Power Flow Control Converters for LVDC Distribution Grids

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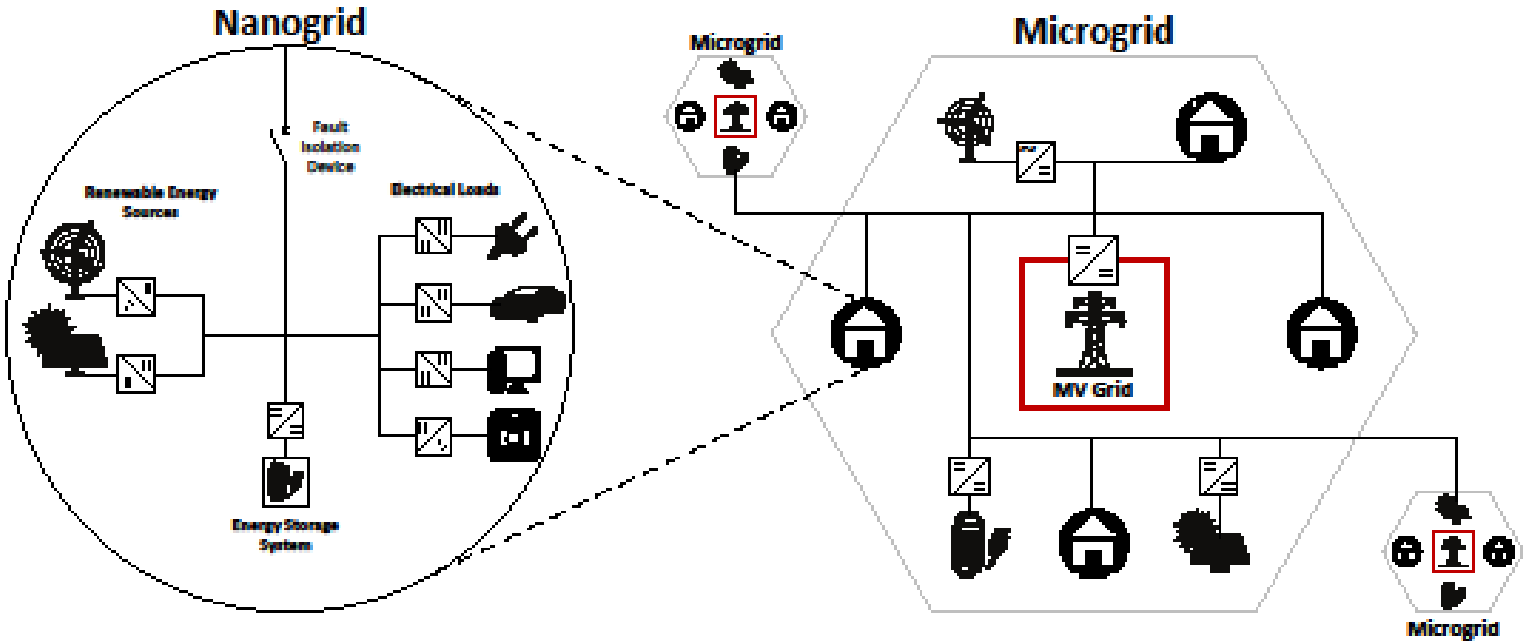
Outline

I. Context
II. Motivating Example
III. Power Flow Control
IV. Simulation Results
V. Experimental Results
VI. Concluding remarks & Extensions

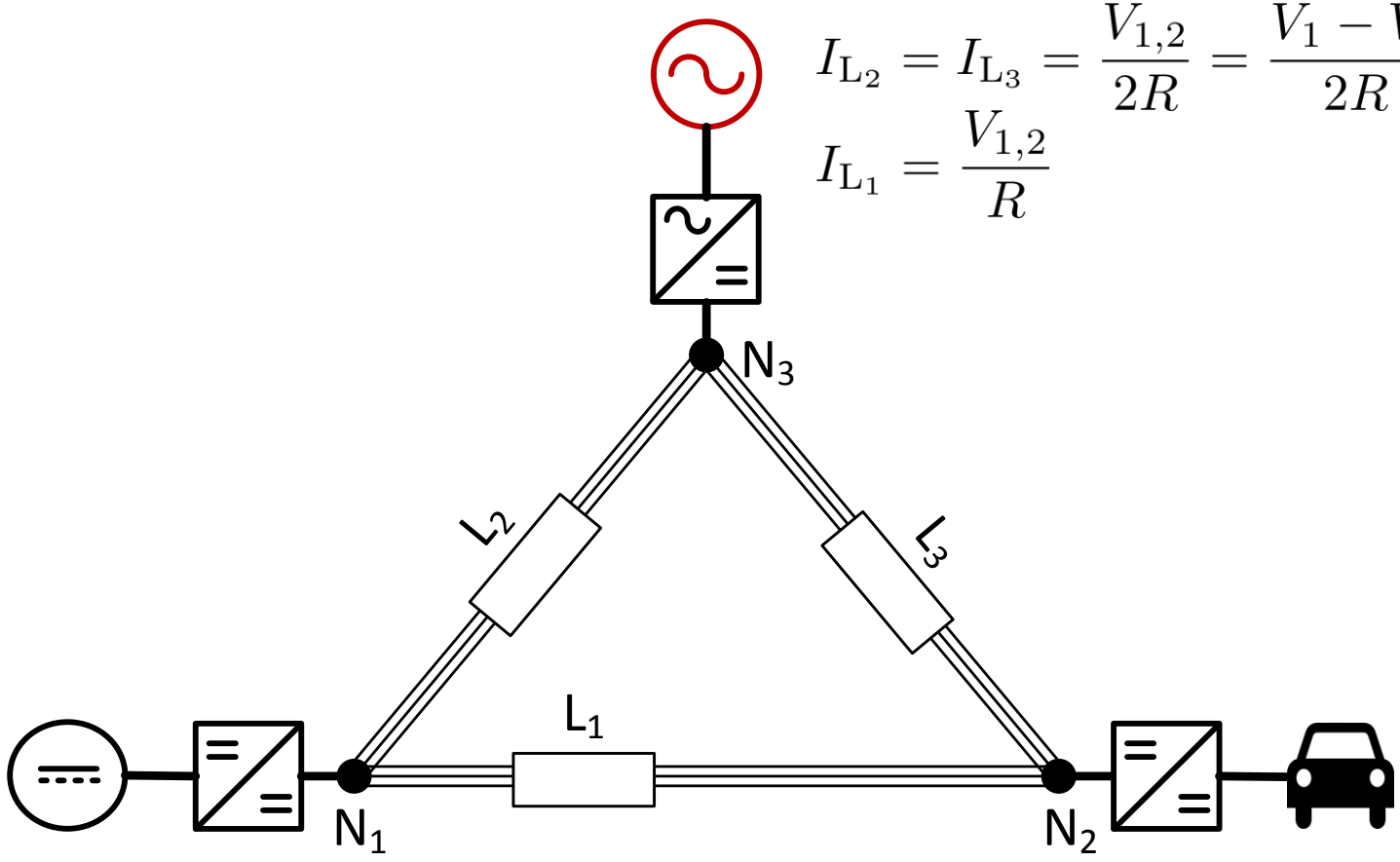
DCSmart


Nanogrid
Fault Isolation Device
Renewable Energy Sources
Electrical Loads
Energy Storage System
Microgrid
Microgrid
MV Grid
Microgrid

