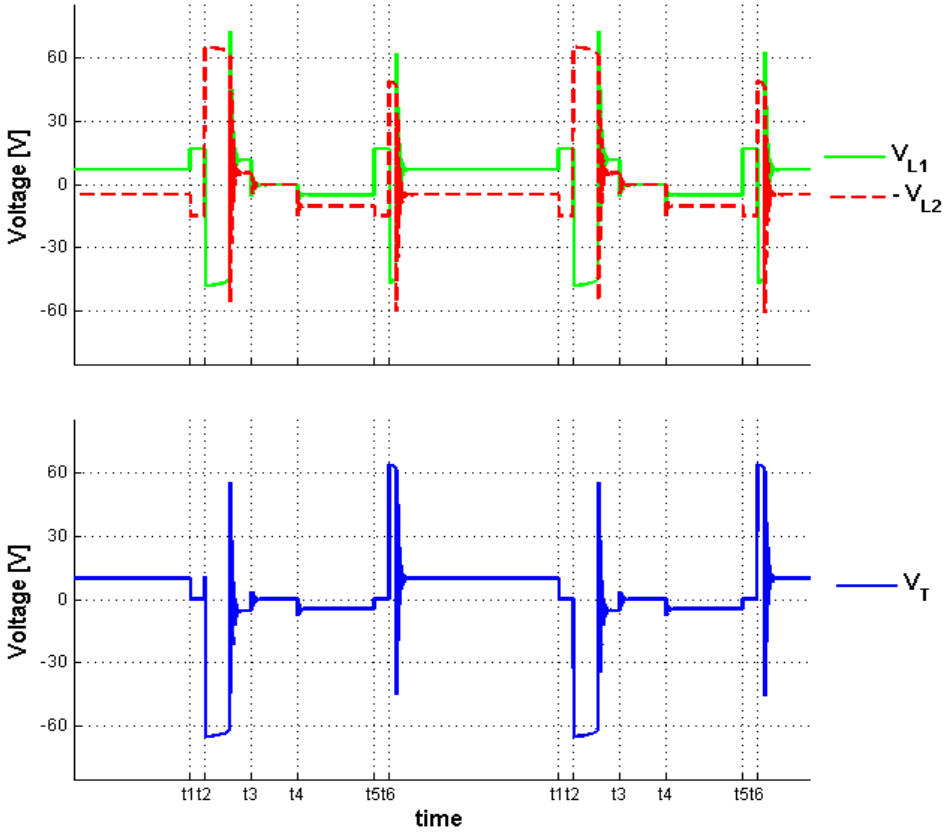
Battery module 2



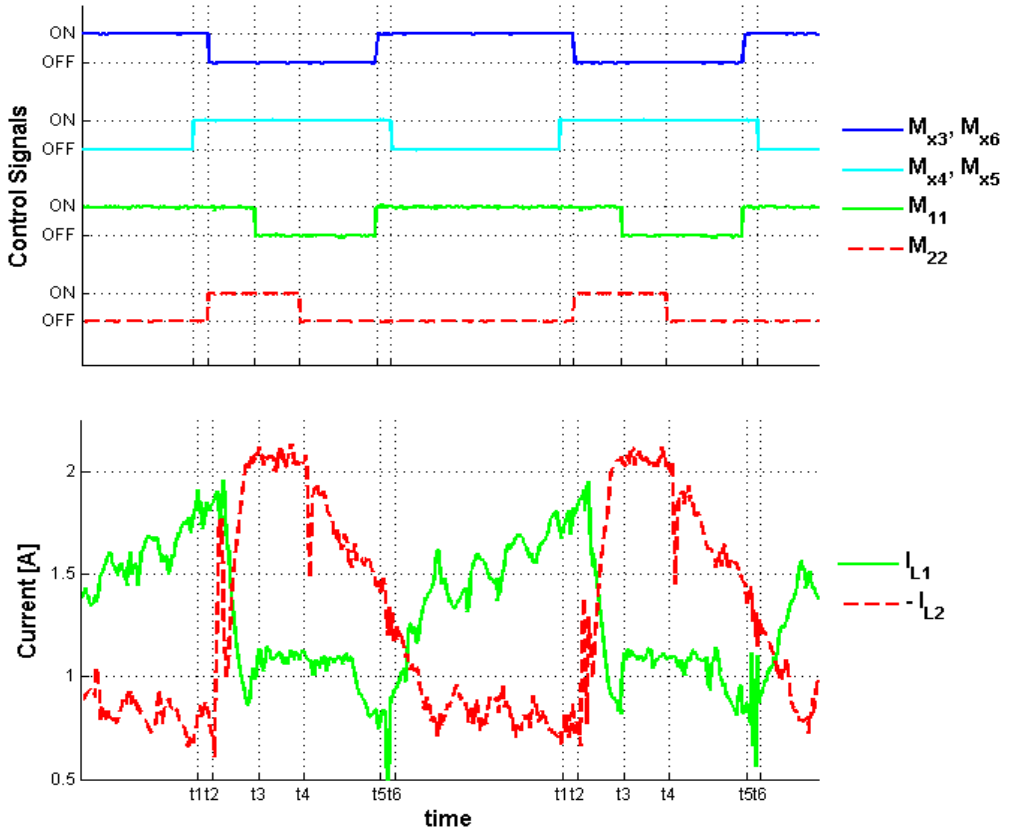
Common transformer

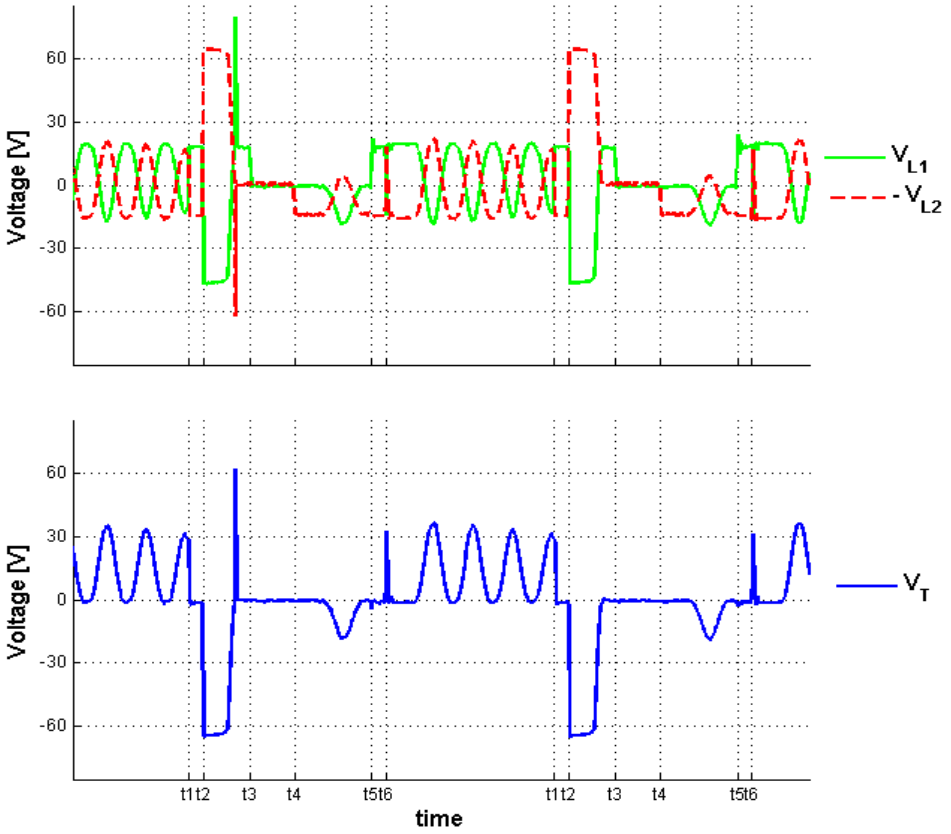
Operating Sequence: Simulation





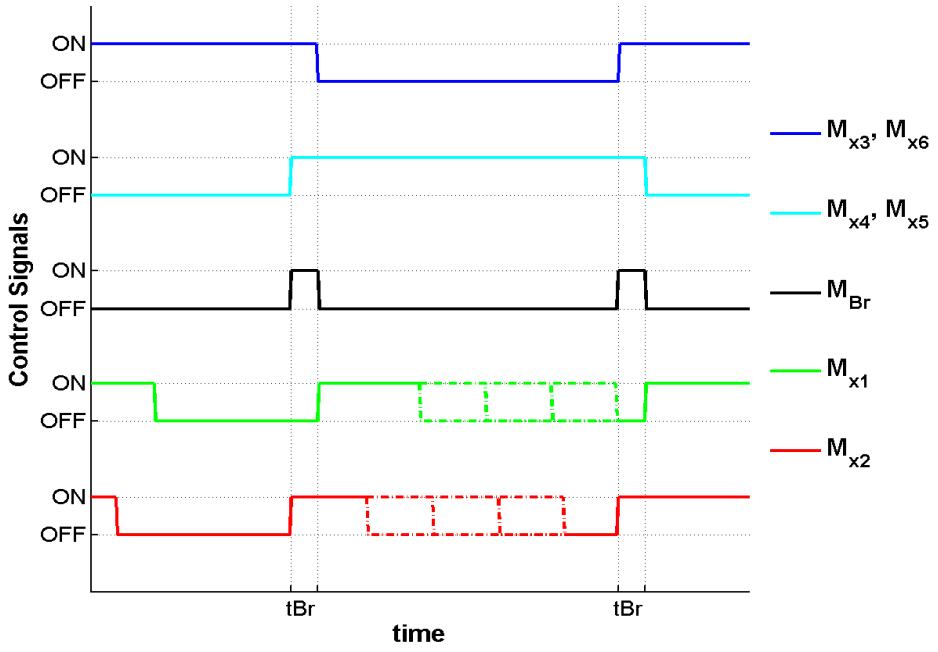
Operating Sequence: Measurement



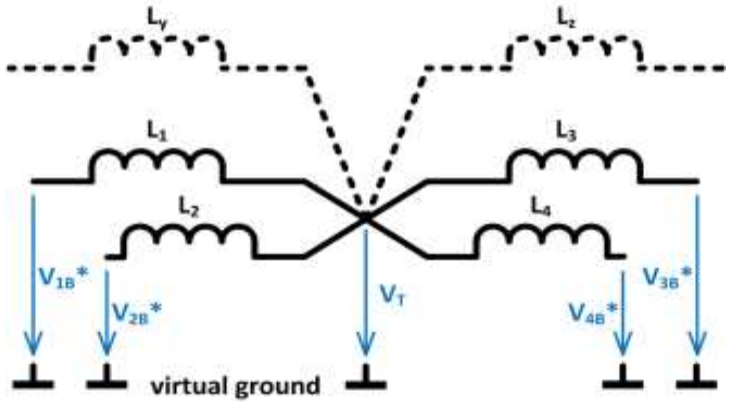


Measures to Reduce Voltage Clamping

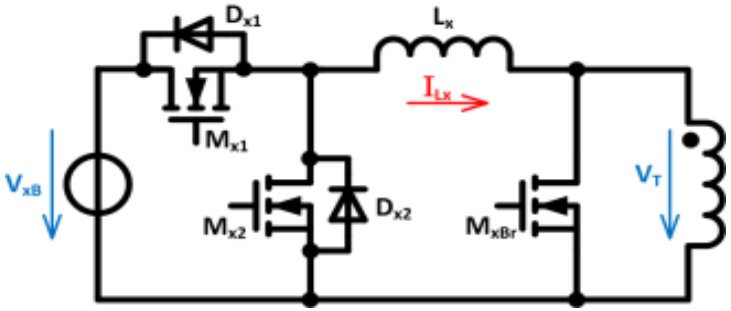
- Decrease L_σ of the common transformer
- Increase L_H of the common transformer
- Avoid changes of the transformer current during the short circuit of the H-bridge by
  - turning OFF M_{x1}
  - turning ON M_{x2}
- Clamp the voltage to the battery module input.



Time Averaged Equations



$$V_T = \frac{\sum_{x=1}^{n} V_{xB}^*}{n}$$



$$V_{xB}^* = V_{xB} \cdot d_{x1} \cdot (1 - d_{x2}) \cdot (1 - d_{Br})$$

$$\frac{dI_{Lx}}{dt} = \frac{(V_{xB} - V_T)}{L_x}$$

Outlook and Summary

Summary

- The best suitable hardware independent characteristics of regenerative charge balancers are direct, simultaneous and bidirectional charge transfer
- A topology with these properties has been proposed, its functionality described and verified with a 2 channel prototype.

Outlook

- Developing a control method based on the derived equations
- Measure the efficiency and compare it to other charge balancers

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Outlook and Summary

Thank you

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