EMR'23, Lille (France)

http://emrwebsite.org

EMR-based comparison of Cascaded H-Bridge and conventional inverter for EV traction chain

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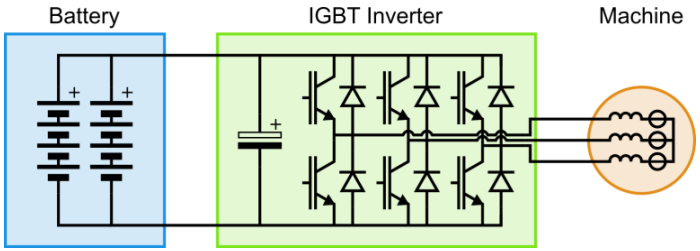
- Outline -

1. Cascaded H-Bridge structure
2. EMR and modeling
3. Simulation results on efficiency

Cascaded H-Bridge structure

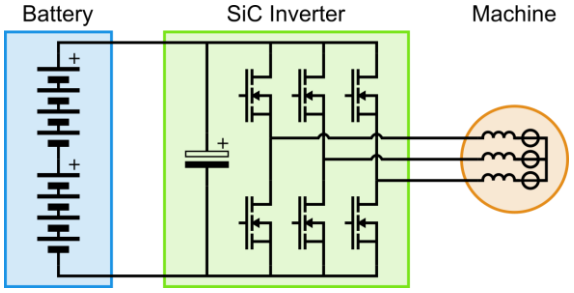
EV Traction Chain

Nowadays

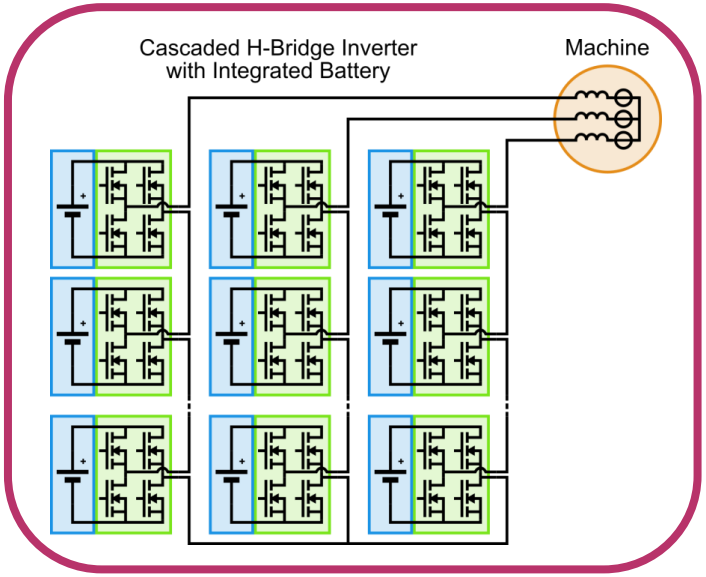


In the Future

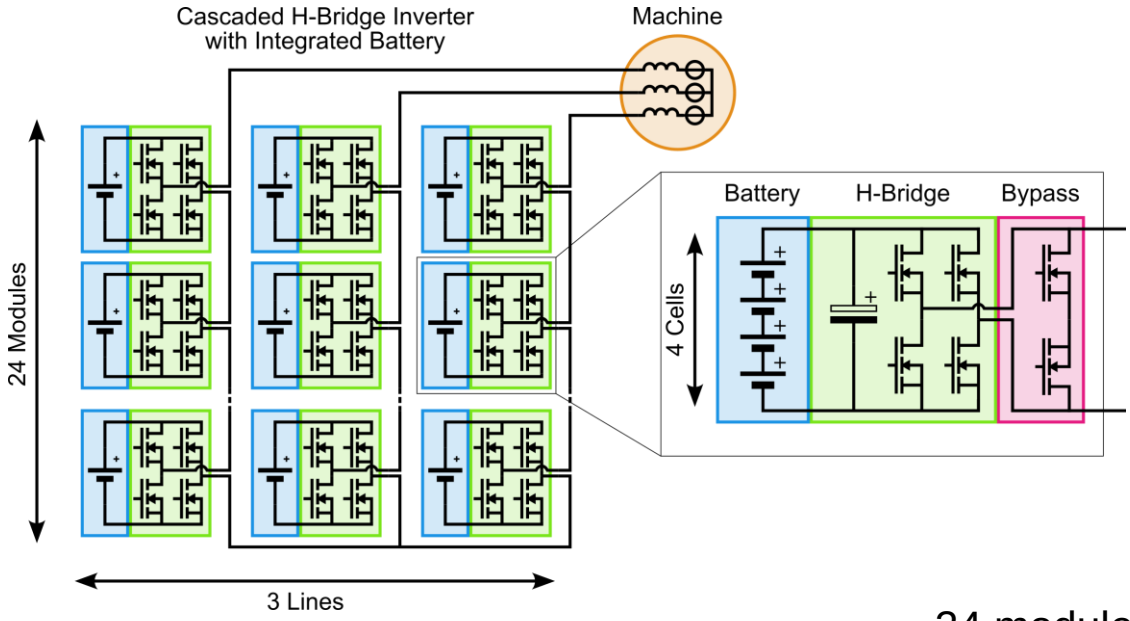
Higher voltage
SiC MOSFET

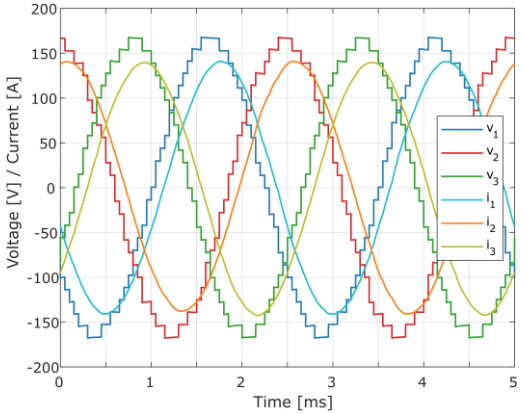


Multilevel Inverter
Lower voltage
Si MOSFET



