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**April 07-09, 2021**  
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Health  
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# Progress in Switching-Cell-Array Power Conversion Research

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**Power Electronics  
Research Group**



**UNIVERSITAT POLITÈCNICA DE CATALUNYA  
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**Departament d'Enginyeria Electrònica**

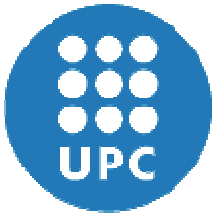


# Outline

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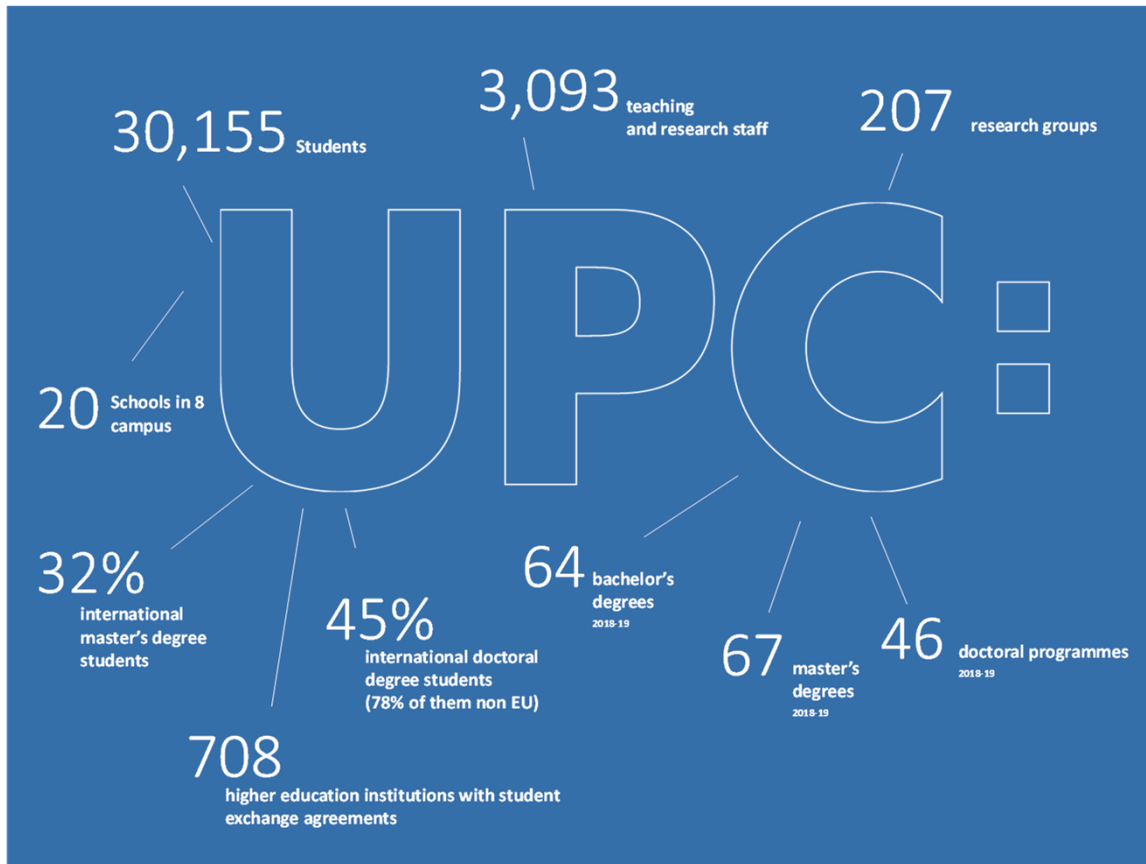
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- Presentation of GREP-UPC.
- Review of power conversion design based on Switching Cell Arrays.
- Latest progress on our SCA power conversion research.
- Conclusion.



