# Comparison of Four-Switch Buck-Boost and Dual Active Bridge Converter for DC Microgrid Applications

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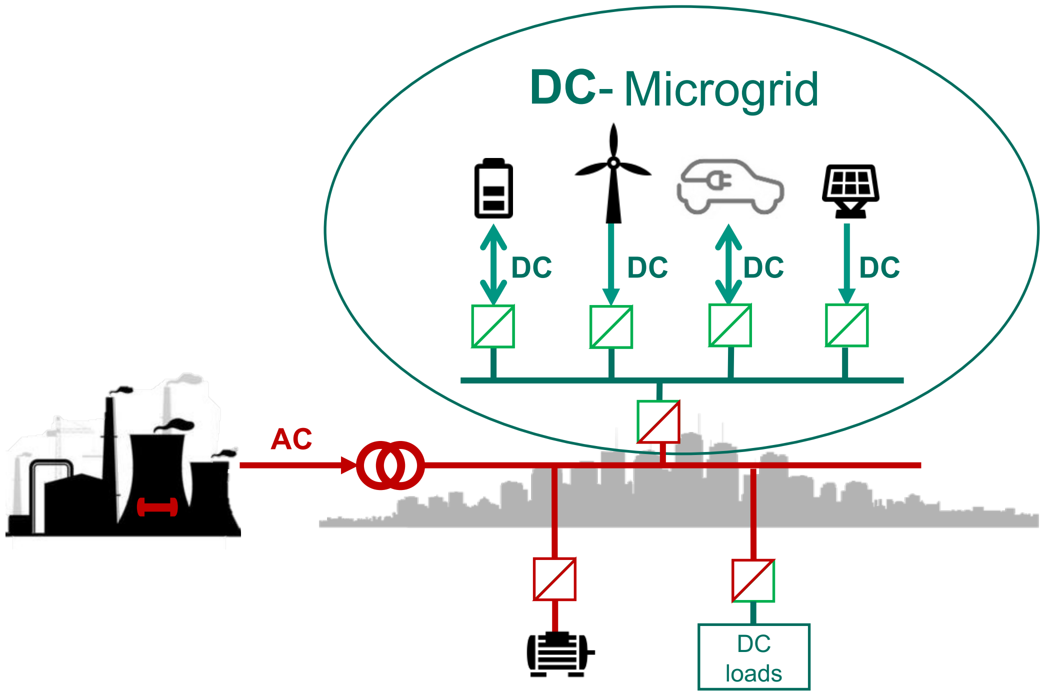
# Outline

- Background
- Converters
- Methodology
- Simulation results
- Conclusion and Outlook