Cascaded H-Bridge Inverter





24 modules of 4 battery cells per line

Low voltage MOSFETs (40 V)

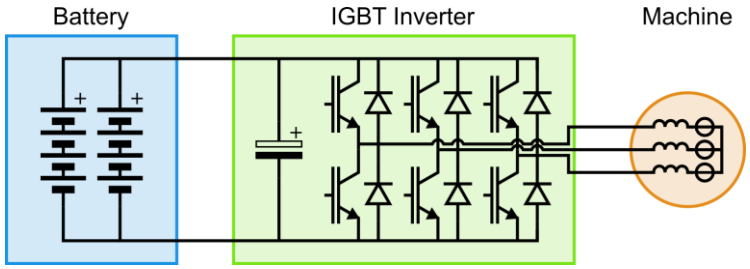
→ Low $R_{DS\ on}$ (< 0.5 mΩ)

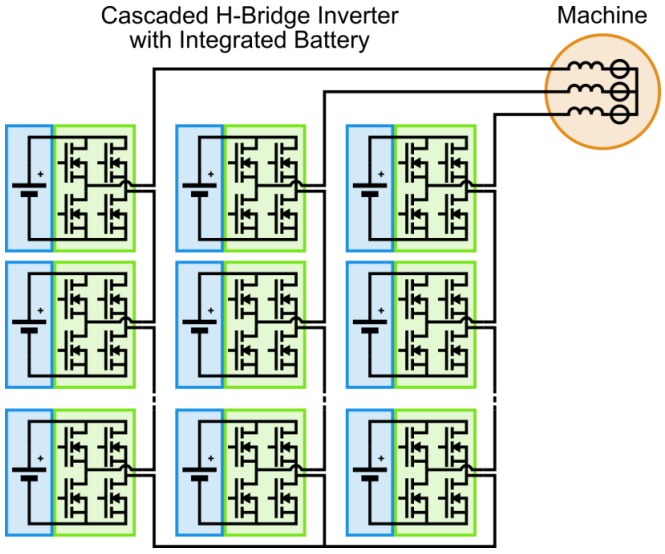
Nearest Level Command (no PWM)

→ Few switching

AC and DC charging without external converter

Fault tolerance

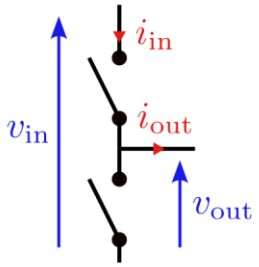


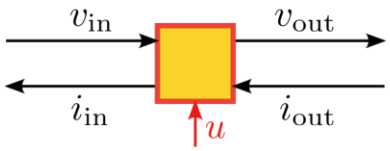


1. Representation and control
   - EMR
   - Modular
   - Compact
   - Numerous freedom degrees
2. Energy management
   - Cell balancing
3. Efficiency estimation
4. Comparison with IGBT and SiC inverters
   - Operating point
   - Realistic conditions