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*International Campus of Excellence*



## Shanghai Global Ranking of Academic Subjects, 2018



# Power Electronics Research Group

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Professors	5
Senior Researchers	1
PhD Students	4



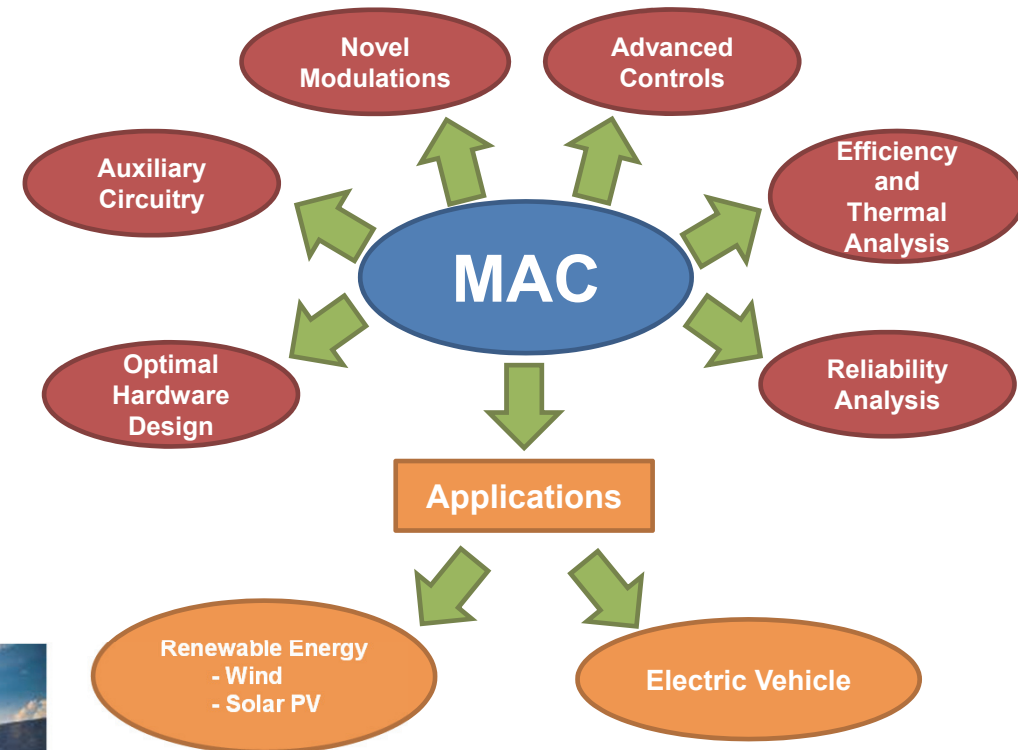
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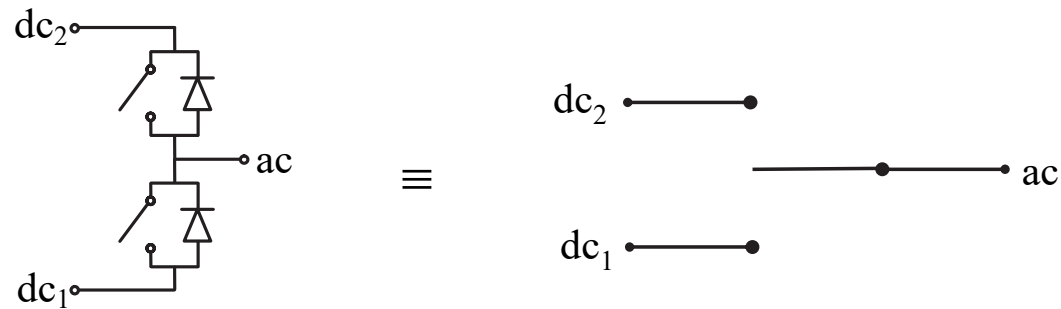
- **Expertise:** Multilevel Power Electronics Conversion
- **Traditional Research Line:**

## MAC: Multilevel Active Clamped topology

- Better efficiency
- Increased power density
- Improved reliability
- Potential for standardization



# **Current Research Line**



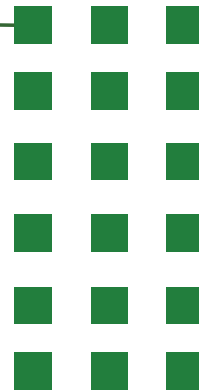
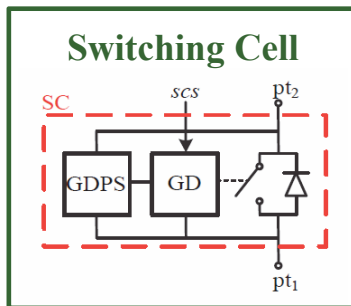
Problems

Device Dispersion	No Fault Tolerance
<p>Different structures, materials, and sizes</p>	<p>If one device fails, the leg must stop</p>