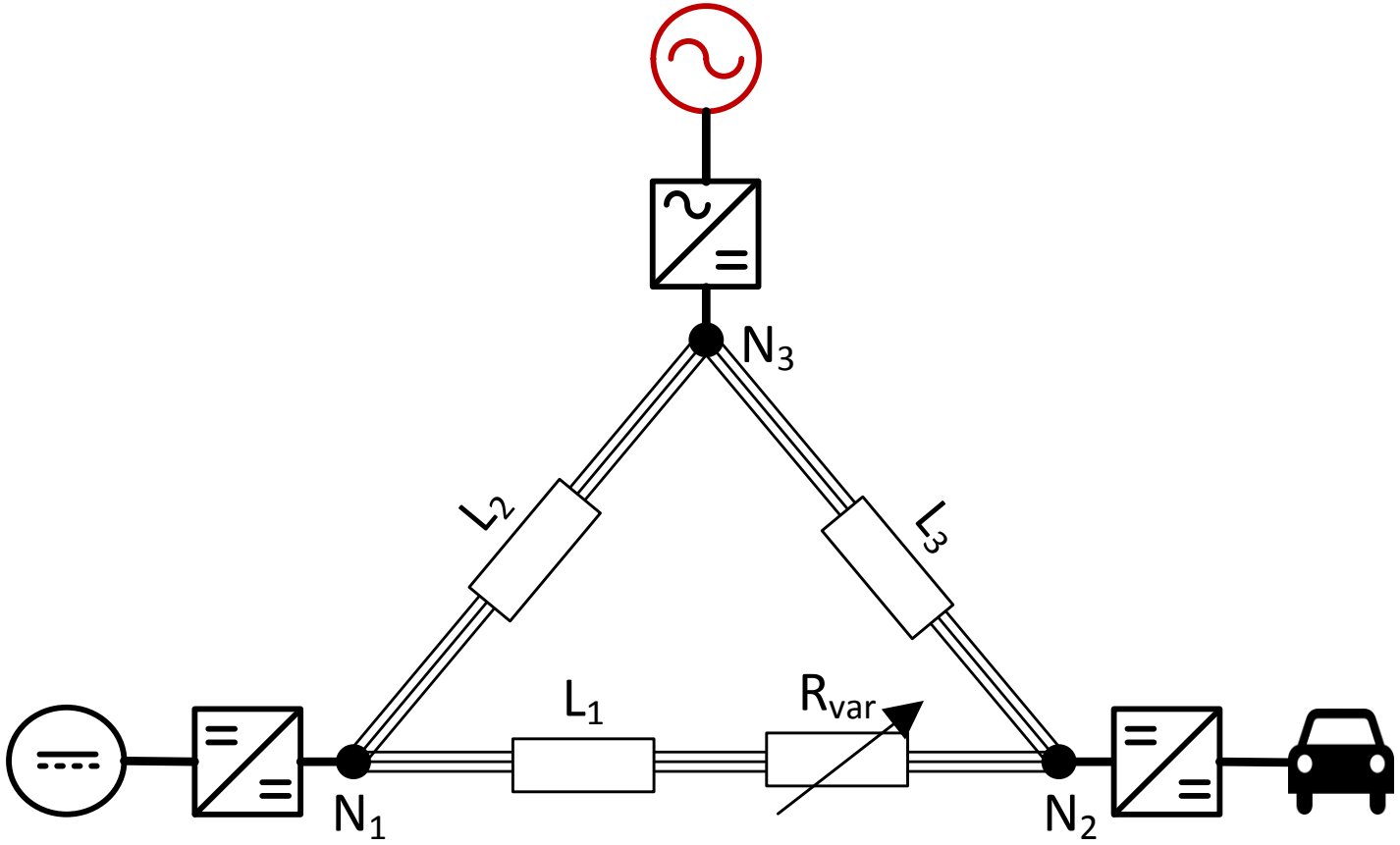
Motivating Example

$$I_{L_2} = I_{L_3} = \frac{V_{1,2}}{2R} = \frac{V_1 - V_2}{2R}$$