EMR and modeling

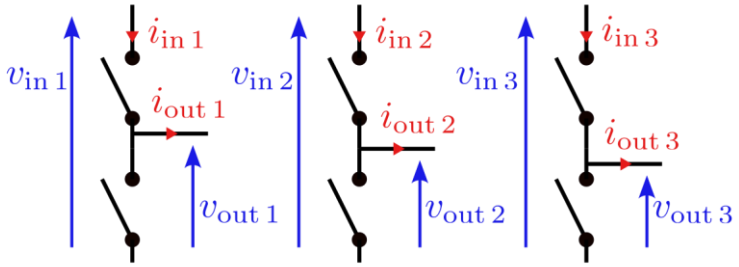
1. One Half-bridge

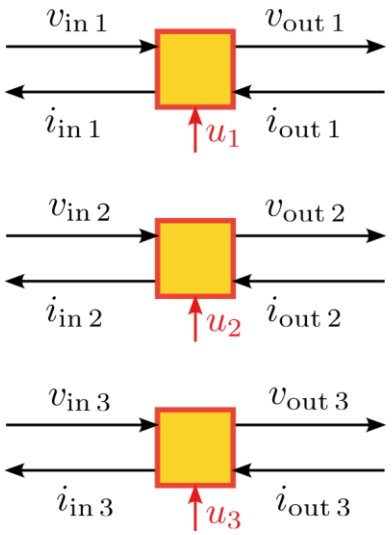




Usual inverter

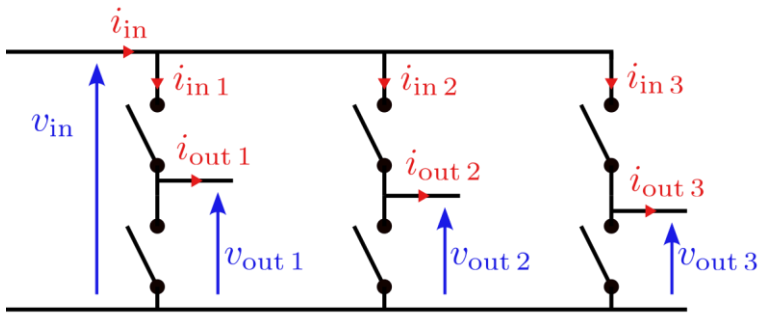
1. One Half-bridge
2. Three Half-bridges

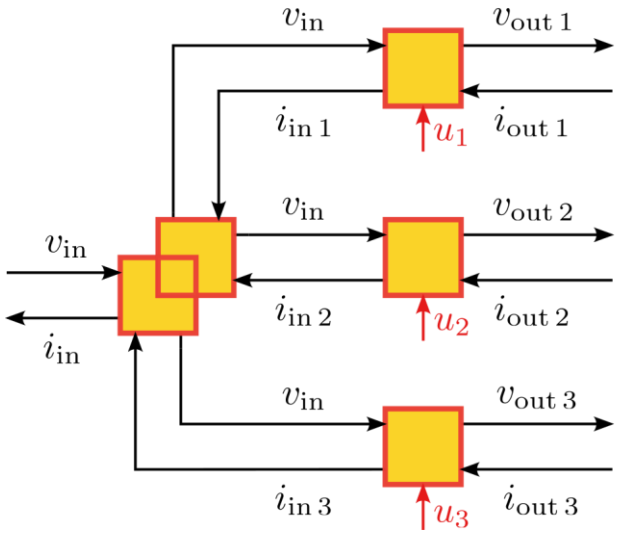




Usual inverter

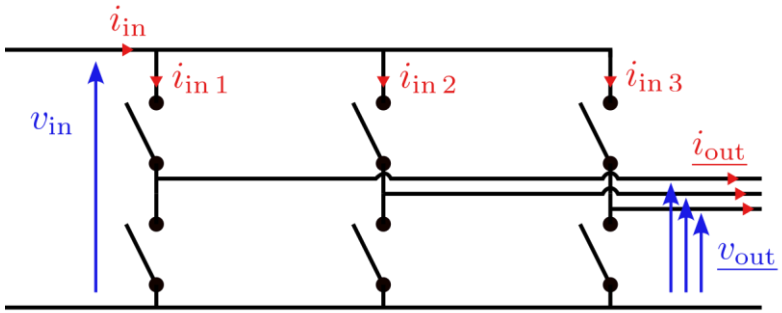
1. One Half-bridge
2. Three Half-bridges
3. Parallel connection

