Droop Control

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HHS / Simulation Research

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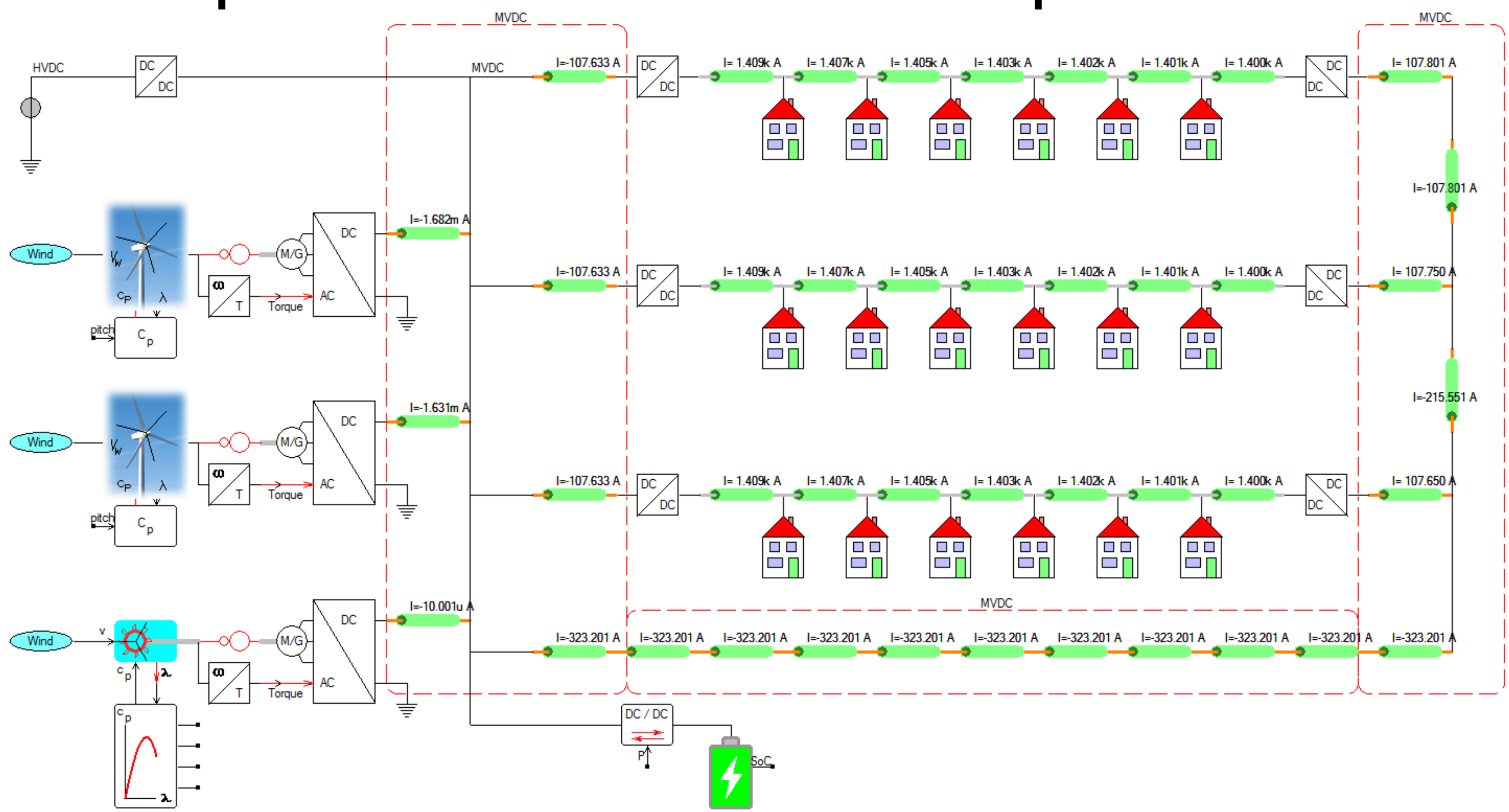
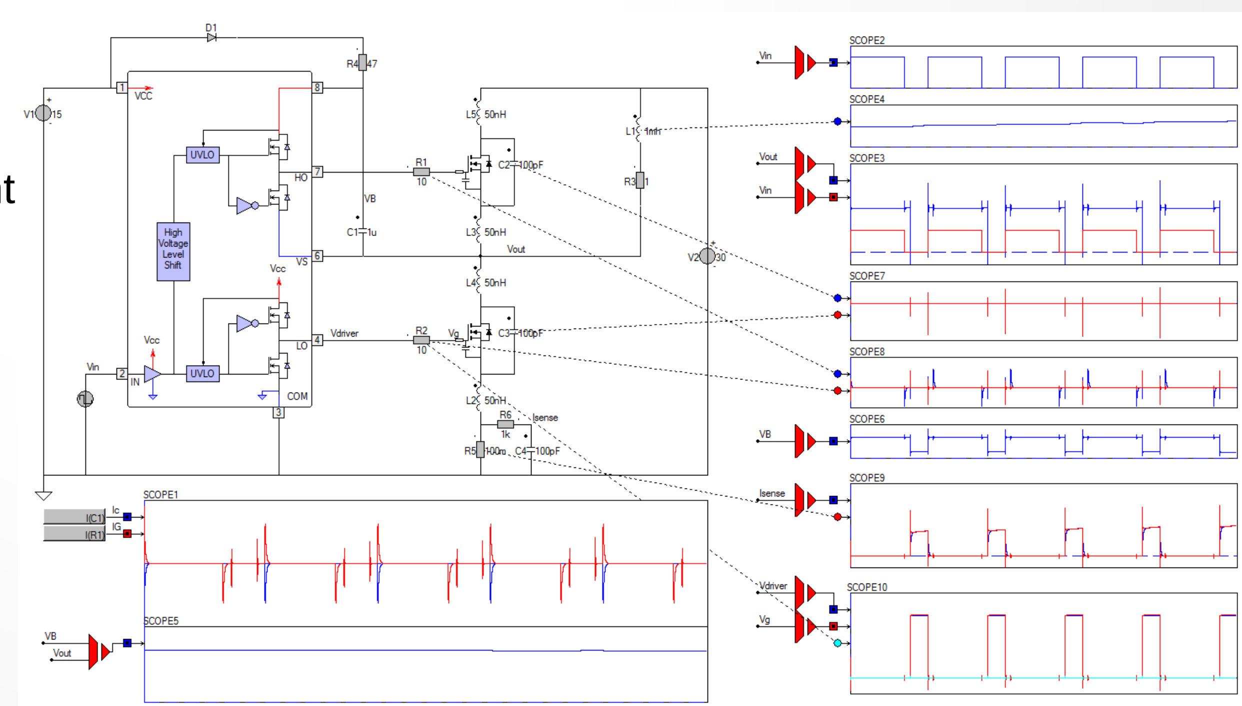