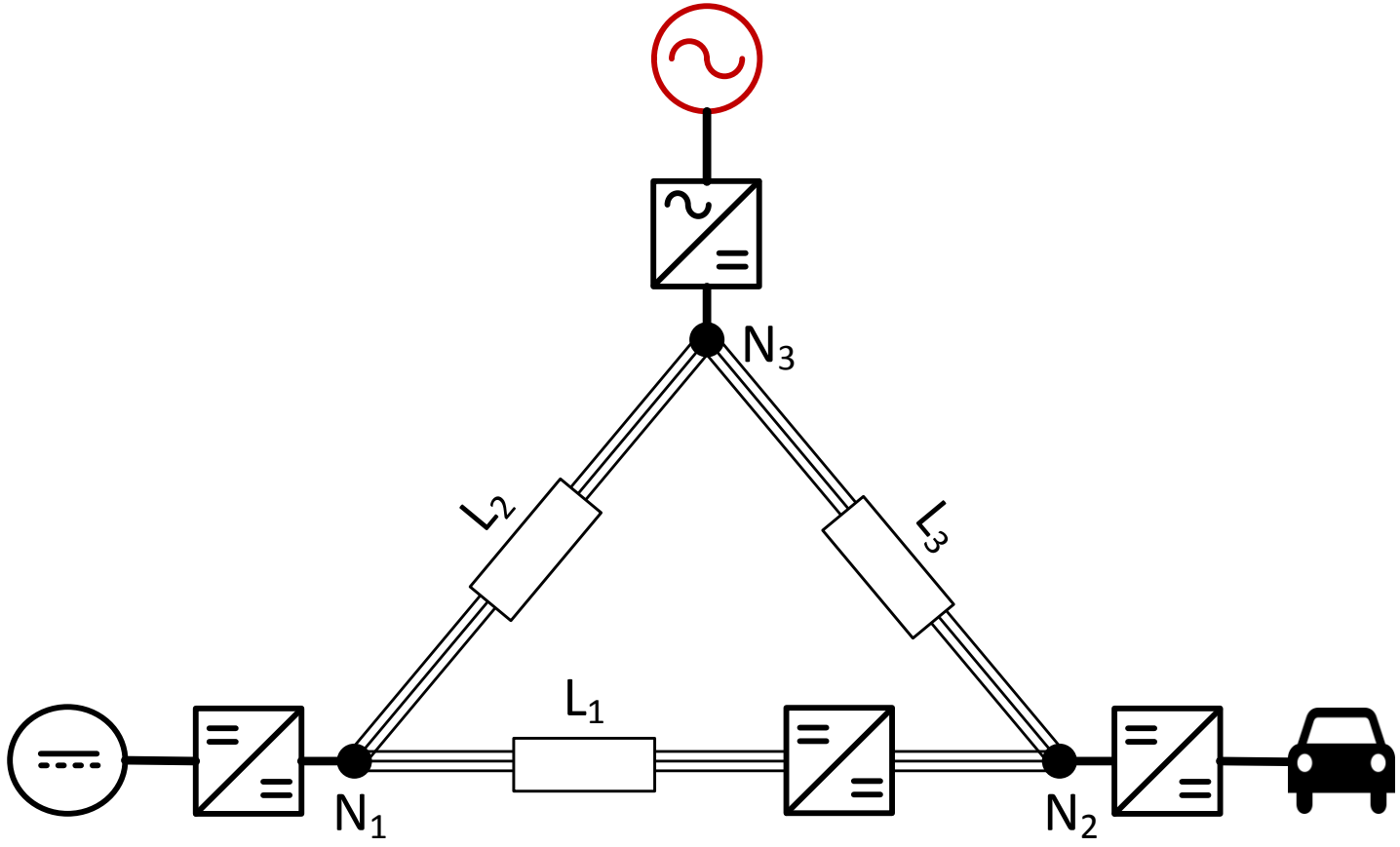
$$I_{L_1} = \frac{V_{1,2}}{R}$$



Variable Resistor



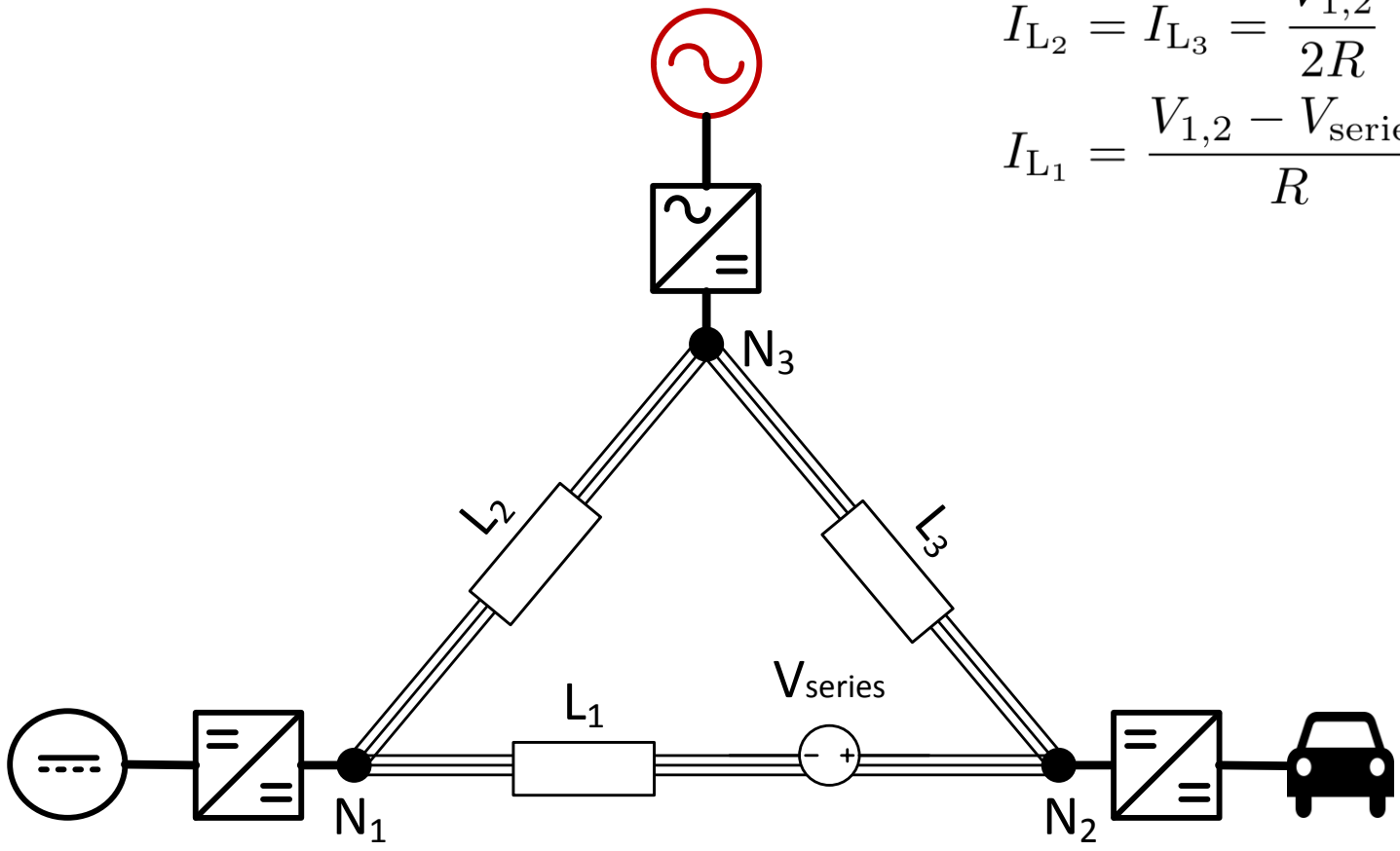
DC-DC “Transformer”