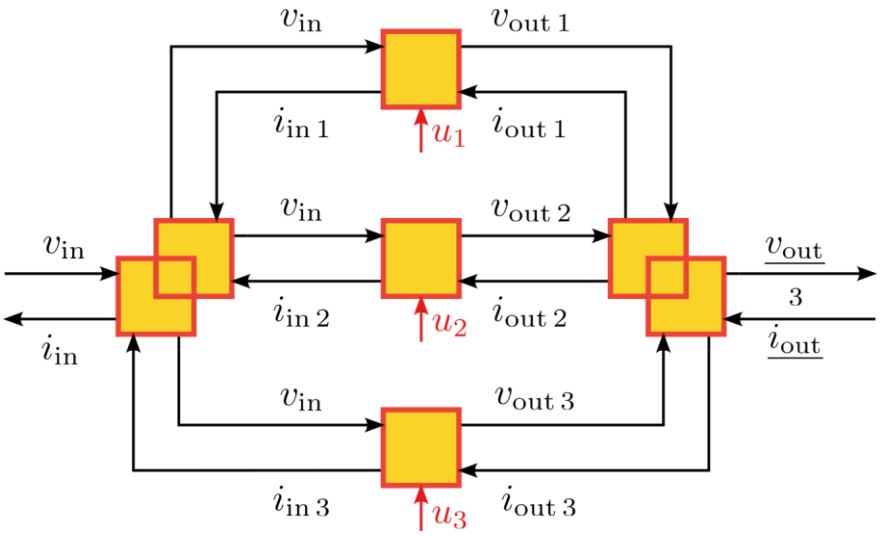




Usual inverter

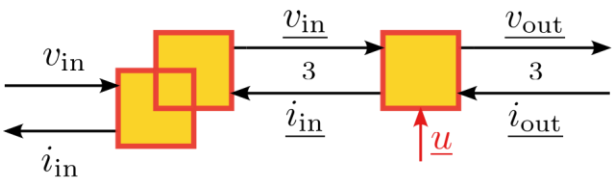
1. One Half-bridge
2. Three Half-bridges
3. Parallel connection
4. Output vectorization