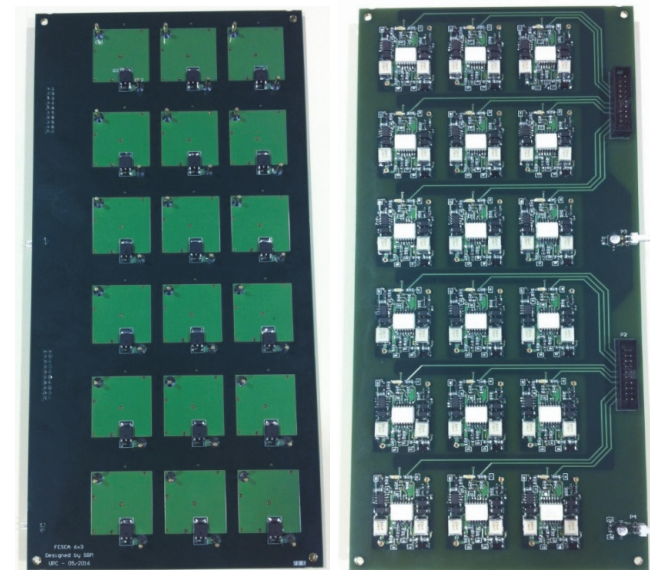
# Proposed Power Converter Design Approach

- Build converter legs from an array of standard switching-cells.

Inexpensive  
high performance  
switching cell thanks  
to scale economies



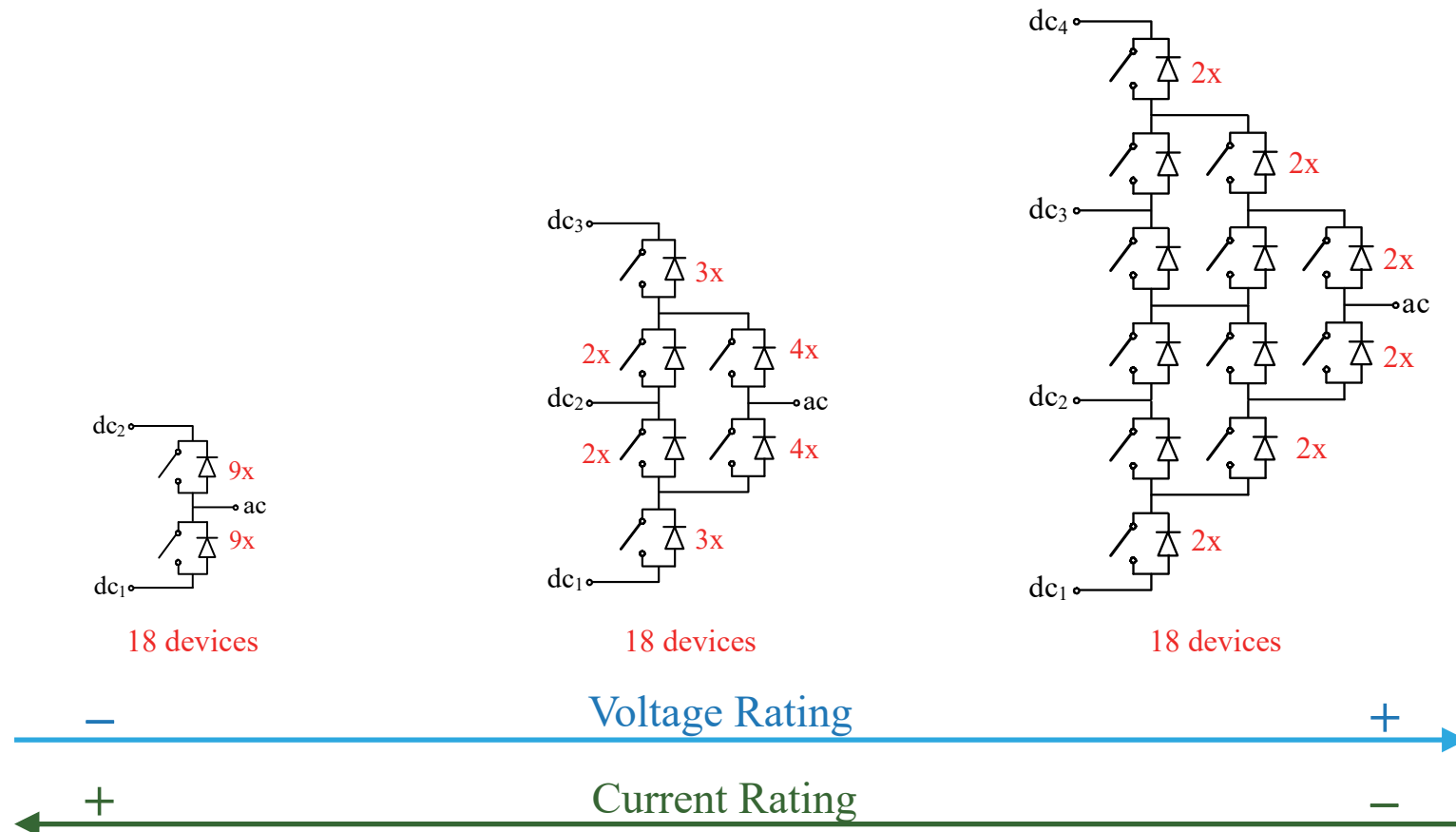
6x3 matrix  
(18 devices)