Series Voltage Injection

$$I_{L_2} = I_{L_3} = \frac{V_{1,2}}{2R}$$

$$I_{L_1} = \frac{V_{1,2} - V_{\text{series}}}{R}$$



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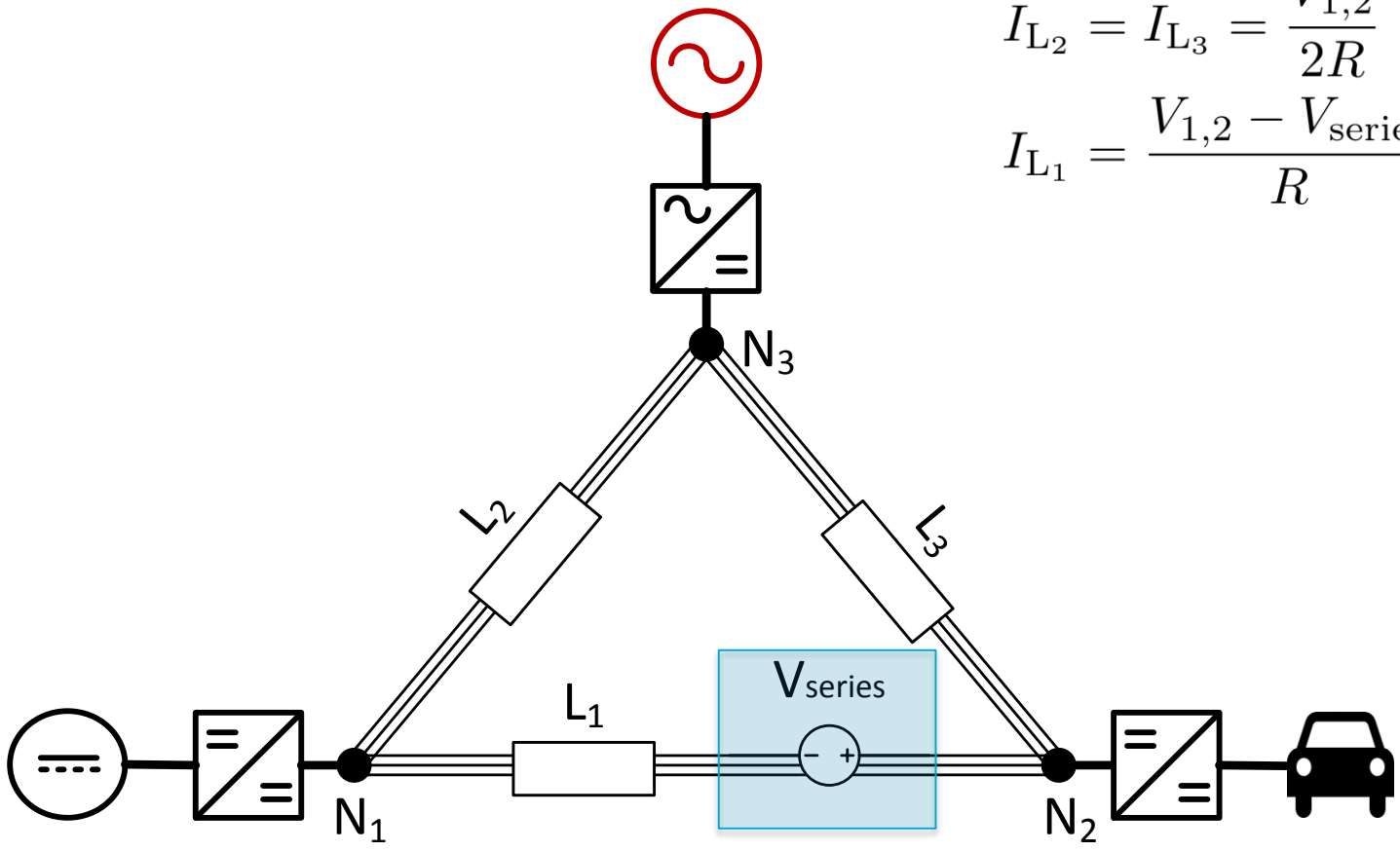
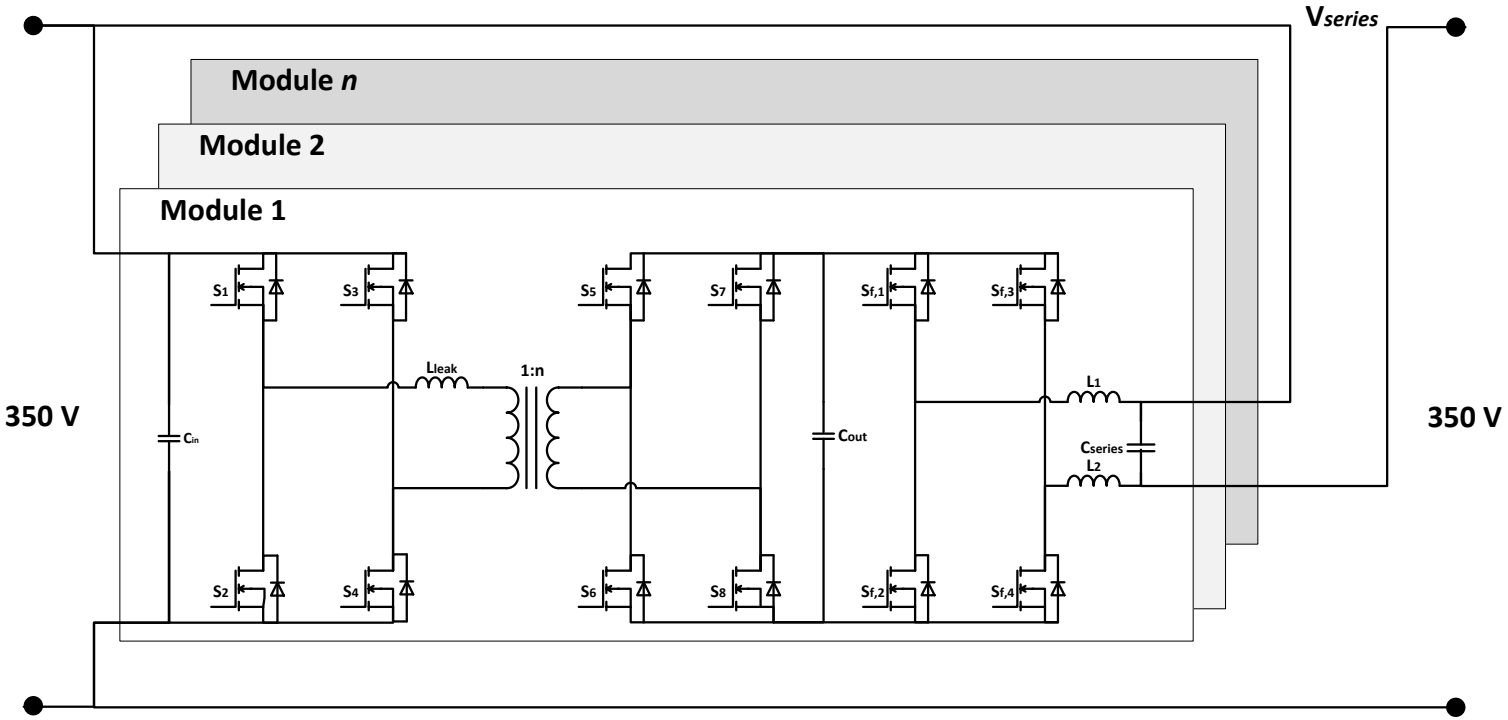
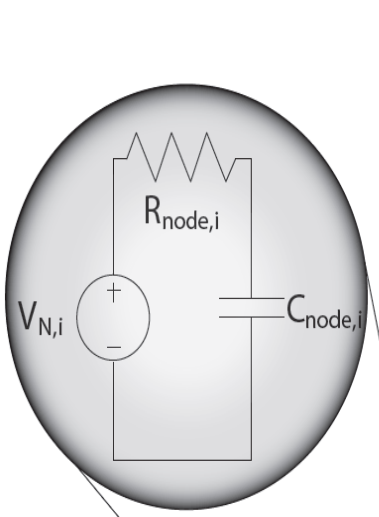