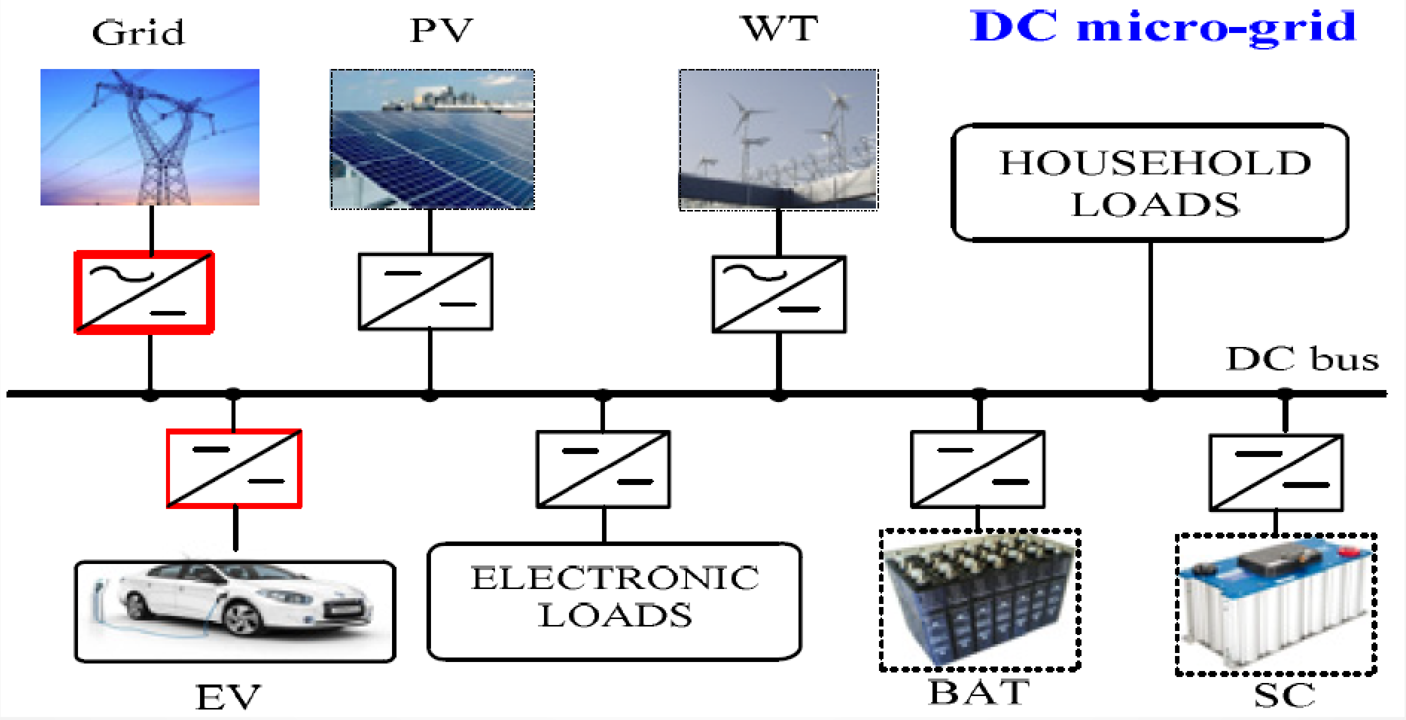
Contents



D1
R4
VCC
UVLO
High Voltage Level Shift
HO
VB
VS
LO
COM
Vdriver
Vout
Isense
SCOPE1
SCOPE2
SCOPE3
SCOPE4
SCOPE5
SCOPE6
SCOPE7
SCOPE8
SCOPE9
SCOPE10

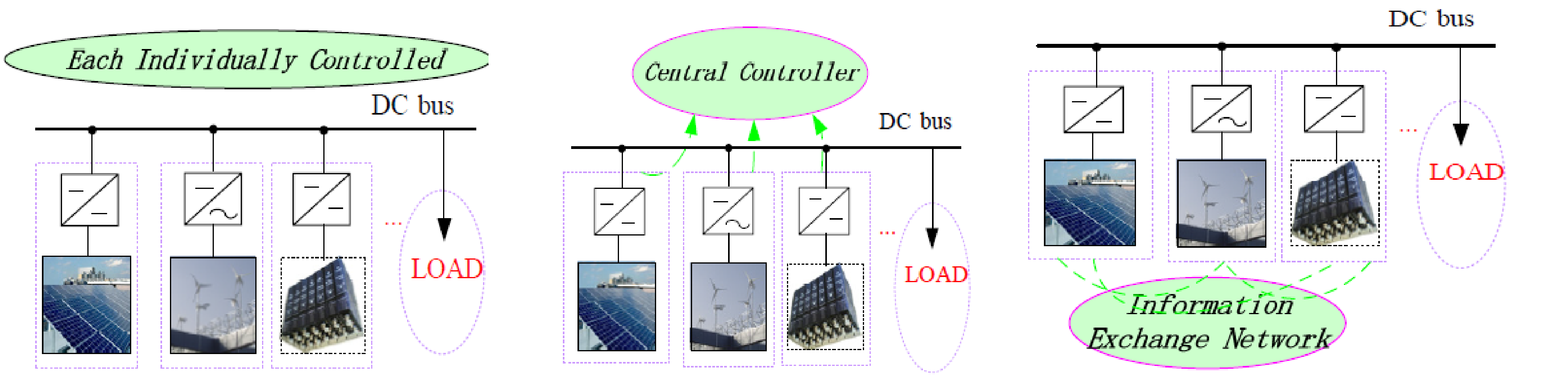
Introduction

- What is droop control?
- Why do we need it?
- Is it easy to implement?