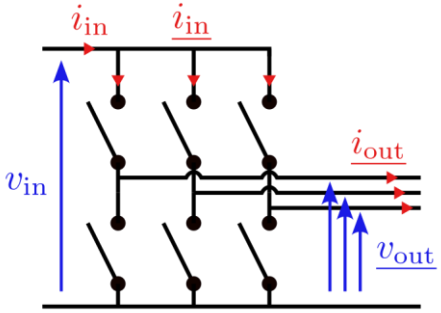


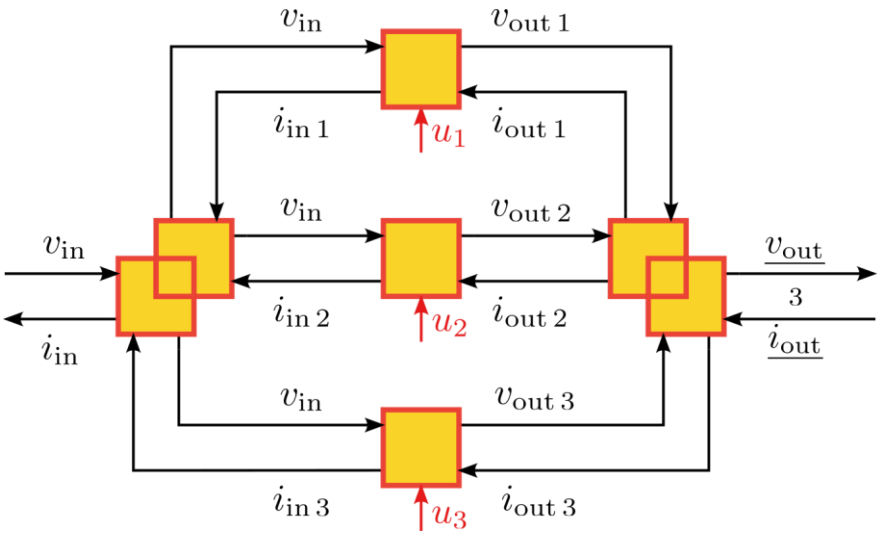


Usual inverter

1. One Half-bridge
2. Three Half-bridges
3. Parallel connection
4. Output vectorization
5. Half-bridges vectorization





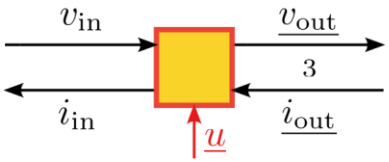


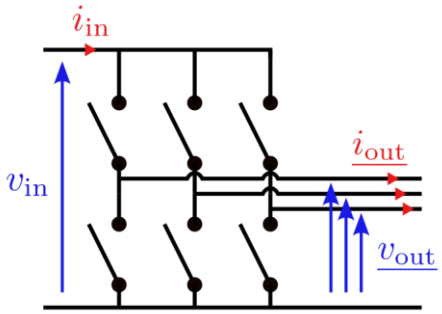
Usual inverter

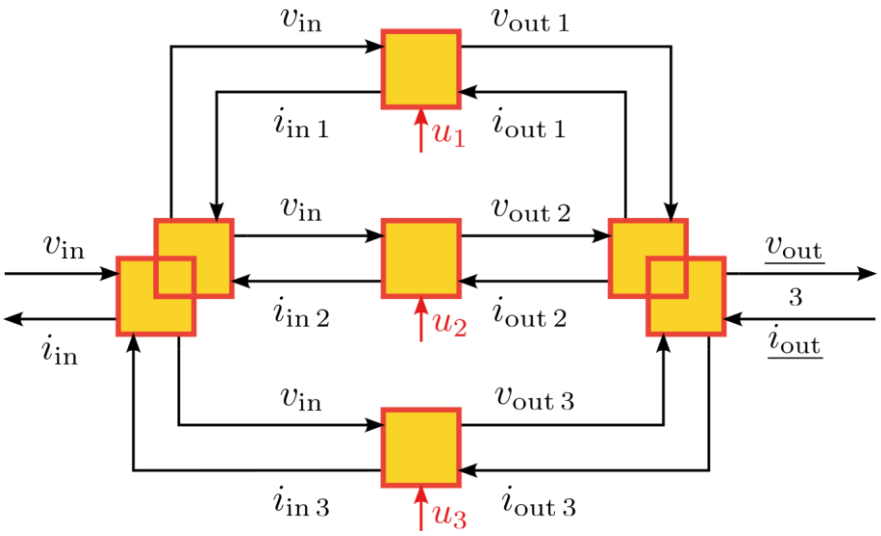
1. One Half-bridge
2. Three Half-bridges
3. Parallel connection
4. Output vectorization
5. Half-bridges vectorization
6. Implicit parallel coupling

Several levels of modelling and vectorization

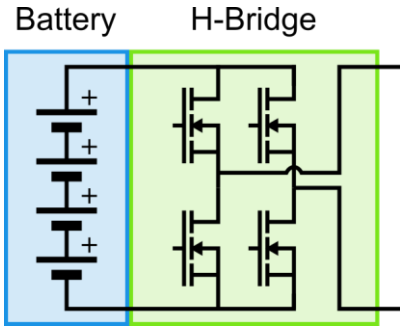
Representation depends on the most important root element