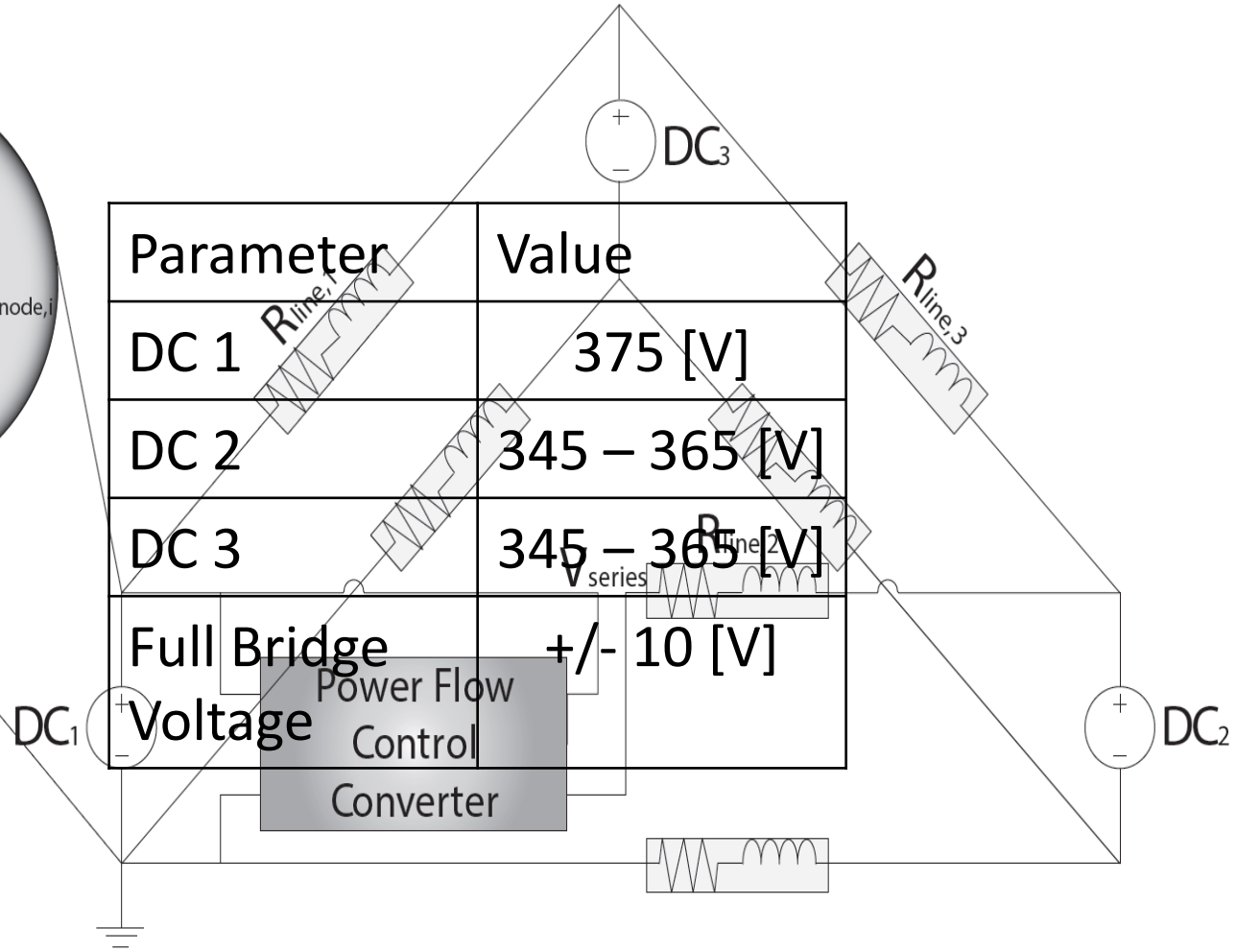
Power Flow Control Converter

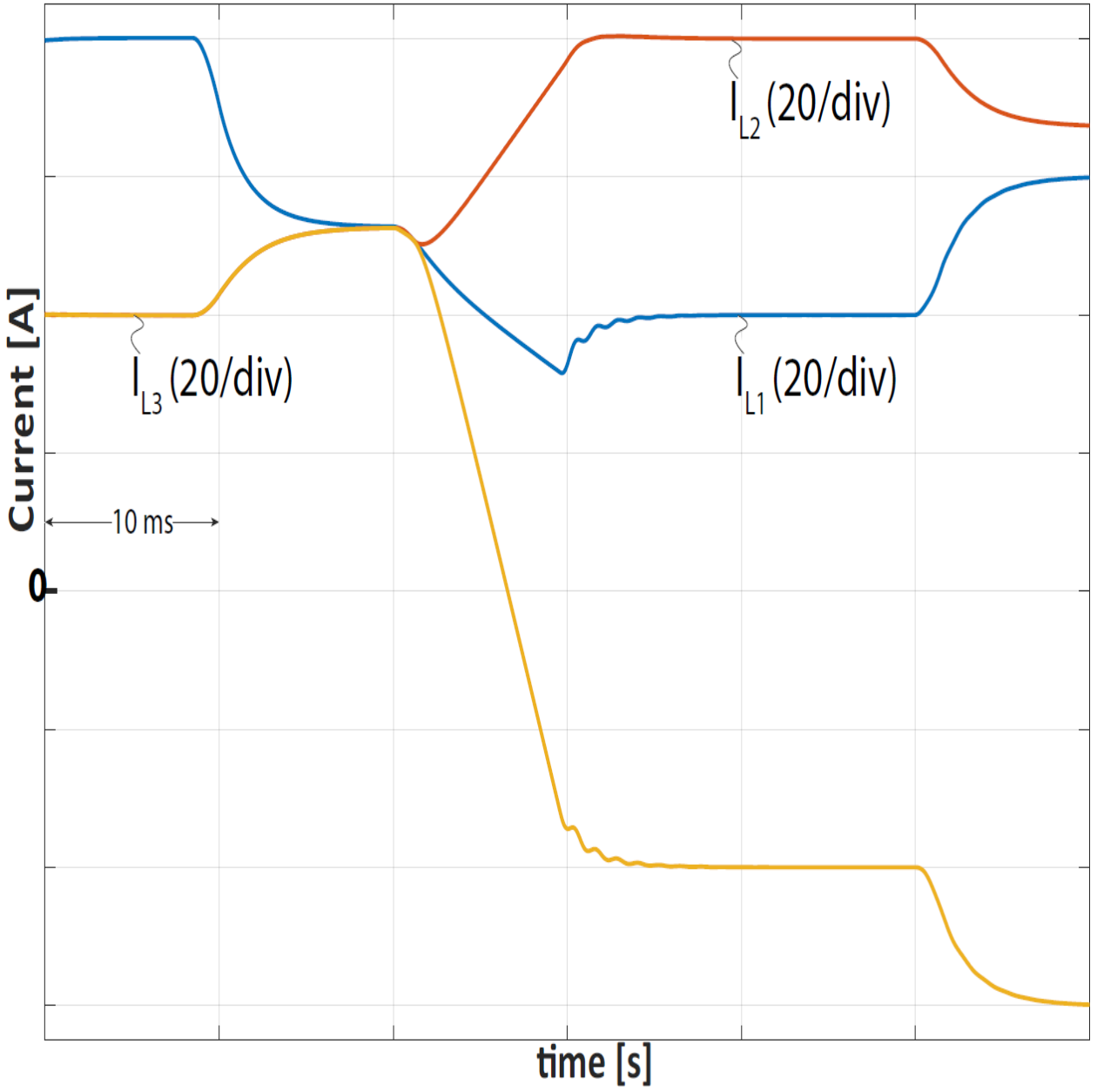


Case Study: Meshed LVDC Grid

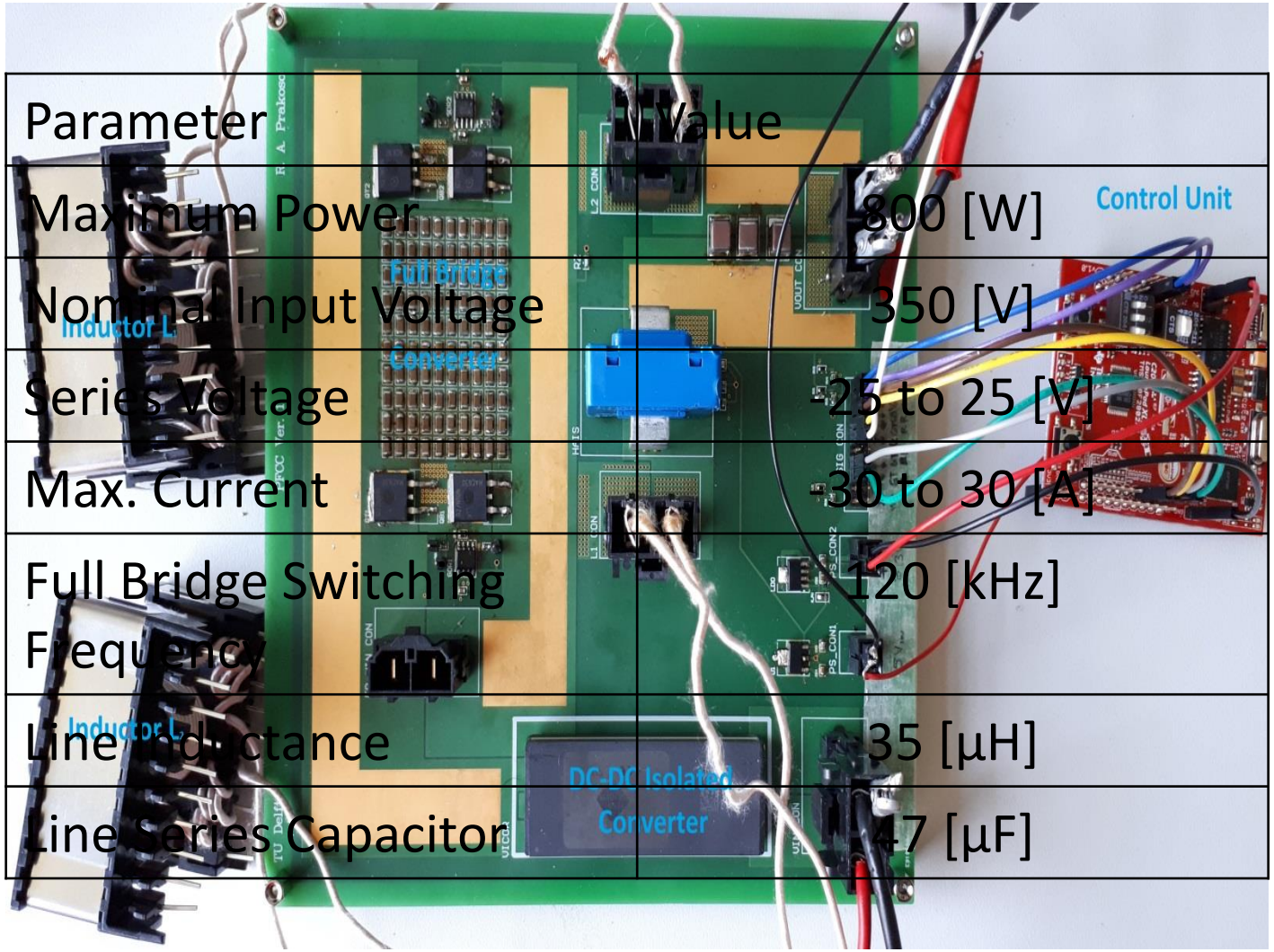


Parameter	Value