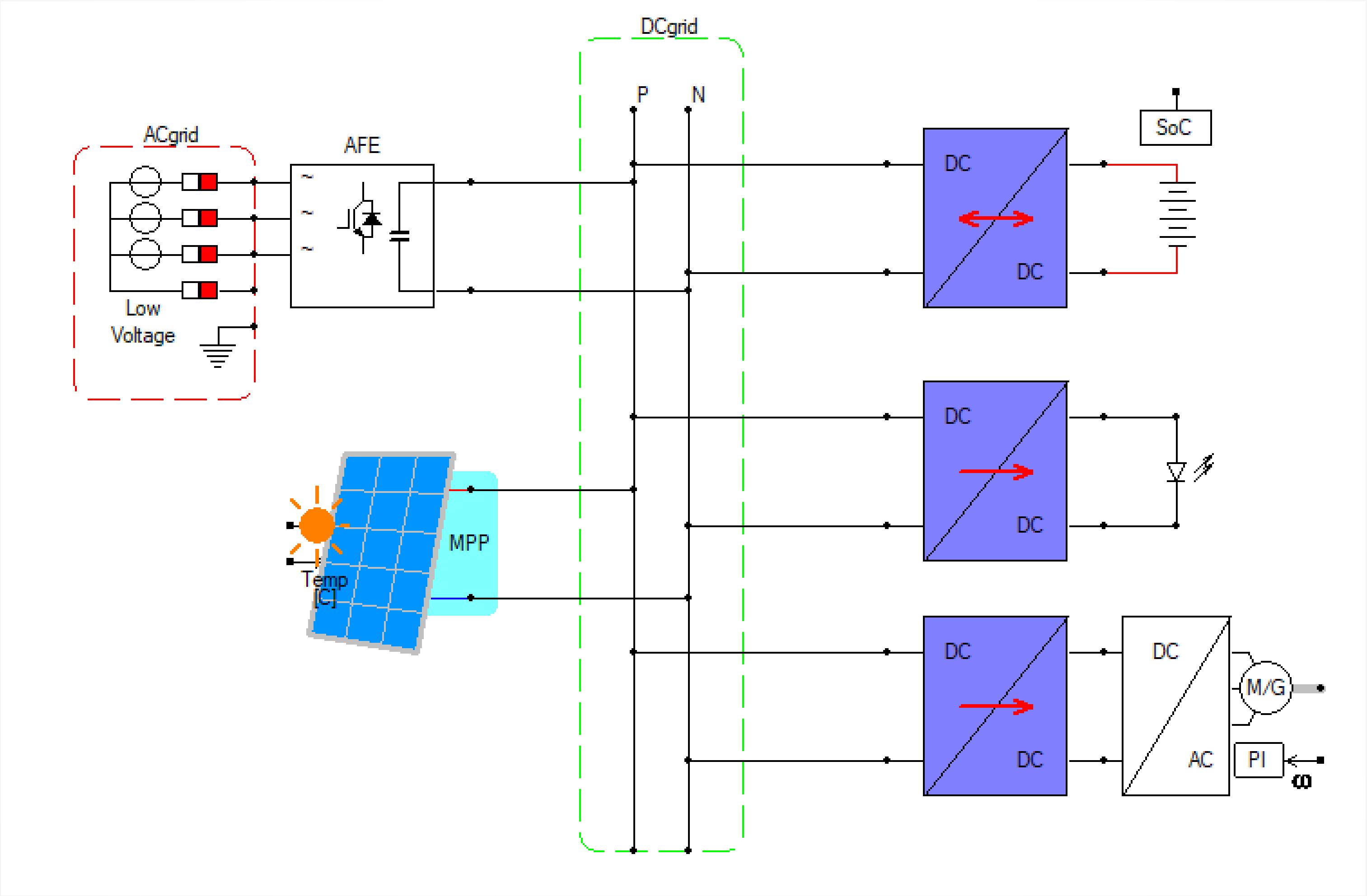
Configuration

- Decentralized control
- Centralized control
- Distributed control



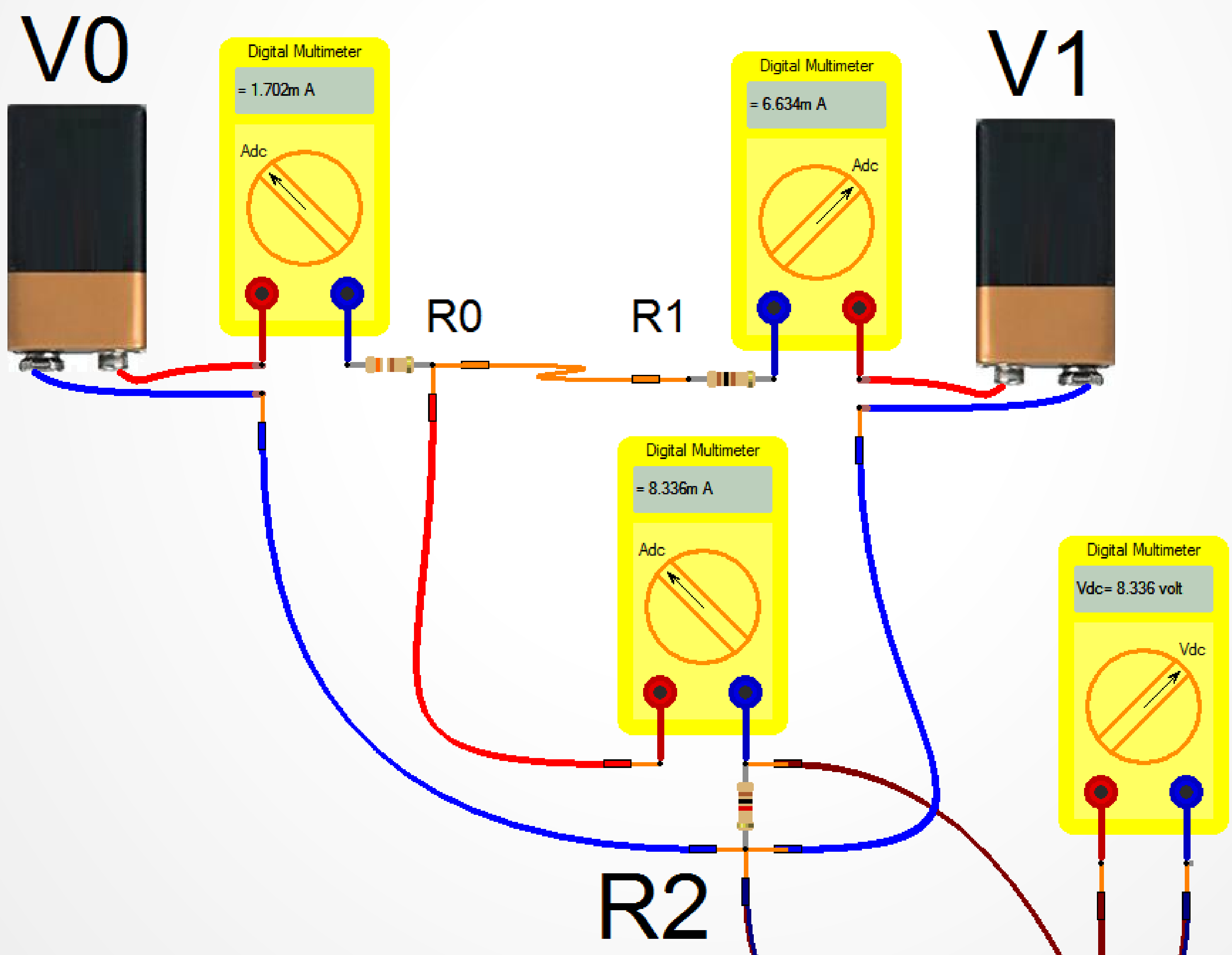
(a) Decentralized control (b) Centralized control (c) Distributed control

Connecting everything just like that?



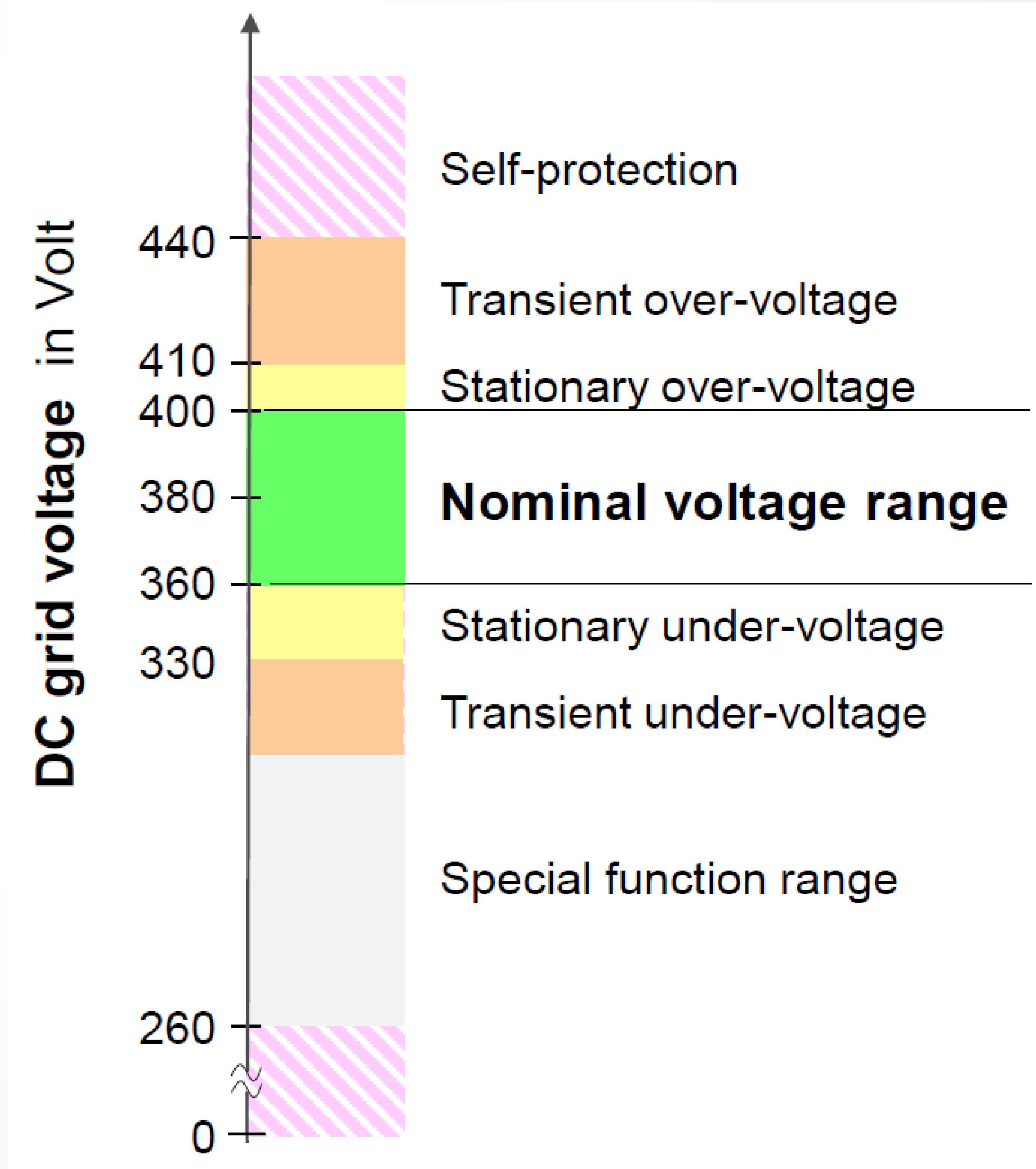
9volt battery example

- Depending on R0 and R1: battery power (V0 or V1)