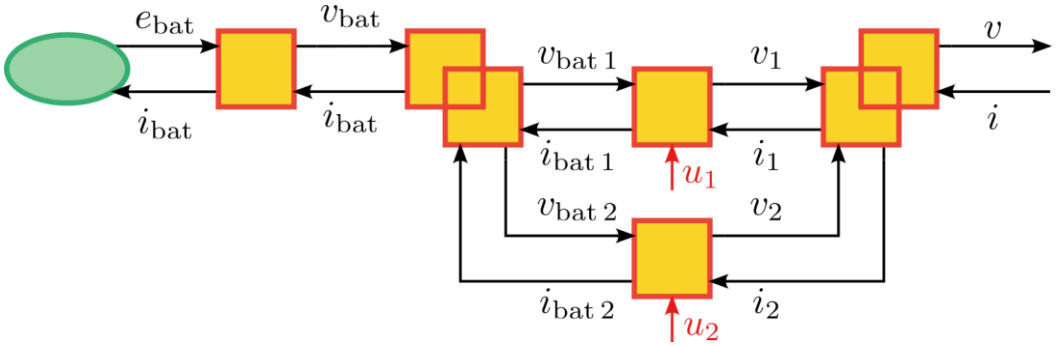






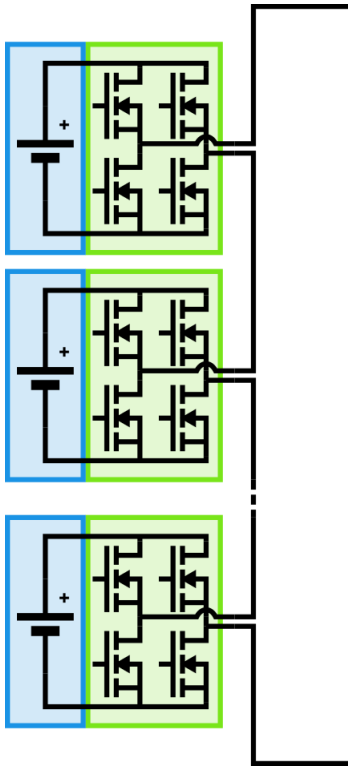
Battery and H-Bridge

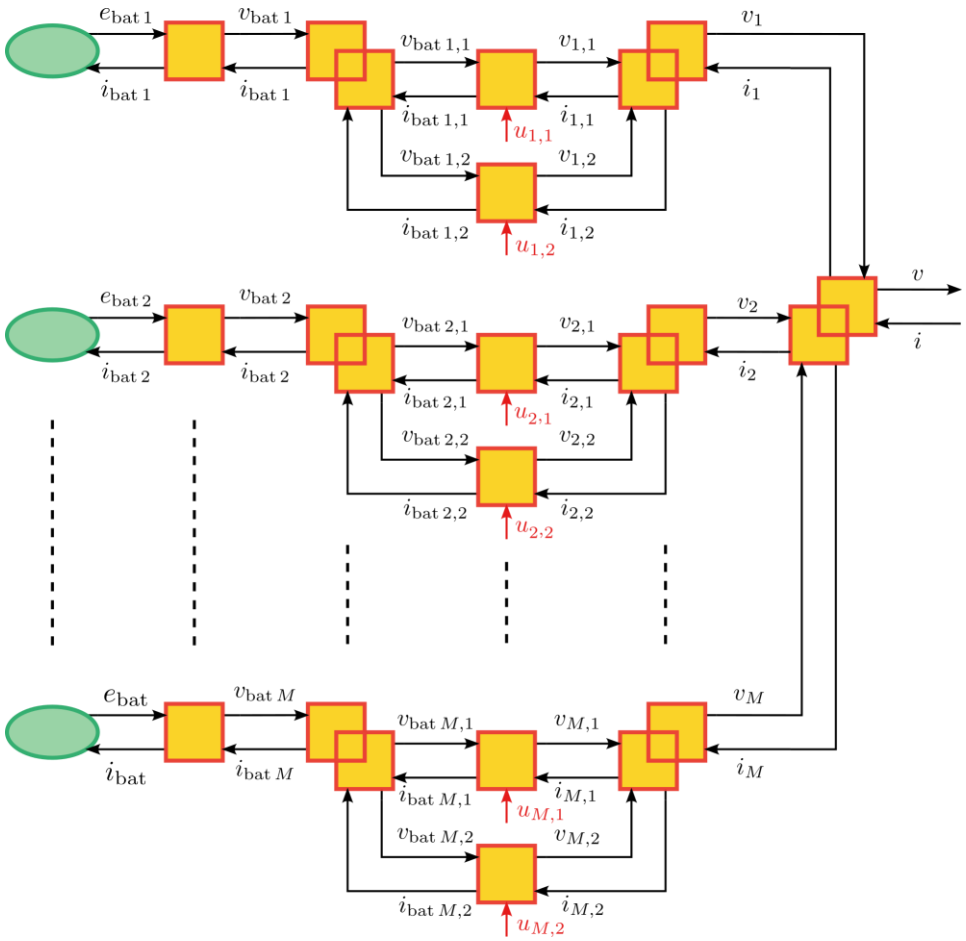




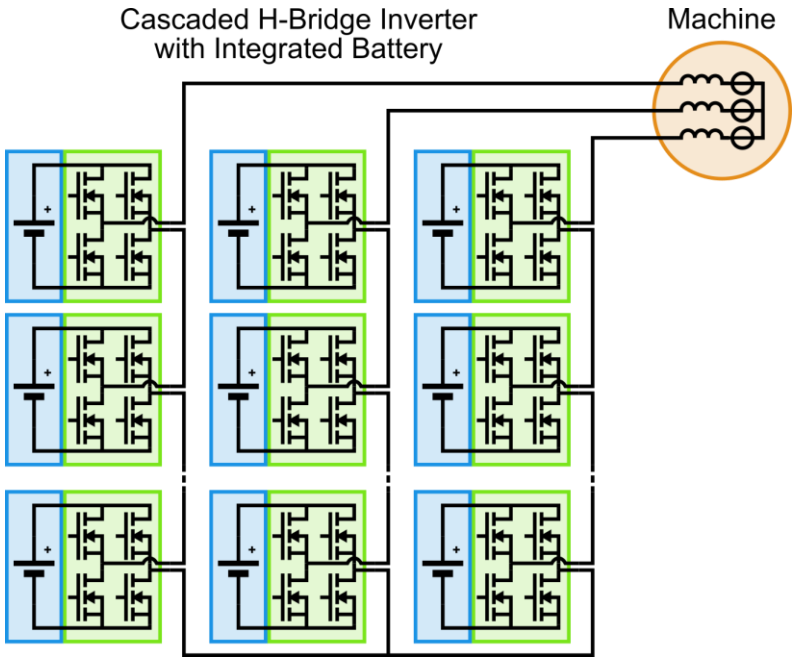
EMR-based comparison of CHB and conventional inverter for EV