# Background

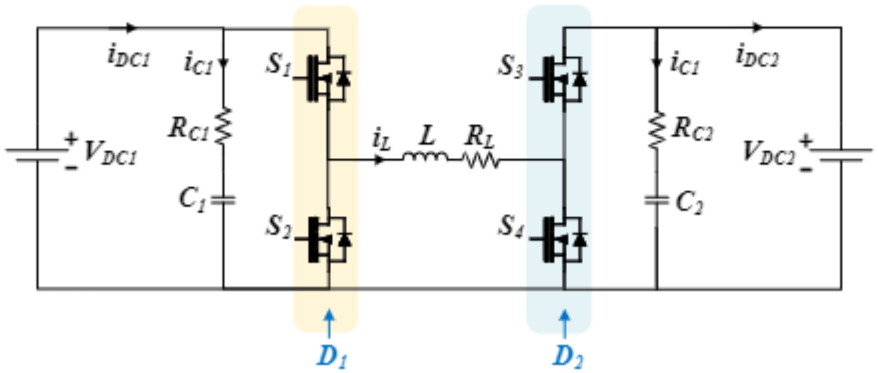


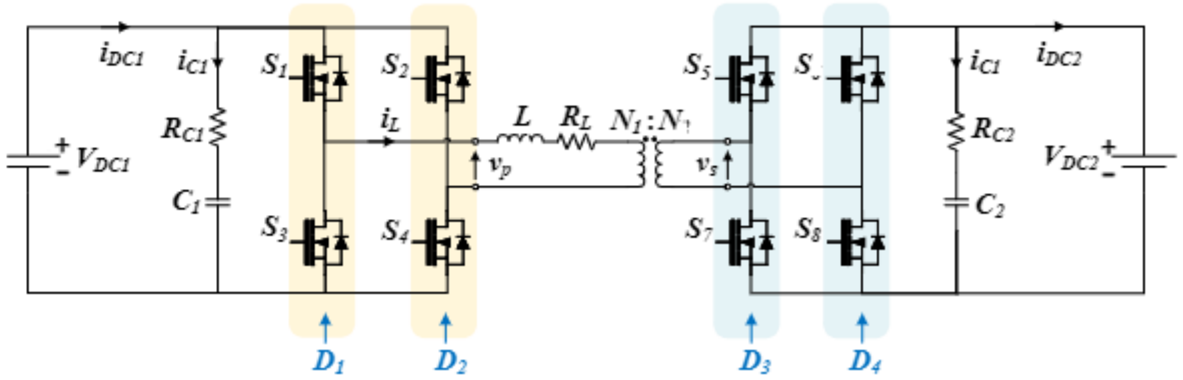

- increase of renewables → Microgrids
- DC-Microgrids are promising improvement in efficiency and stability due to ancillary services
  - More efficiency,
  - More reliable,
  - More flexible,
  - Cheaper,
  - More ecologic (safes chopper and iron)
- Main link device for components in a DC Microgrid is the DC-DC Converter.
- **Which Converter should be used in DC Microgrids?**
- Two very versatile converters are:
  - Four Switch Buck-Boost (FSBB)
  - Dual Active Bridge (DAB)

# Converters

FSBB:
- fewer switches, simple control
- no transformer
- non-isolated

DAB:
- galvanic isolated
- wide voltage range
- more switches
- transformer needed



# Converter losses

MOSFET Losses:
- Switching losses
- Conduction losses
- Dead time losses

$$P_S = \frac{1}{2} V_{DS} I_D (t_r + t_f) f_s$$

$$P_{cond} = R_{on} I_D^2$$

$$P_{dead} = V_{diode} I_{diode} t_{dead} f_s$$

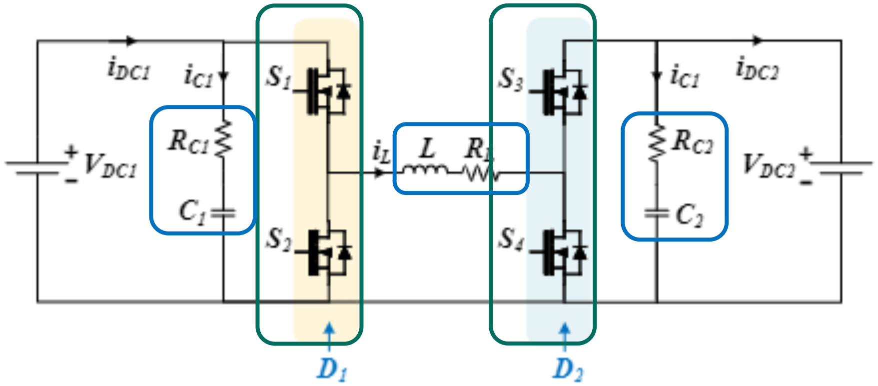
Inductor/Capacitor Losses:
- Conduction losses