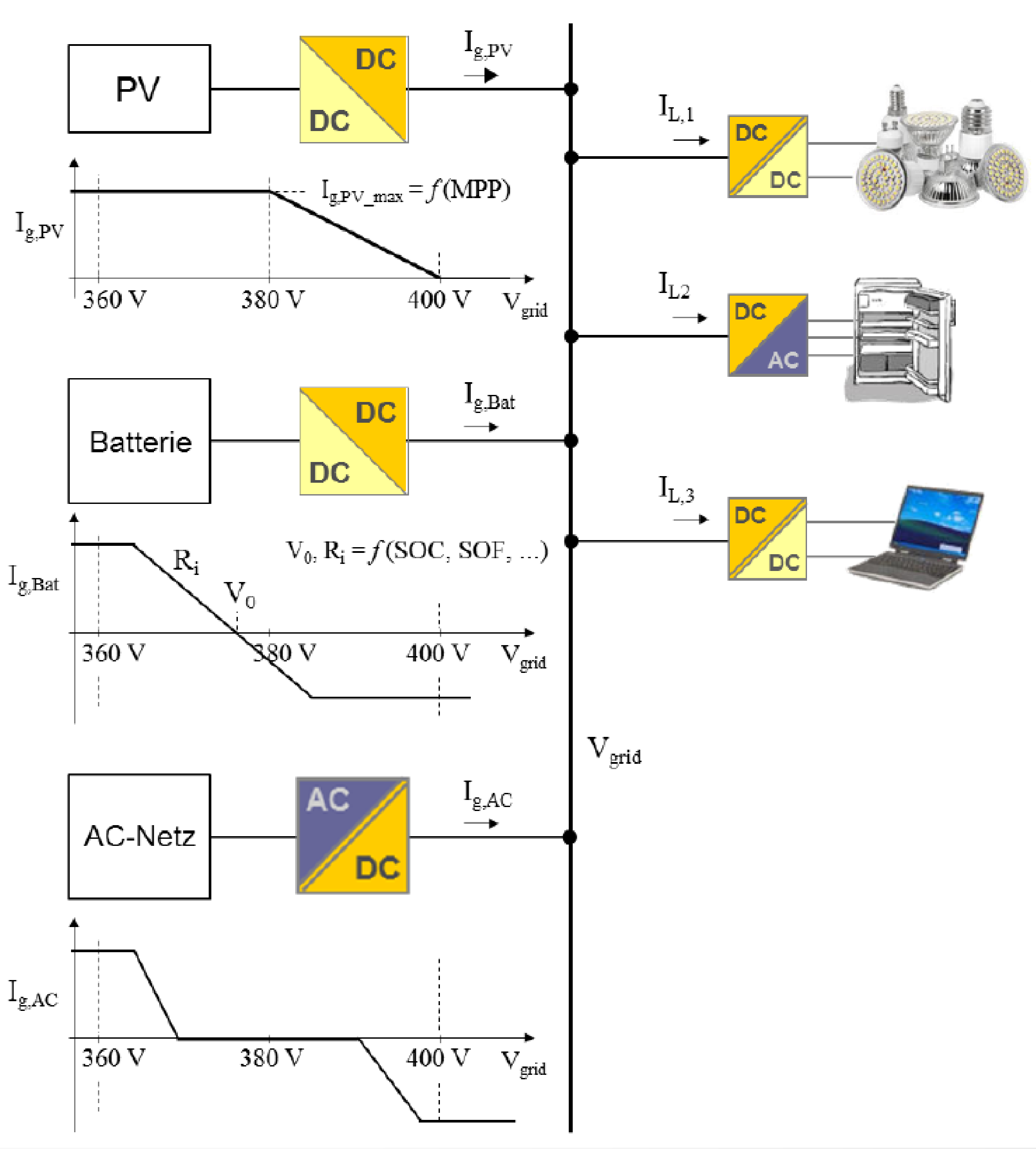
Nominal voltage

- Regulate around nominal voltage



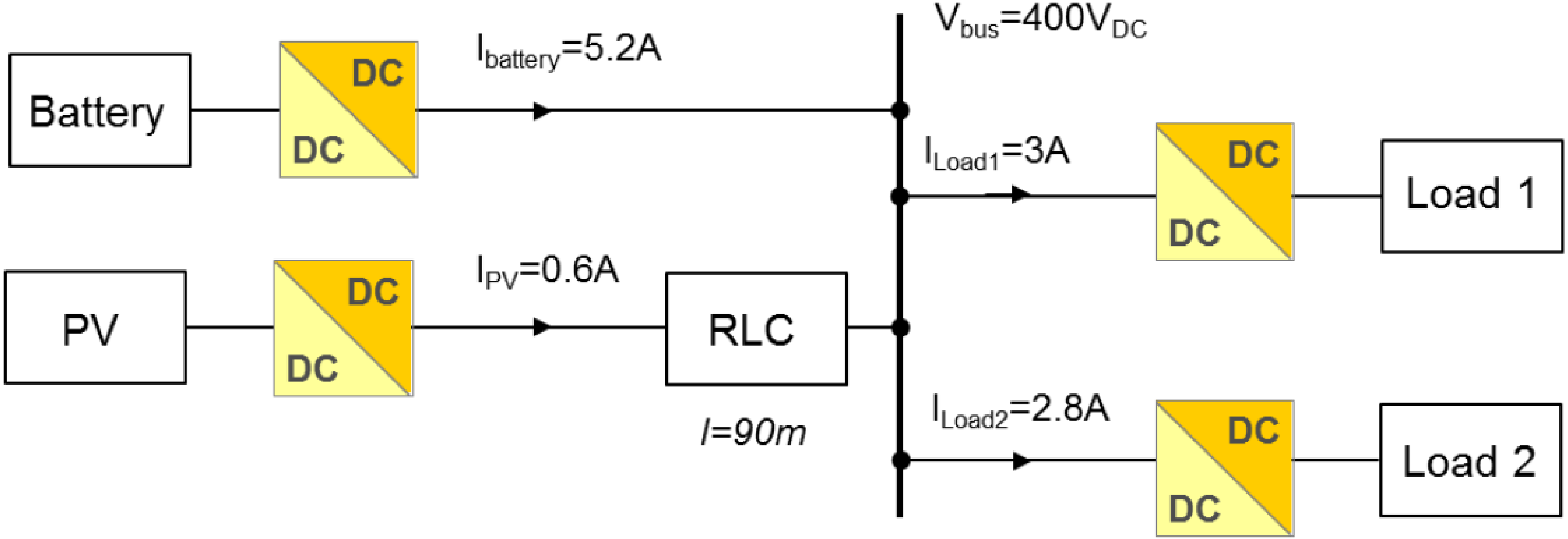
Droop control

- Control via the Vgrid voltage



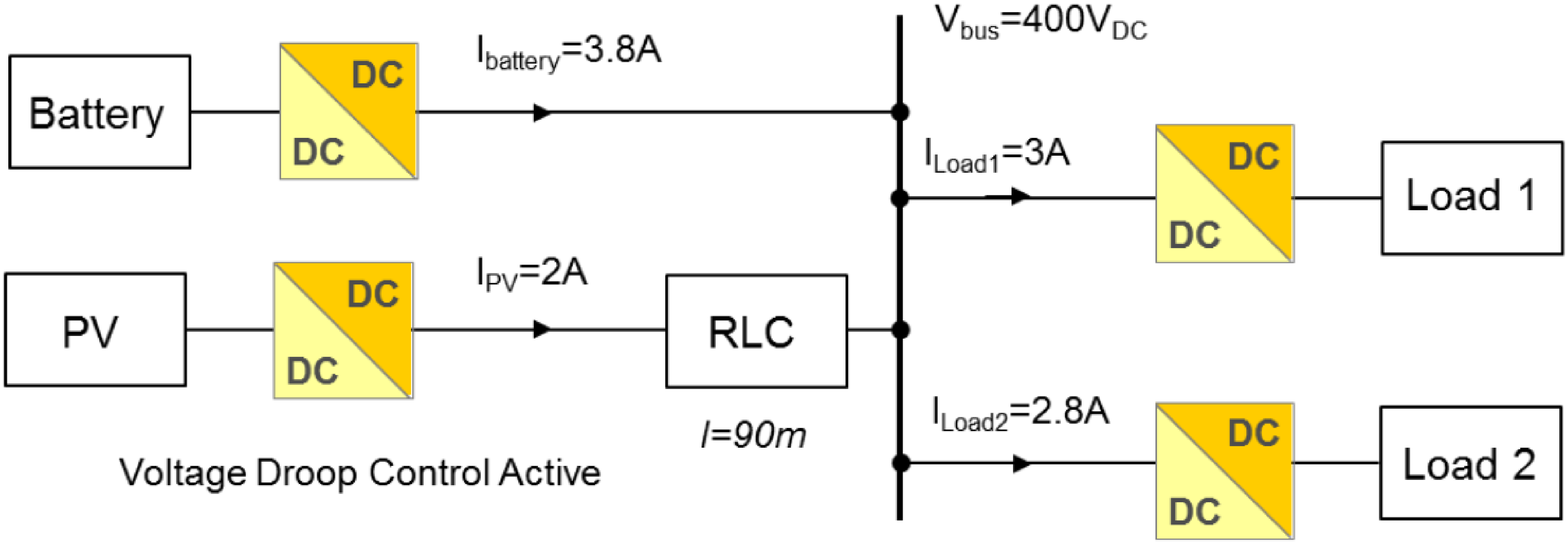
Without droop control