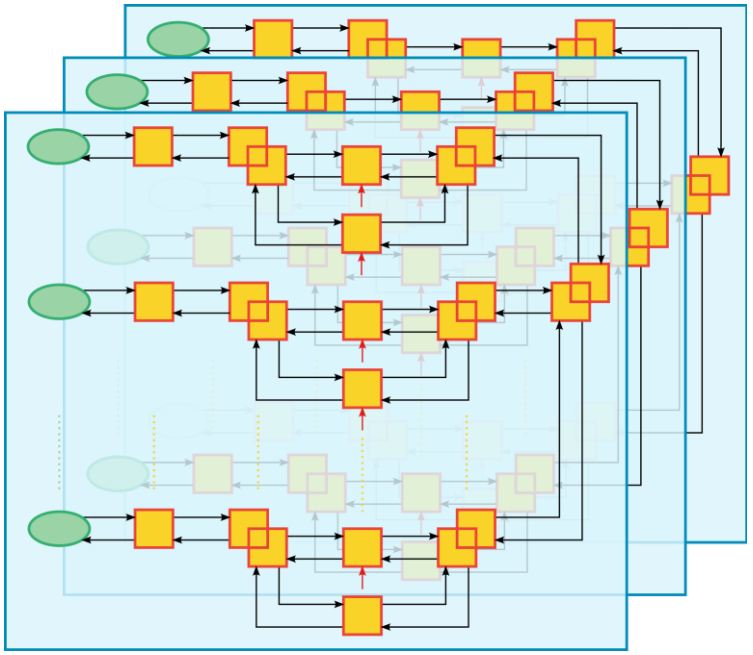
Cascaded H-Bridges





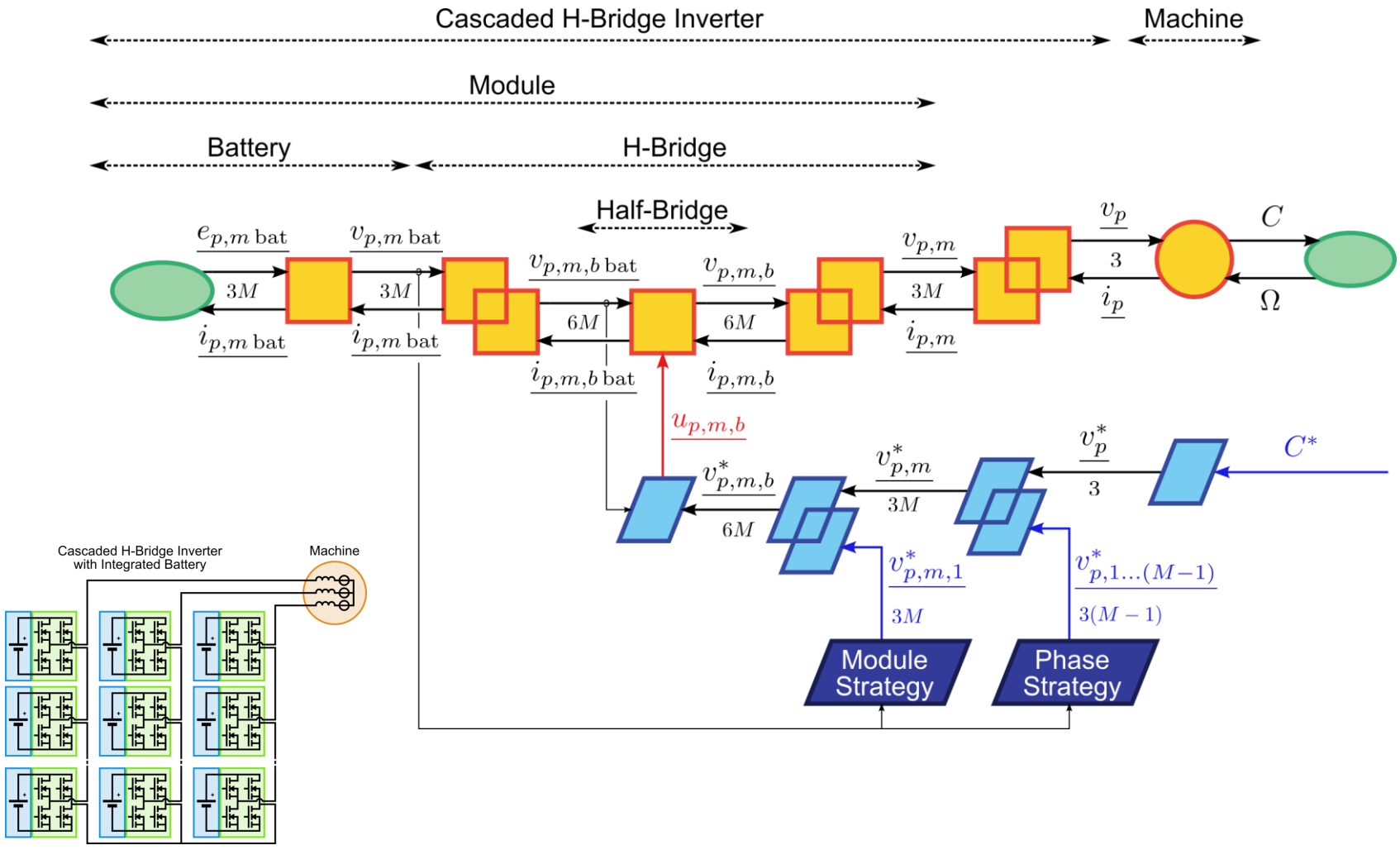
Cascaded H-Bridge Inverter





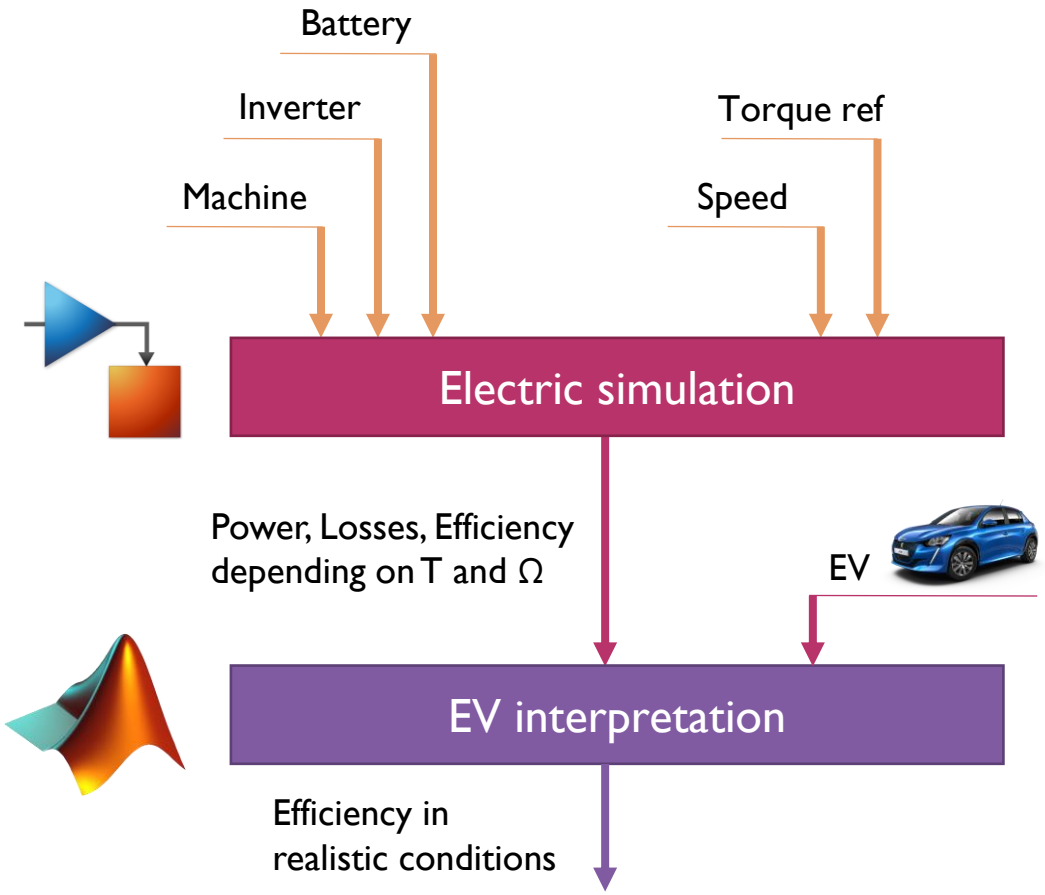
Too many blocs
Too many dimensions
Too many control inputs
➔ Need for vectorization

Cascaded H-Bridge Inverter



Simulation results on efficiency

Workflow


Battery
Inverter
Machine
Torque ref
Speed
Electric simulation
Power, Losses, Efficiency
depending on T and Ω
EV
EV interpretation
Efficiency in
realistic conditions

Thank you !

It’s time for questions