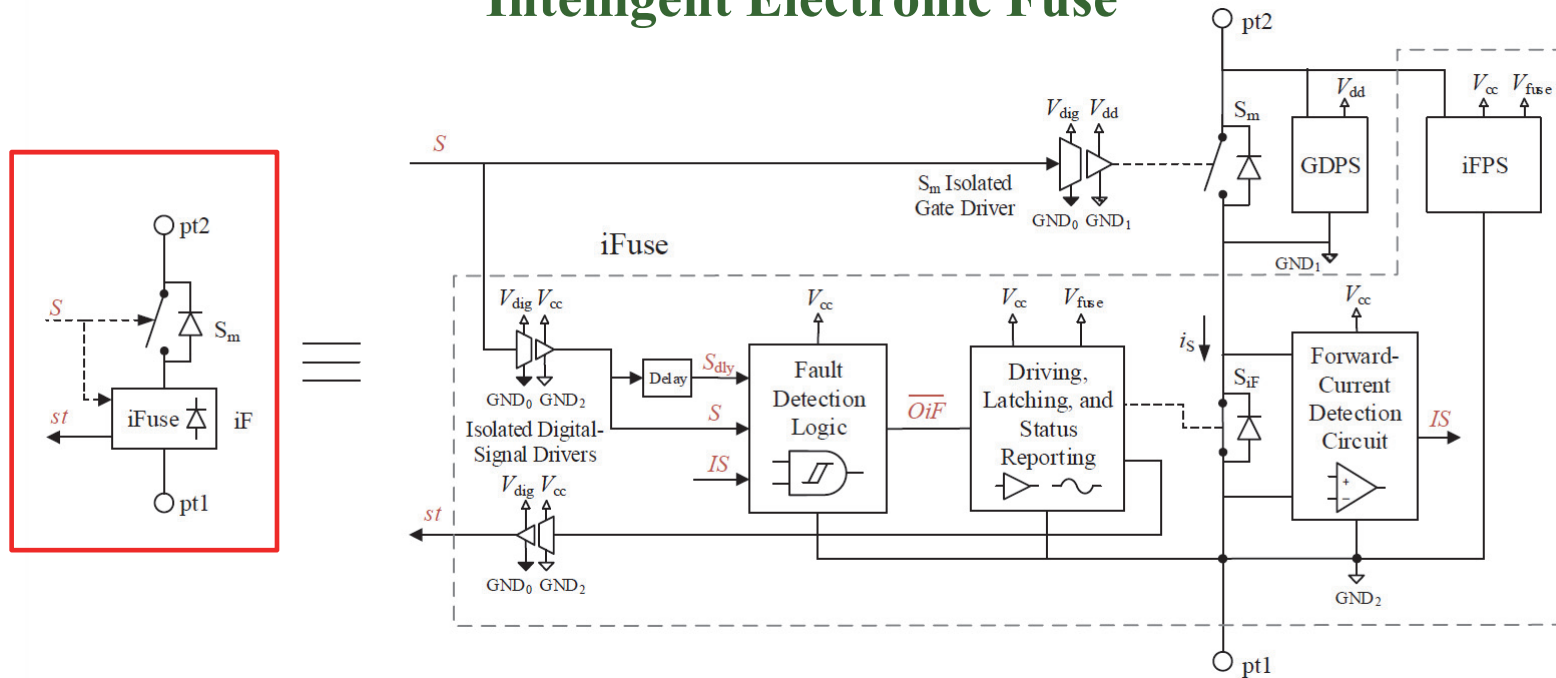
# Proposed Power Converter Design Approach