- Most power is coming from the battery,
- Nearly nothing from the PV



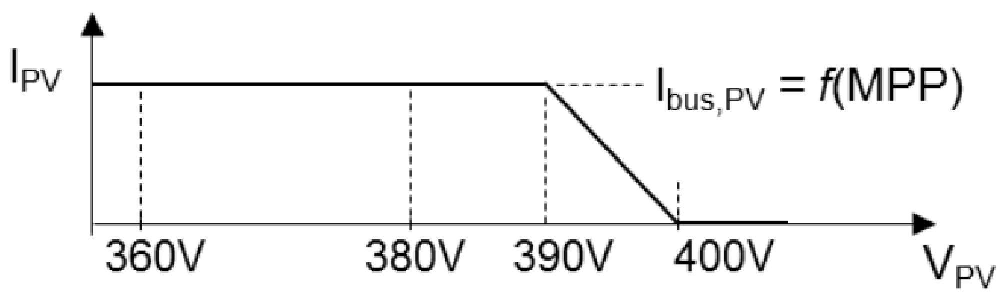
With droop control

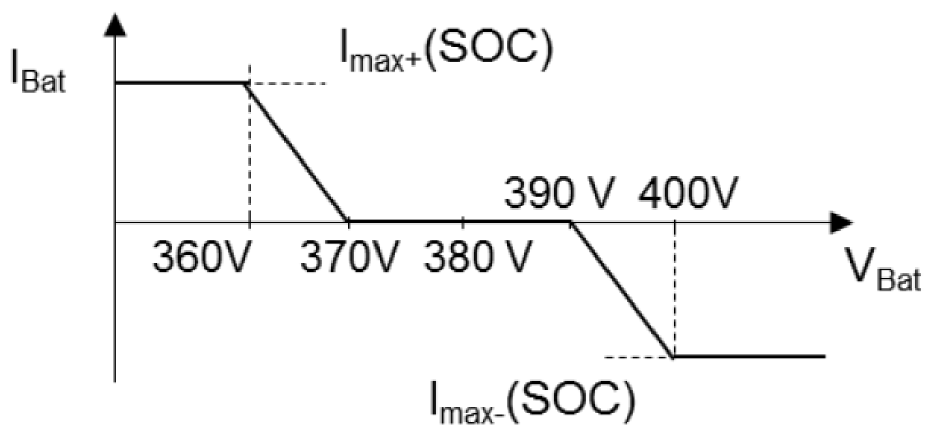
- More equal power distribution
- The PV also delivers power