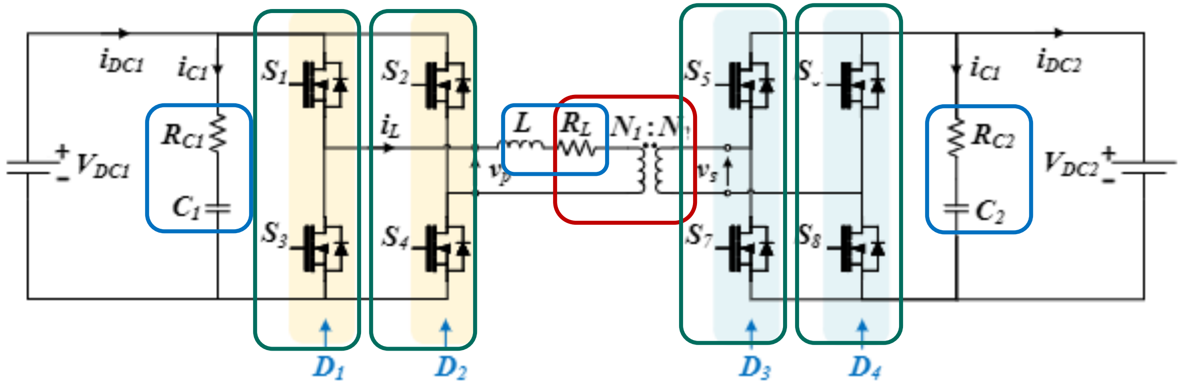
$$P_L = R_L I_L^2$$

$$P_C = R_C I_C^2$$

Transformer Losses:
- Conduction losses

$$P_T = R_T I_T^2$$



# Short Circuit Contribution – mathematical description

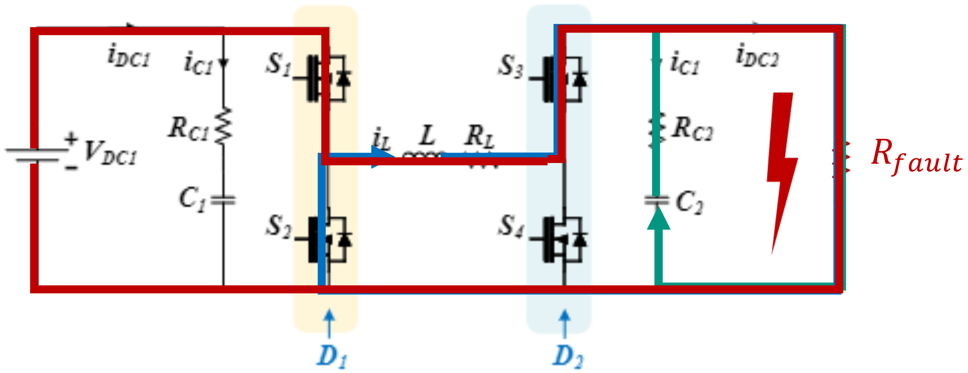
Fault contributions:

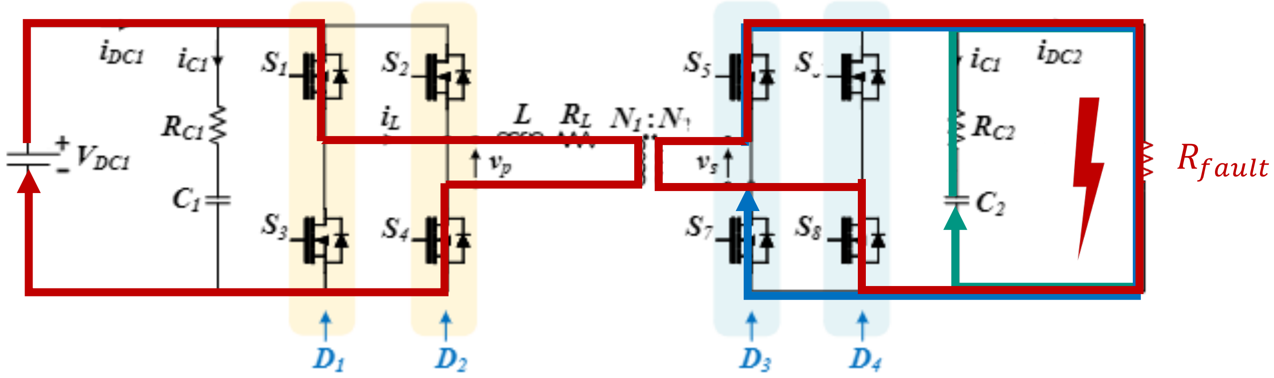
Capacitor discharge:

$$(R_{fault} + R_C)\frac{di_{fault,C}(t)}{dt} + \frac{1}{C} i_{fault,C}(t) = 0$$

Inductor forced current through freewheeling diodes:

$$L\frac{di_{fault,L}(t)}{dt} + (R_L + R_{fault})\, i_{fault,L}(t) = 0$$

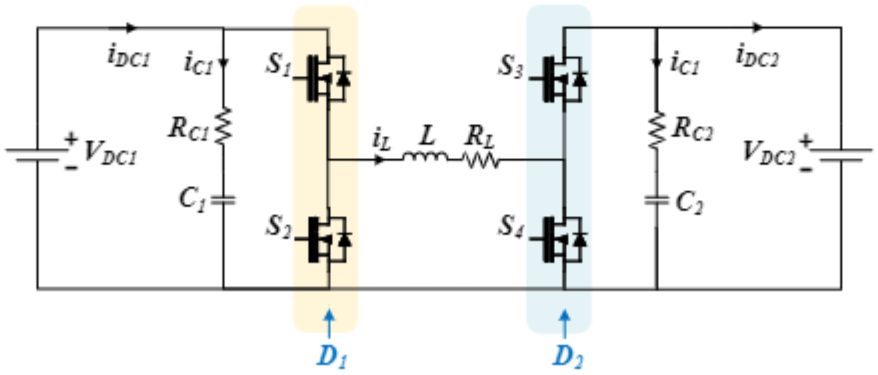


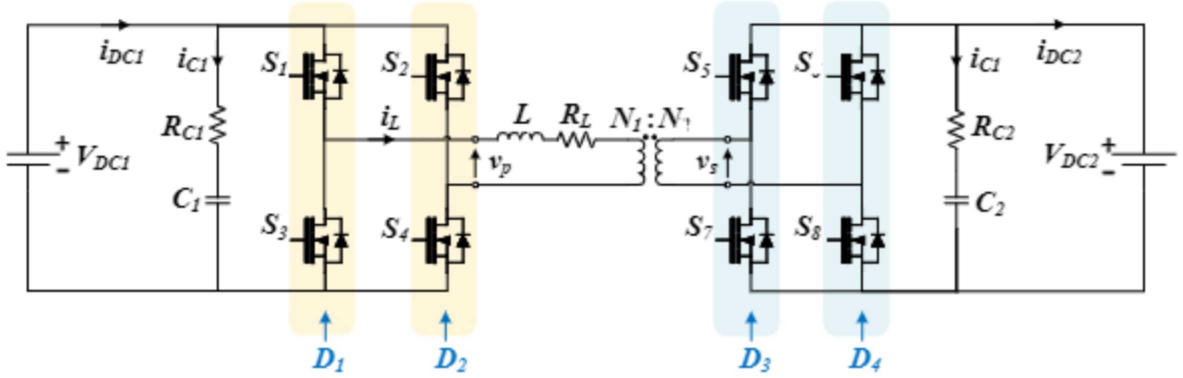



# Short Circuit Contribution – System Parameters

| System Parameters | | | |
|---|---|---|---|
| **Name** | **Value** | **Name** | **Value** |
| $P$ | 5 kW | $C_1$ | 235 $\mu$F |
| $f_{sw}$ | 20 kHz | $C_2$ | 235 $\mu$F |
| $V_{DC1}$ | 400 V | $L_{DAB}$ | 177.78 $\mu$H |
| $V_{DC2}$ | 750 V | $L_{FSBB}$ | 5.5 mH |

| Loss Parameters | | | |
|---|---|---|---|
| **Name** | **Value** | **Name** | **Value** |
| $t_r$ | 22 ns | $R_{on}$ | 80 m$\Omega$ |
| $t_f$ | 14 ns | $R_{C1}$ | 0.02 $\Omega$ |
| $t_{dead}$ | 150 ns | $R_{C2}$ | 0.02 $\Omega$ |
| $R_{L\ FSBB}$ | 0.3 $\Omega$ | $R_{L\ DAB}$ | 0.03 $\Omega$ |