- Properly interconnecting the cells of a given matrix we can build multilevel converter legs of different voltage and current ratings. E.g., using a 6x3 matrix:



- This technology offers an opportunity to increase system efficiency, reliability, power density, and other system performance features at a competitive cost.
- In order to achieve these goals, our current research lines are:
  - Switching-Cell Level:
    - Definition of the required SC functionality.
    - Conception of different types of SCs: standard, switching optimized, conduction optimized.
    - Implementation of simple SC laboratory prototypes.
  - Switching-Cell-Array level:
    - Optimum SCA configuration.
    - Optimum SC interconnection to implement converter legs under different conditions.
  - System Level:
    - Optimum converter control to improve system performance.

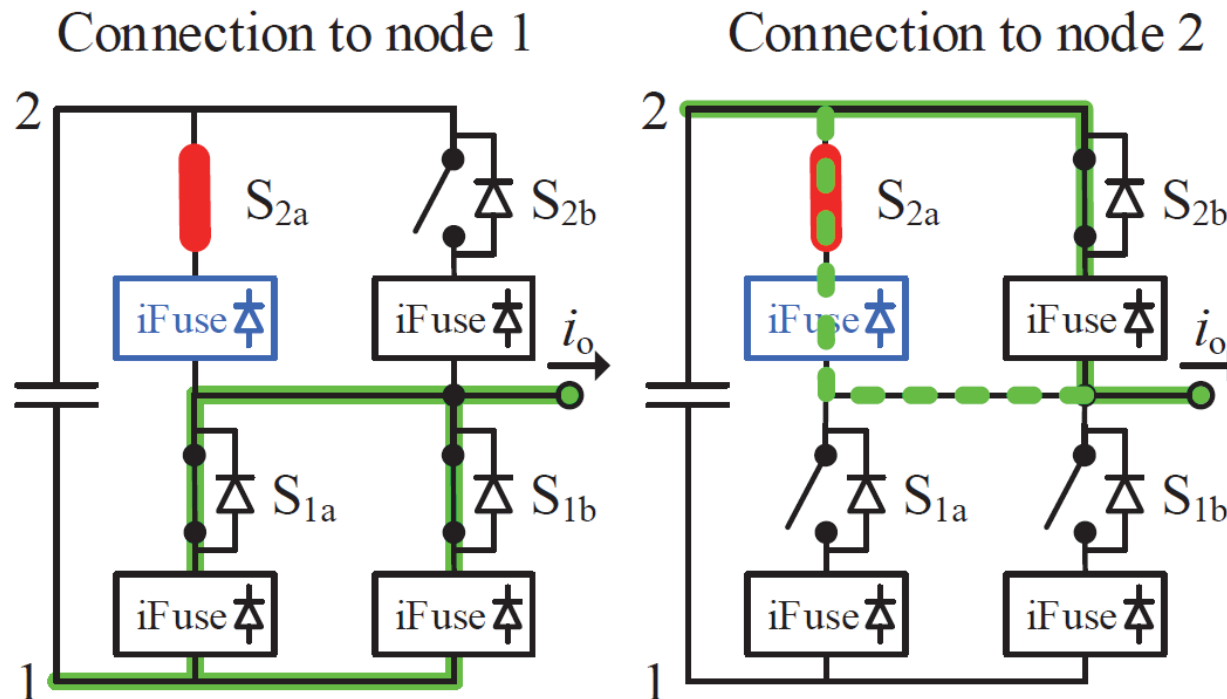
## Intelligent Electronic Fuse



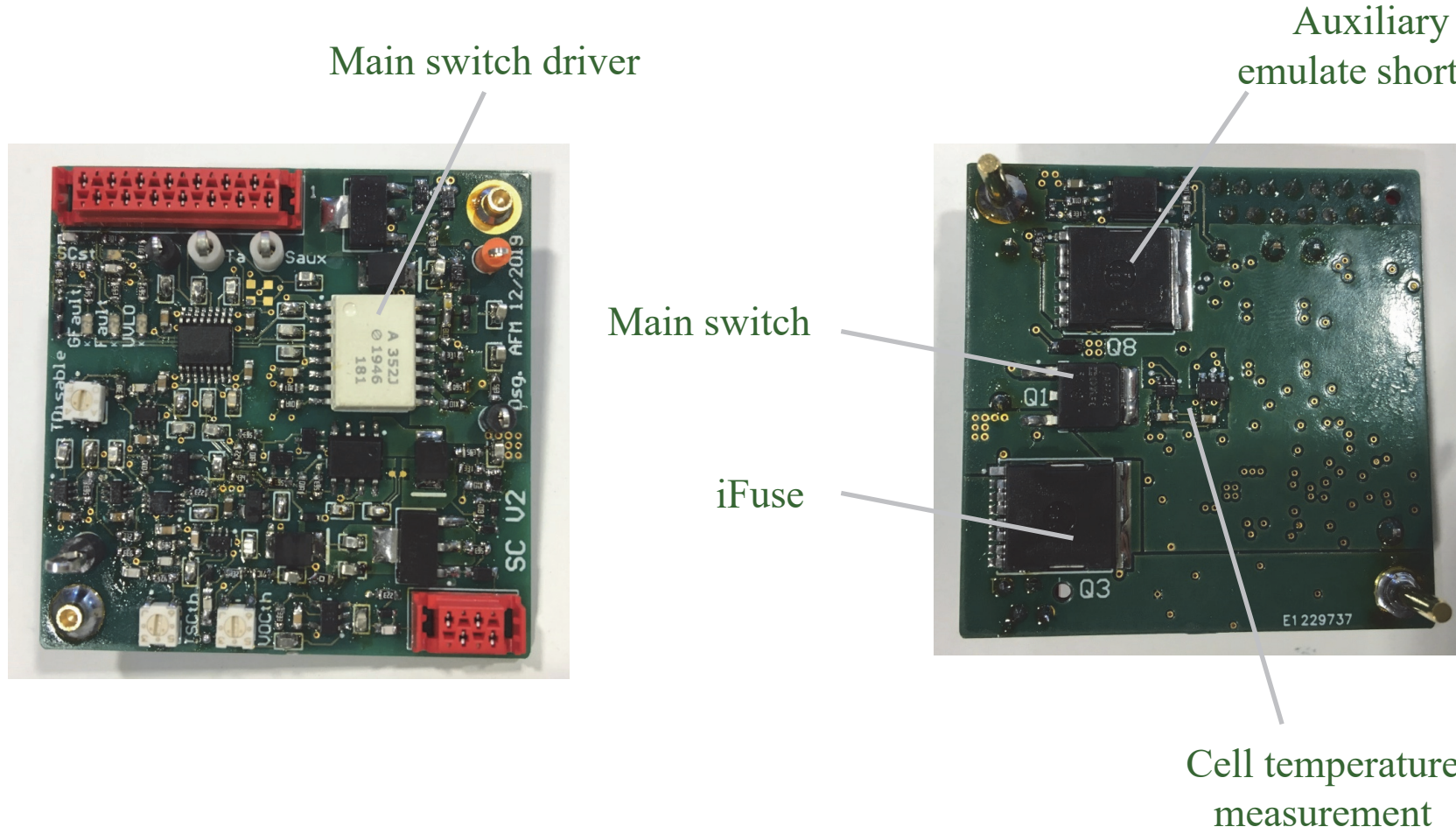
- Protection law: Open iFuse if
 
$$\left\{ \begin{array}{l} S = 0 \text{ and Forward\_Current} \gg 0 \\ \text{OR} \\ S = 1 \text{ and Blocking\_Voltage} \gg 0 \end{array} \right.$$

## Intelligent Electronic Fuse

- Simple application example:



# Switching-Cell Level



Main switch driver

Auxiliary switch to emulate shortcircuit faults

Main switch

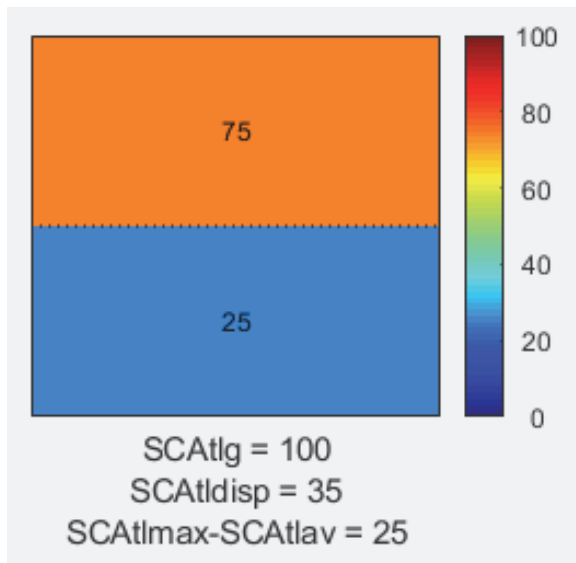
iFuse

Cell temperature measurement

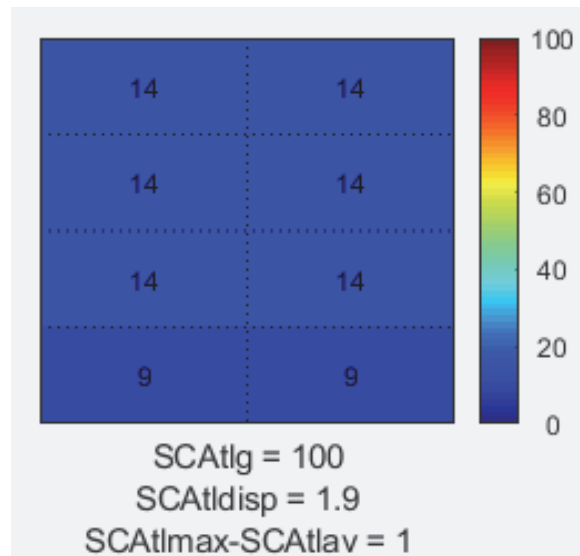
## Thermo-Electrical Modeling

- Comparison of loss distribution of a 2-level leg under different matrix configurations:

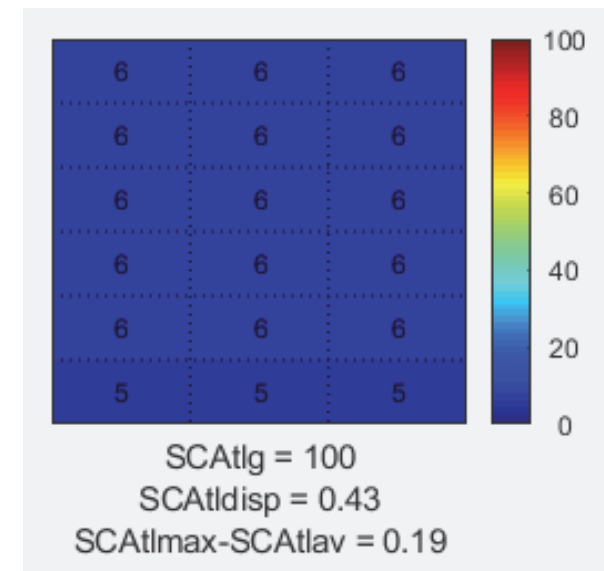
### 2x1 SCA



### 4x2 SCA



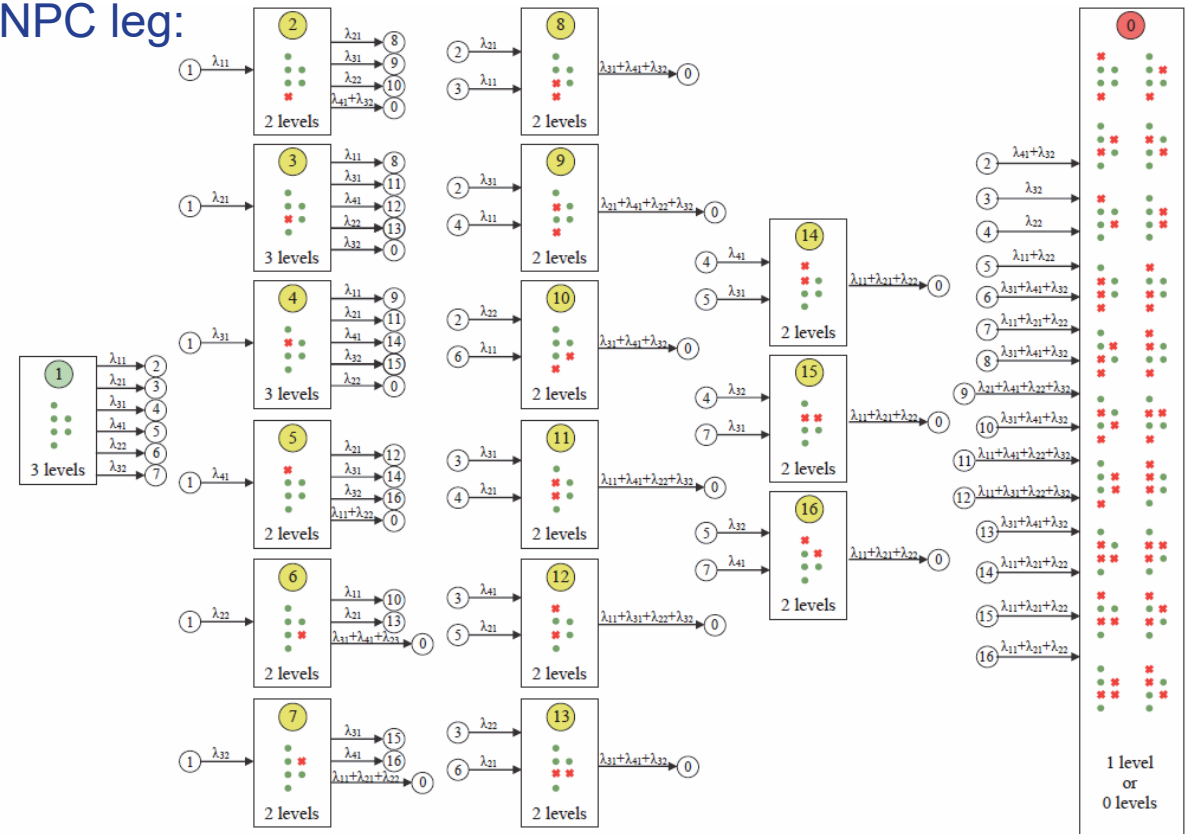
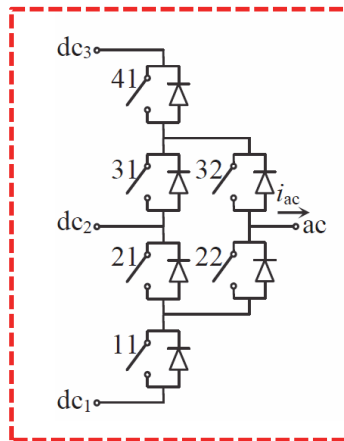
### 6x3 SCA



- Increasing granularity offers opportunities for improvements.

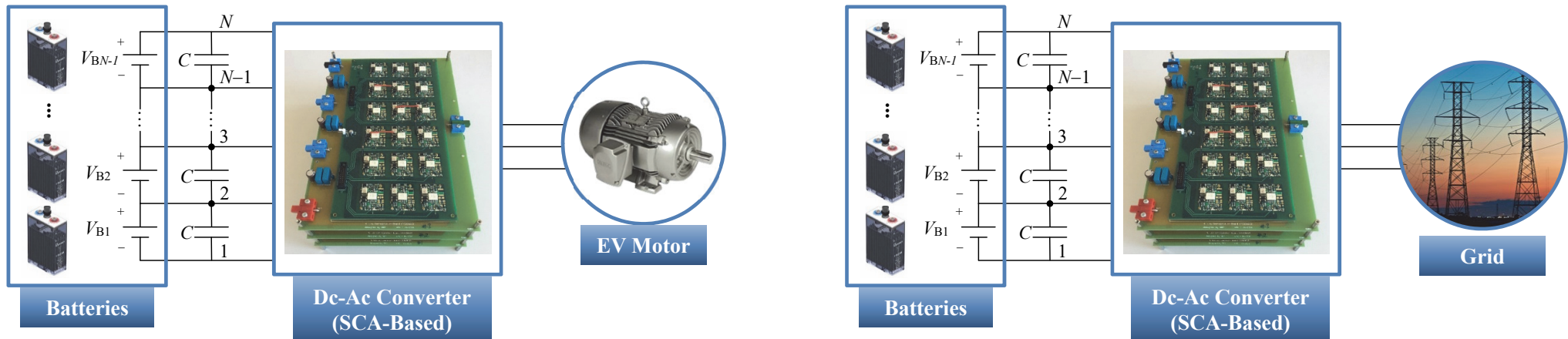
## Reliability Modeling Through Markov Chains

- Markov chain diagram of a three-level ANPC leg:



➤ Fast and precise calculation of MTTF from these models.

- Main focus on applications involving batteries (electric vehicle and grid):



+

Other conversion configurations required for electric vehicles





# Conclusion

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- Design of power converters based on SCAs is certainly unusual and a challenge, but it offers new exciting opportunities.
- Our research on this topic is so far progressing satisfactorily.



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