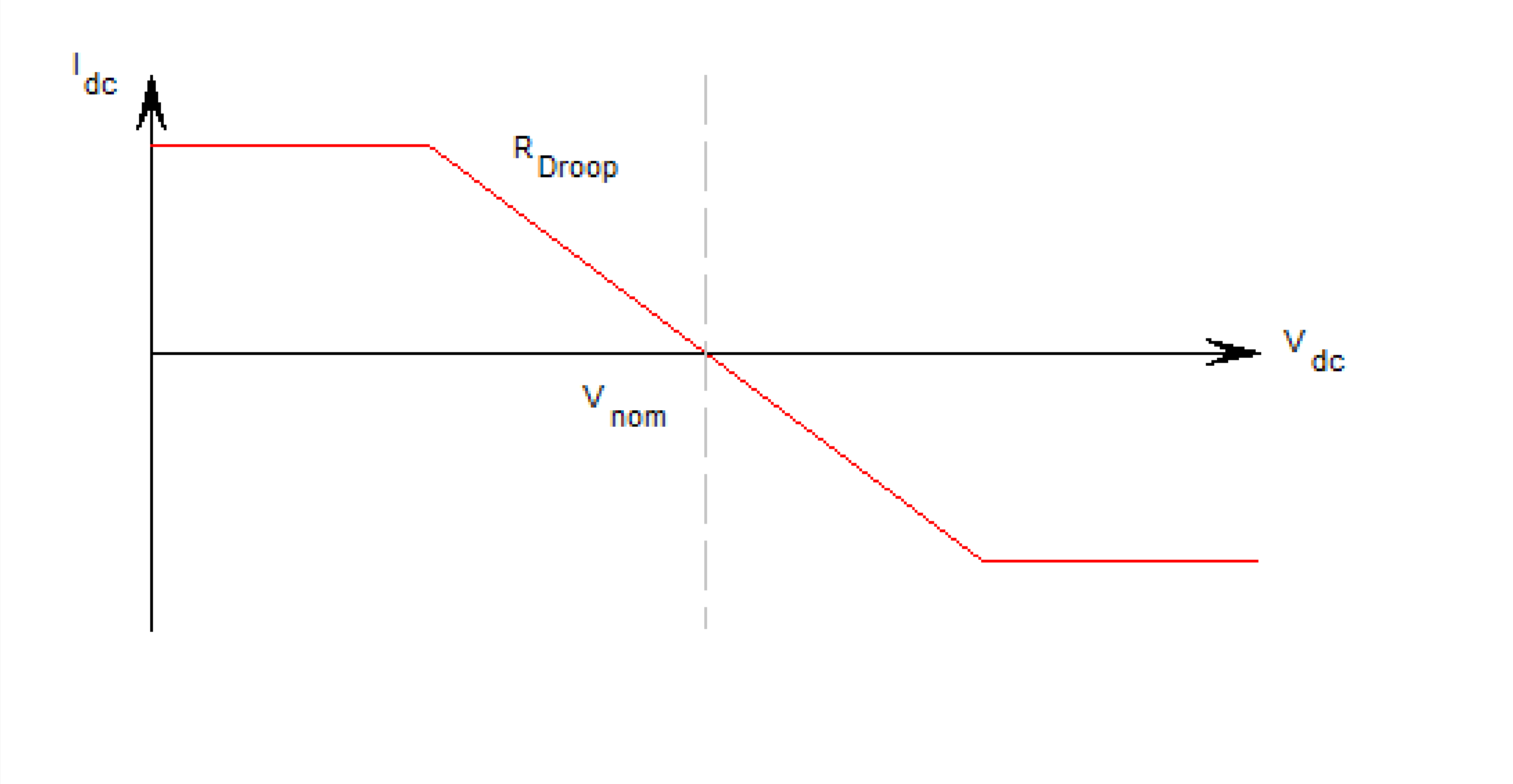
Droop characteristic

- Depending on Vbus:
  - we select the load current