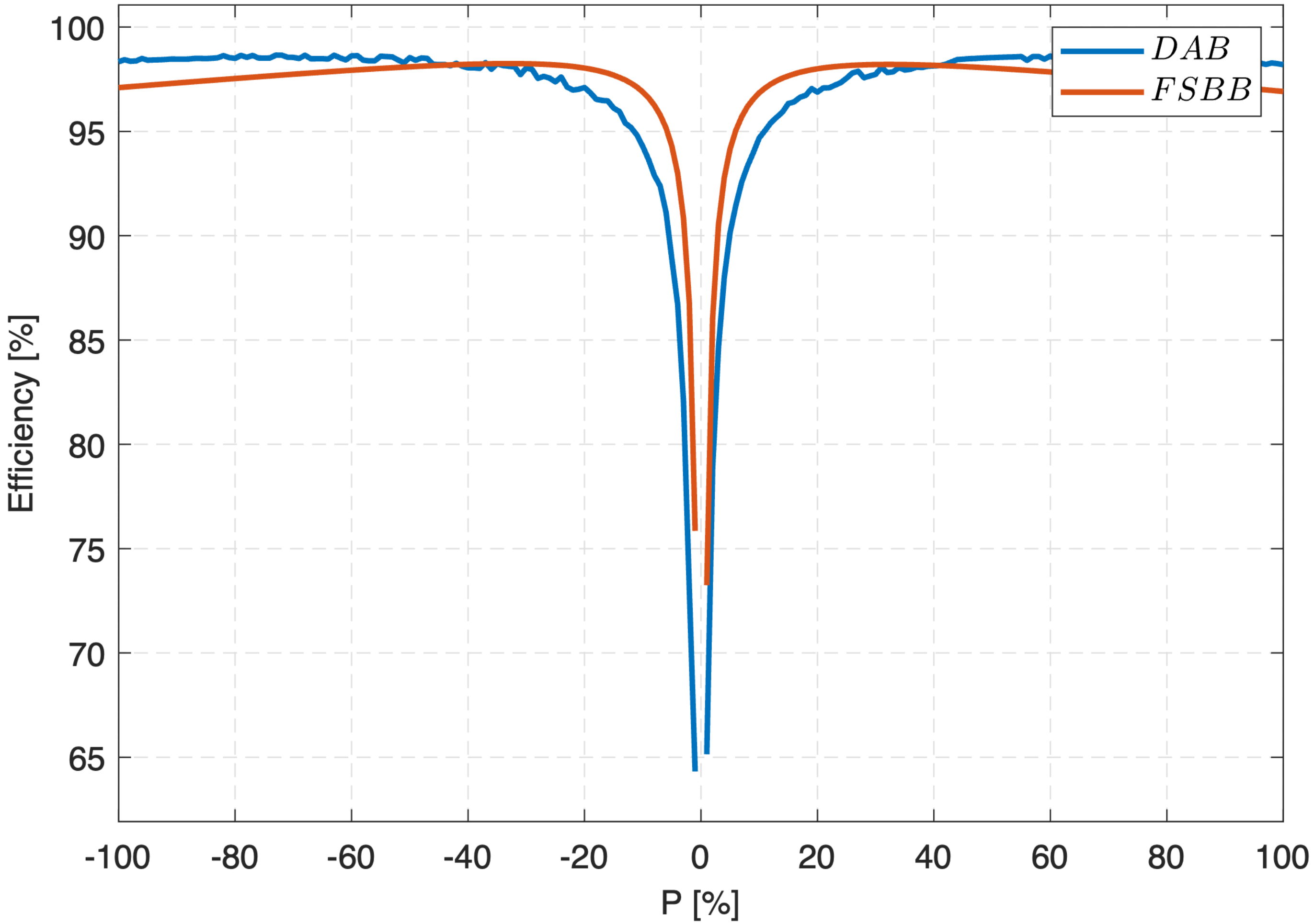



# Simulation results

- Efficiency

FSBB

DAB



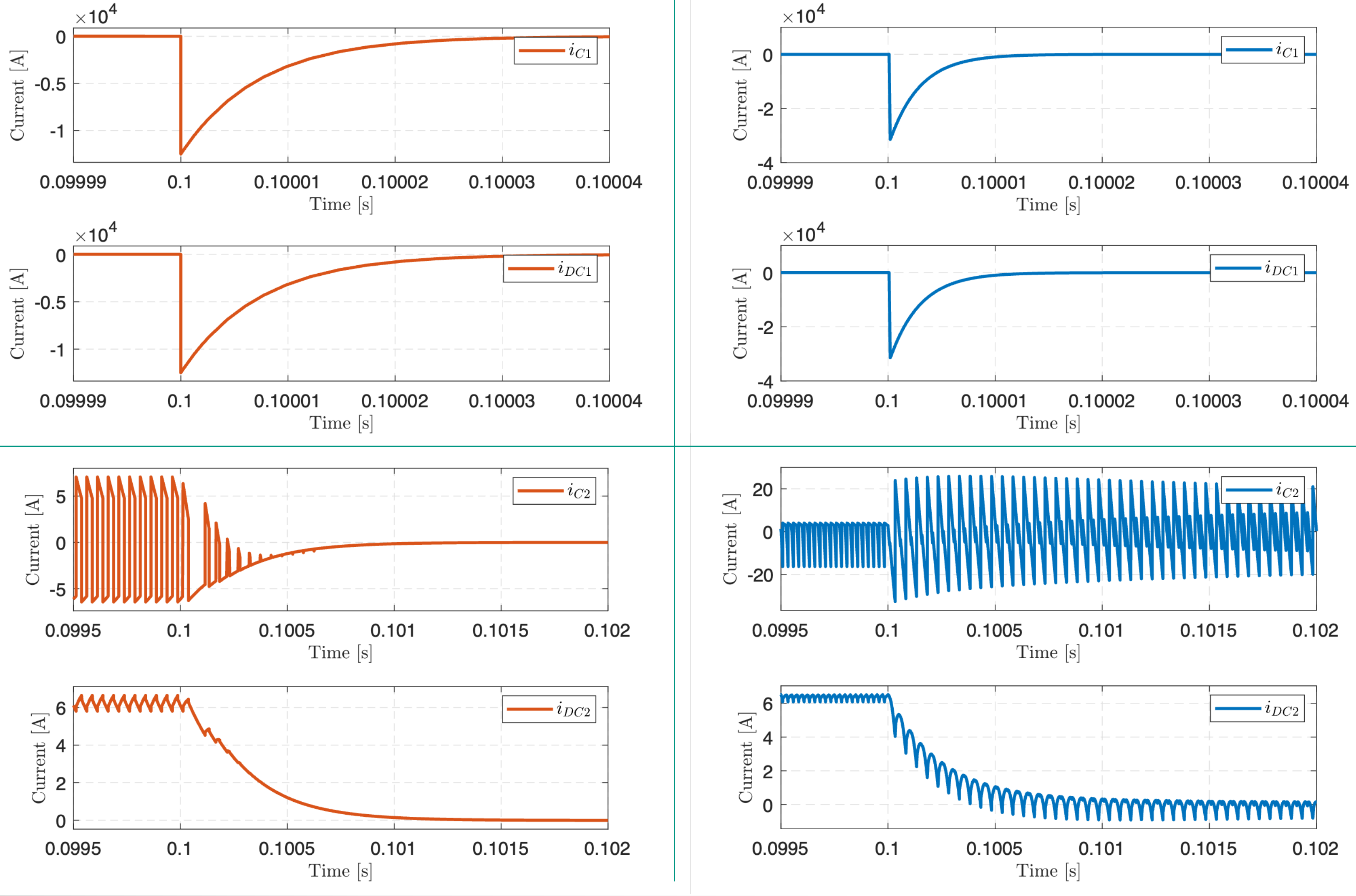
# Simulation results – LV fault

FSBB DAB

Current

LV

HV



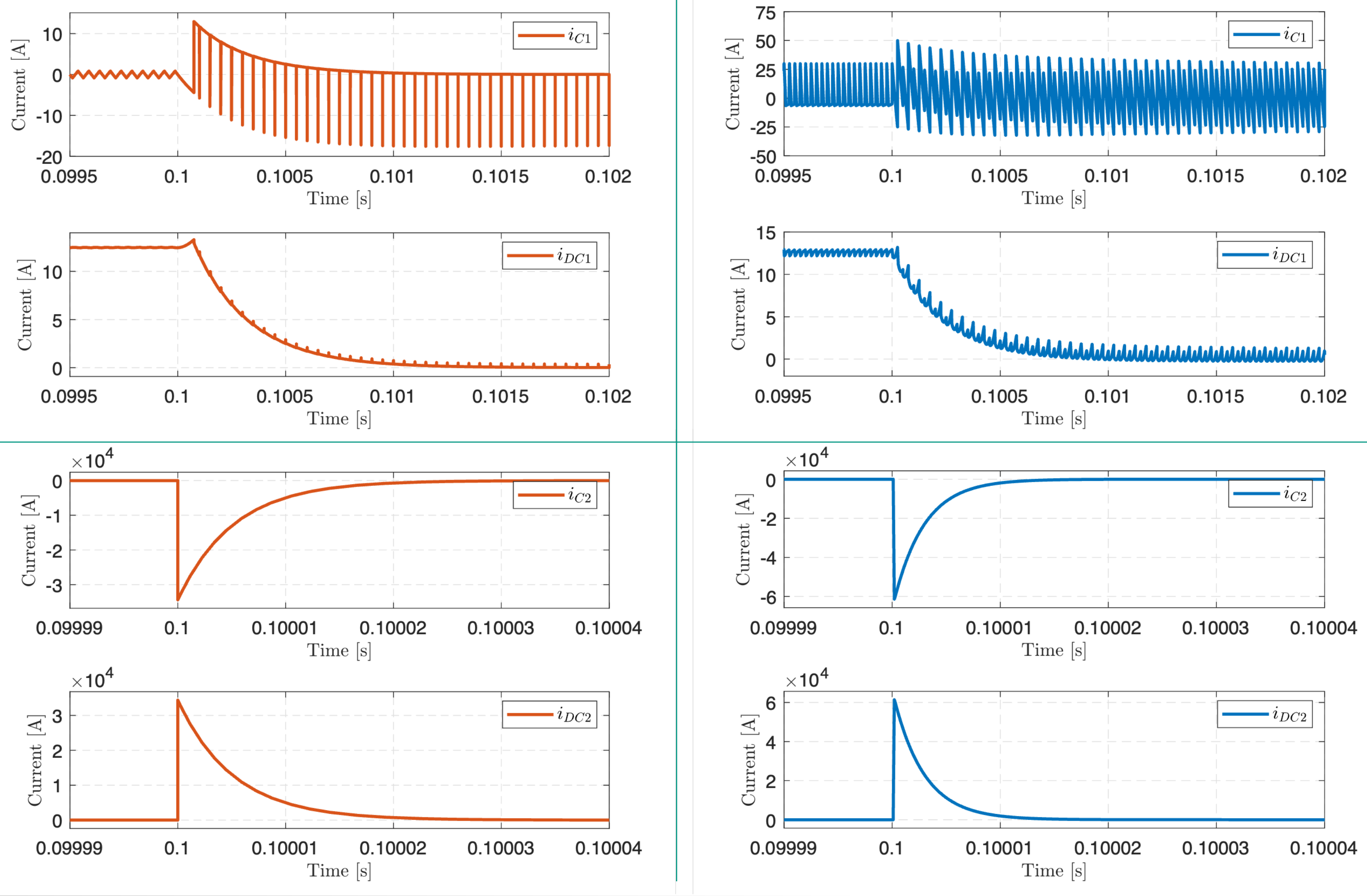
# Simulation results – HV fault

FSBB | DAB

Current

LV

HV



# Conclusion

- largest contribution results from the discharge of the capacitors
- Contribution through the converters from each side can be suppressed
  - DAB intrinsic
  - FSBB by control
- FSBB more efficient for low power conversion
- DAB more efficient for high power conversion

https://www.elab2.kit.edu/anlagenverbund.php

Outlook:

- Real plant experiments
- Interaction analysis

# THANK YOU
# Questions?

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