DC 1	375 [V]
DC 2	345 – 365 [V]
DC 3	345 – 365 [V]
Full Bridge Voltage	+/- 10 [V]

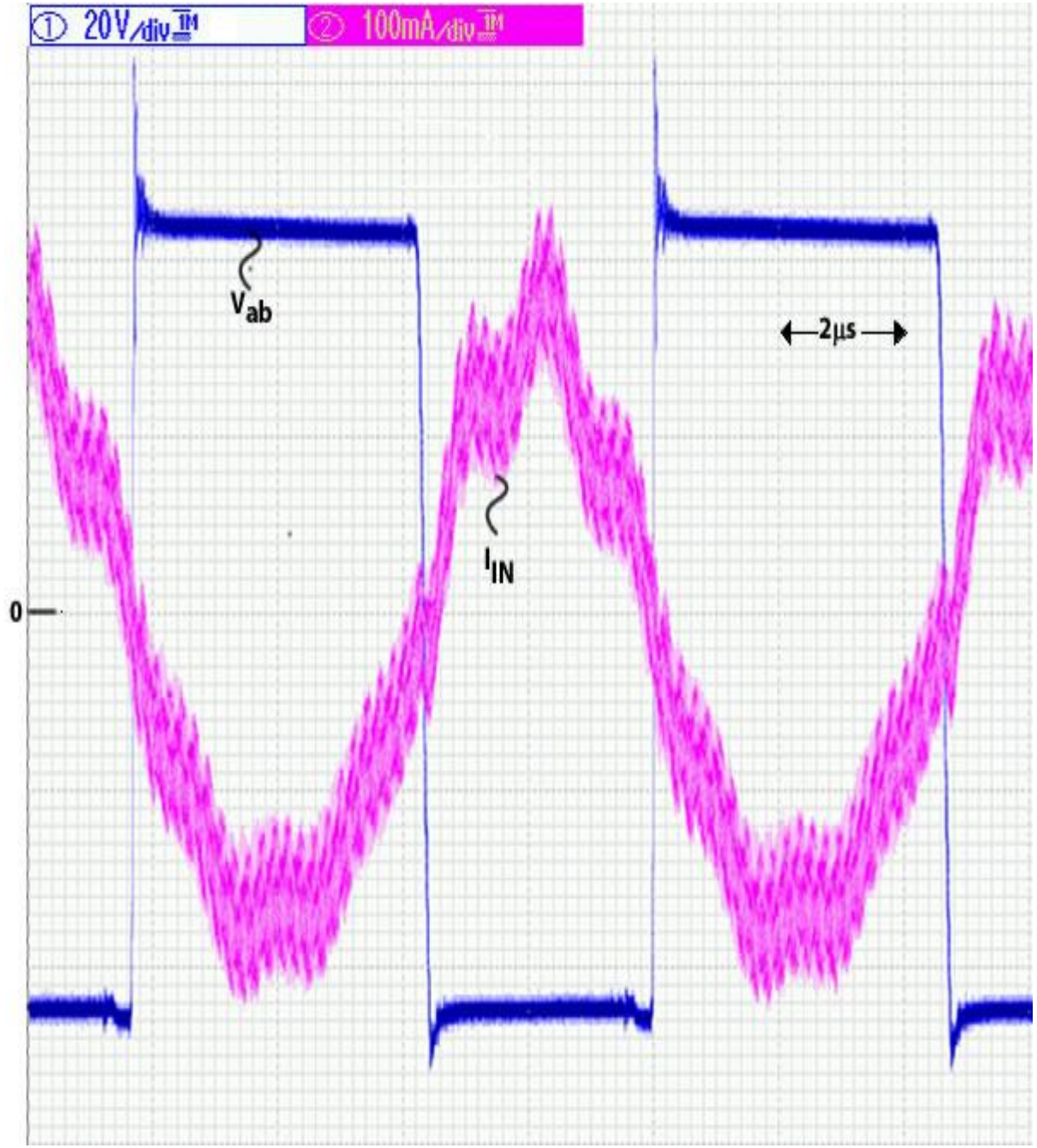



Current [A]
0
10 ms
I_{L3} (20/div)
I_{L2} (20/div)
I_{L1} (20/div)
time [s]

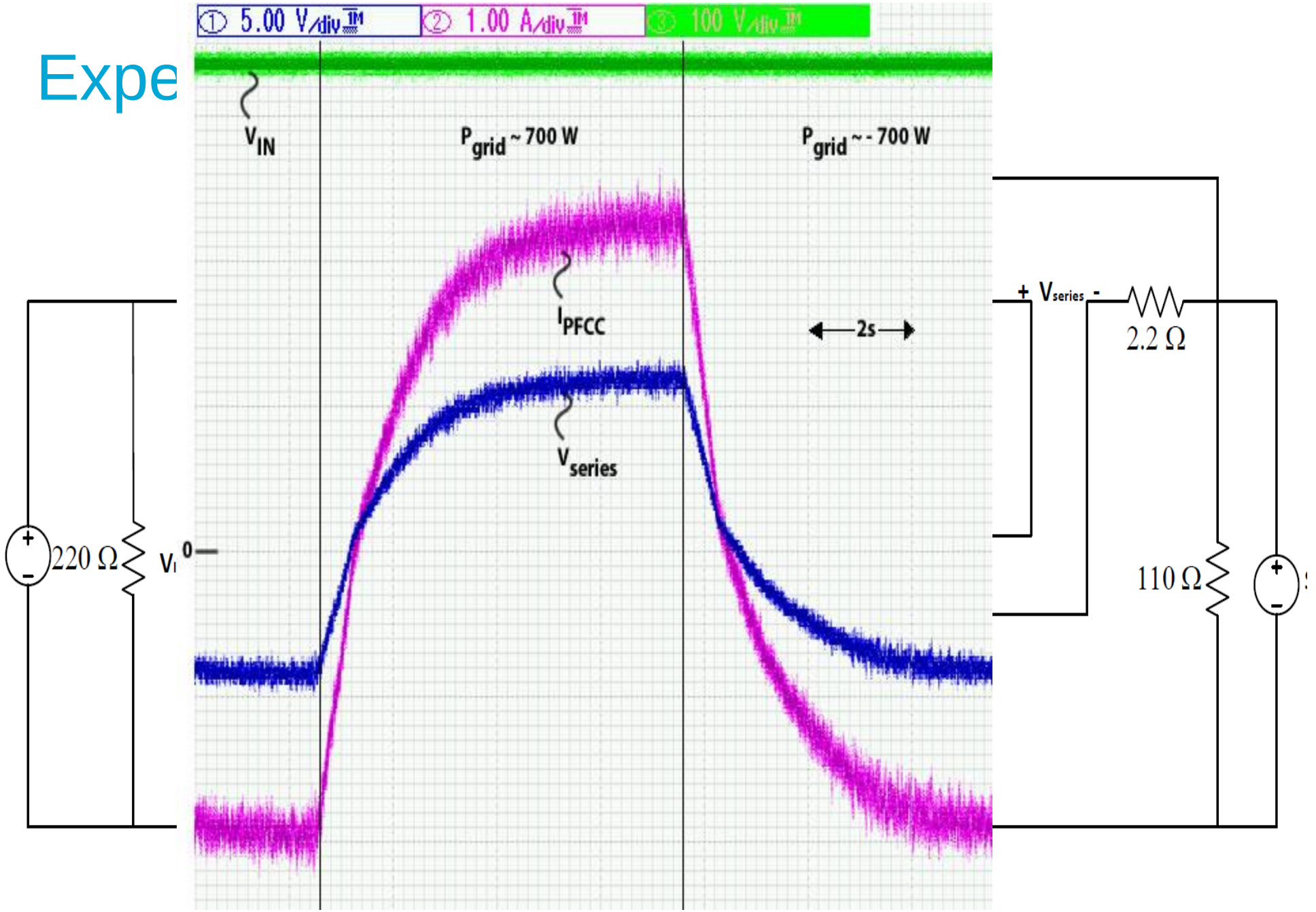
Prototype



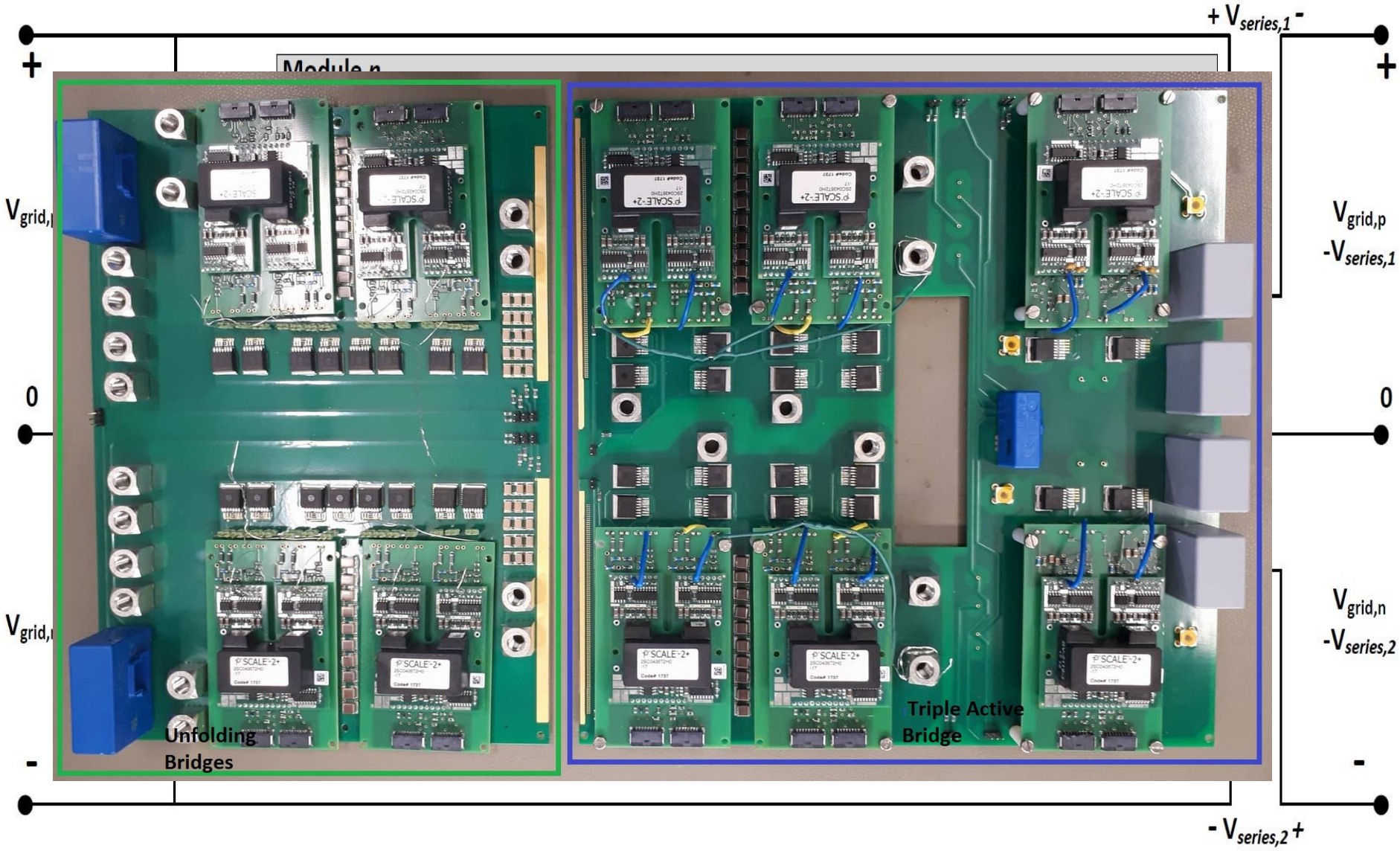
Parameter	Value
Maximum Power	800 [W]
Nominal Input Voltage	350 [V]
Series Voltage	-25 to 25 [V]
Max. Current	-30 to 30 [A]
Full Bridge Switching Frequency	120 [kHz]
Line Inductance	35 [µH]
Line Series Capacitor	47 [µF]


① 20V/div
② 100mA/div
V_{ab}
I_{IN}
2µs
0

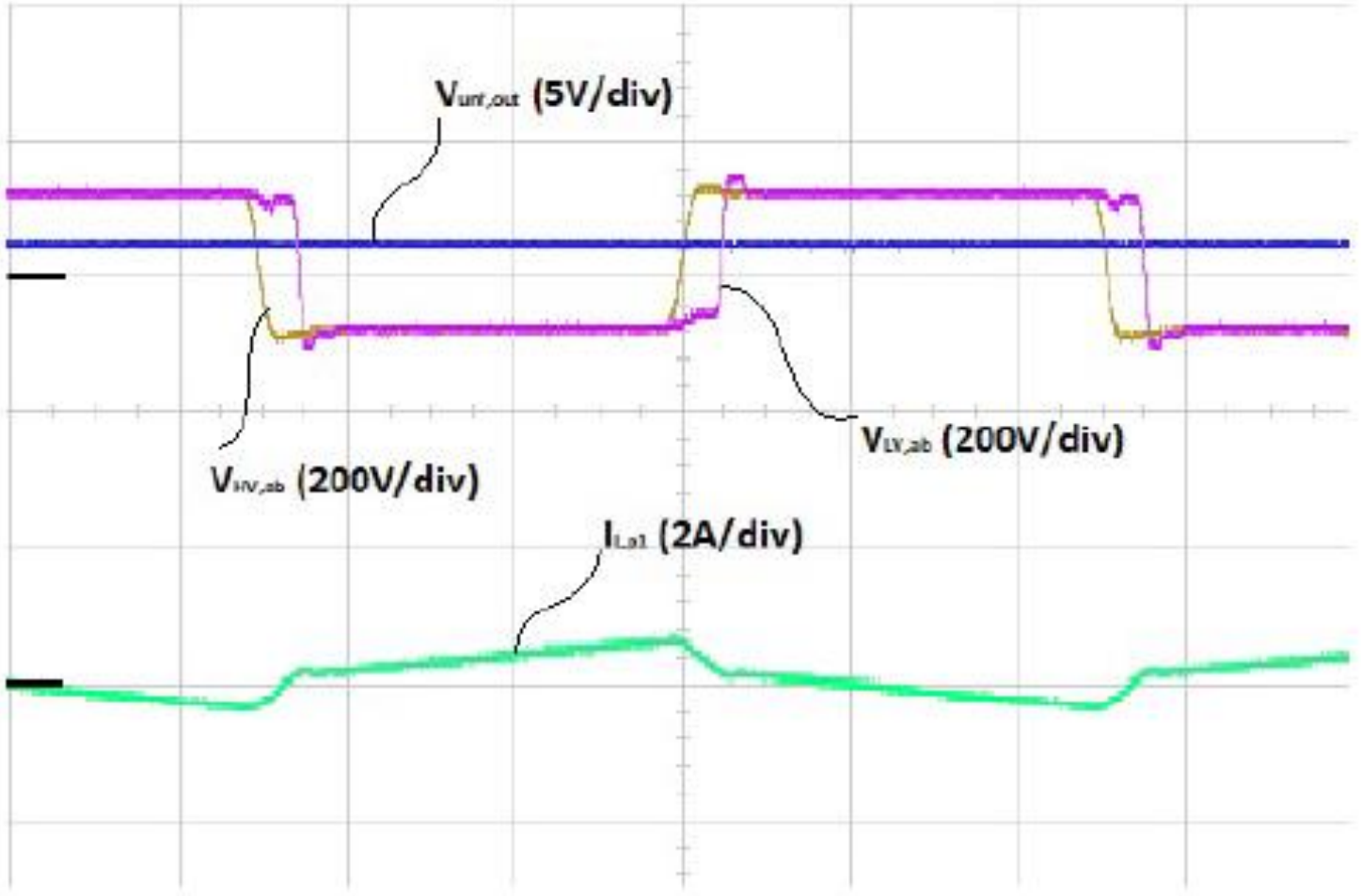
Expe


① 5.00 V/div
② 1.00 A/div
③ 100 V/div
V_IN
P_grid ~ 700 W
P_grid ~ - 700 W
I_PFCC
V_series
2s
220 Ω
+ V_series -
2.2 Ω
110 Ω

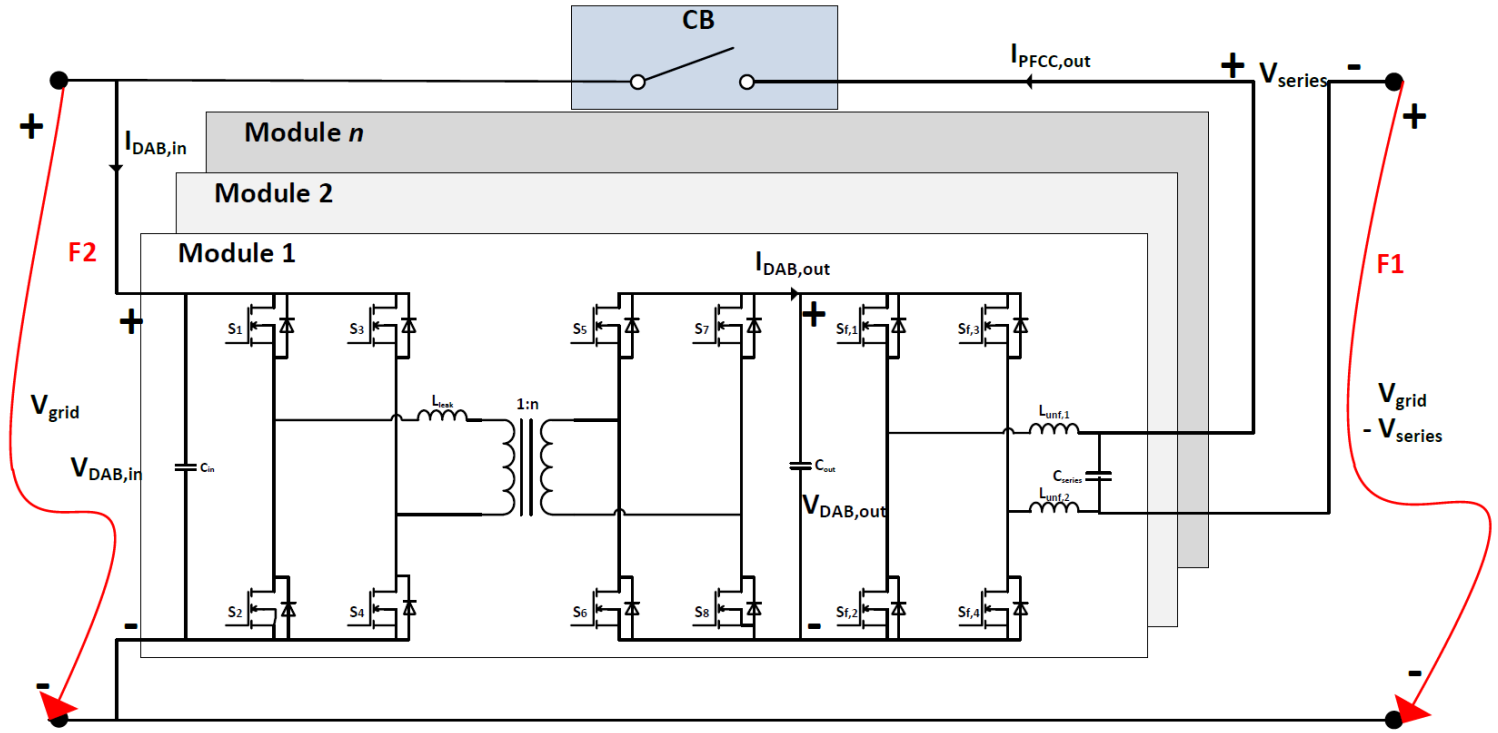
PFCC for Bipolar LVDC Networks



Results



Short-circuit protection



Concluding Remarks

- Partially rated devices are promising alternative for power flow control implementation in LVDC networks.
- Due to the partial power rating, in general significantly higher system efficiency is achieved.
- Three-port solution offers more flexibility for bipolar grids, as well as a port for storage which can be used for peak shaving.
- The PFCC short-circuit protection has been investigated

Thank You

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