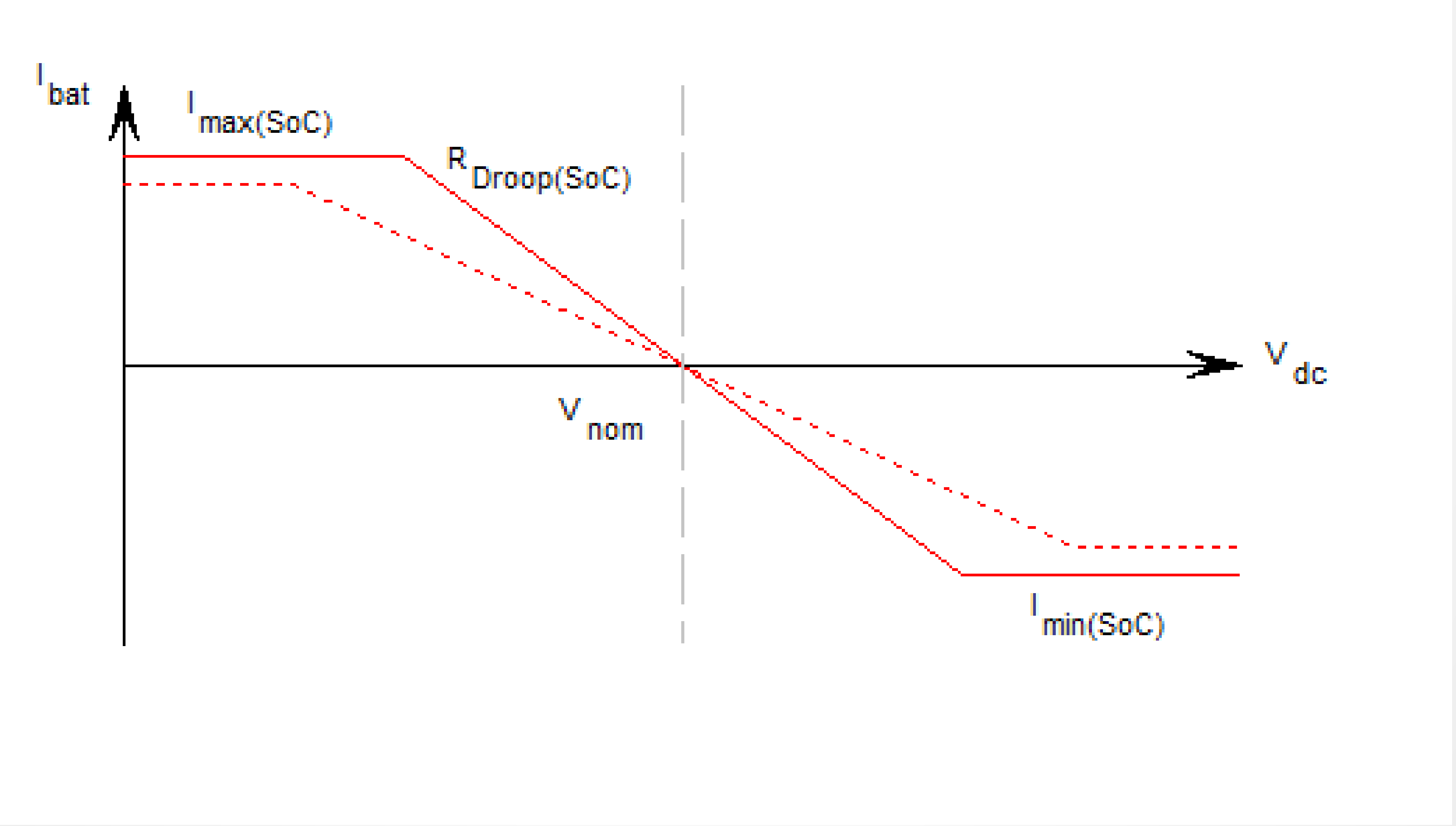




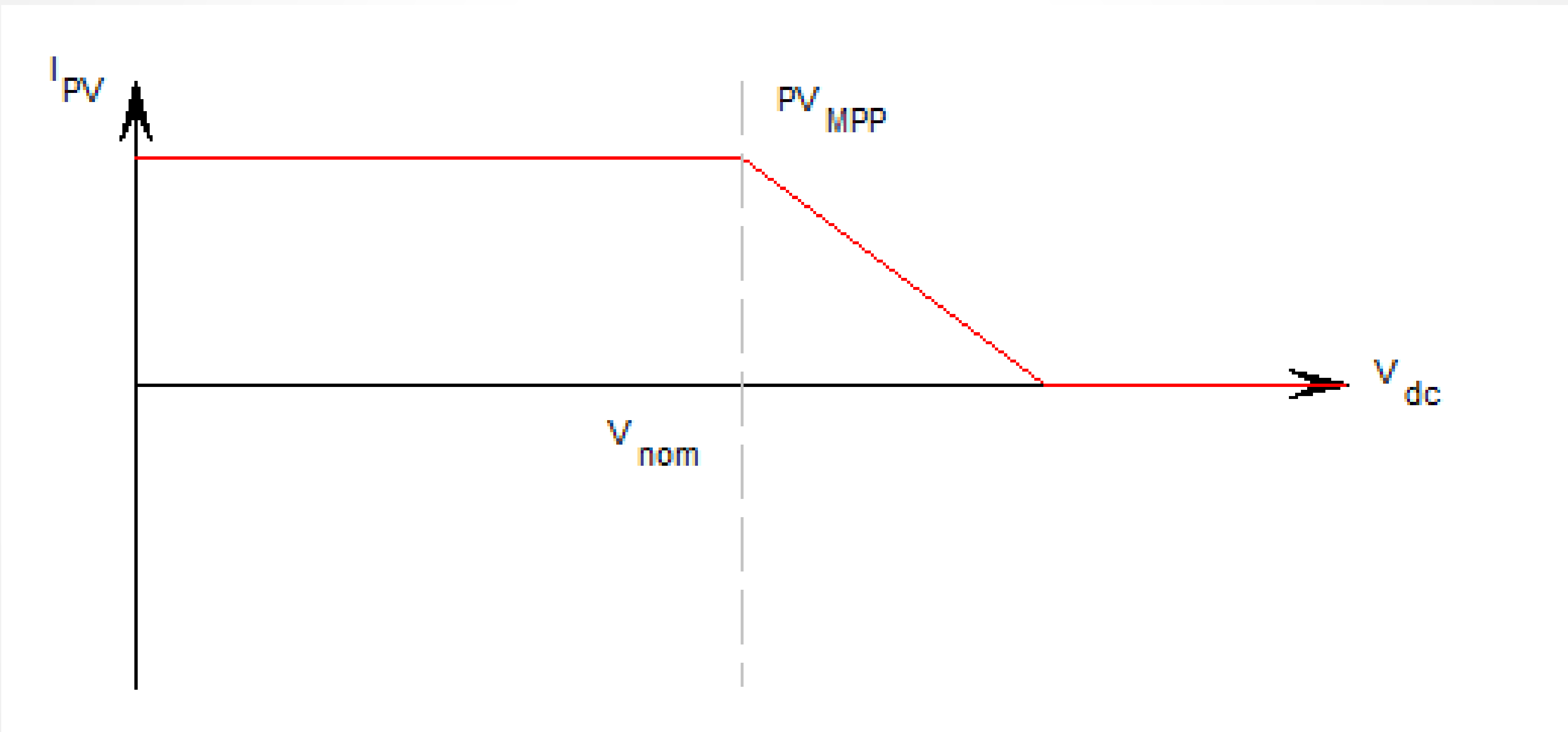
Grid Connection



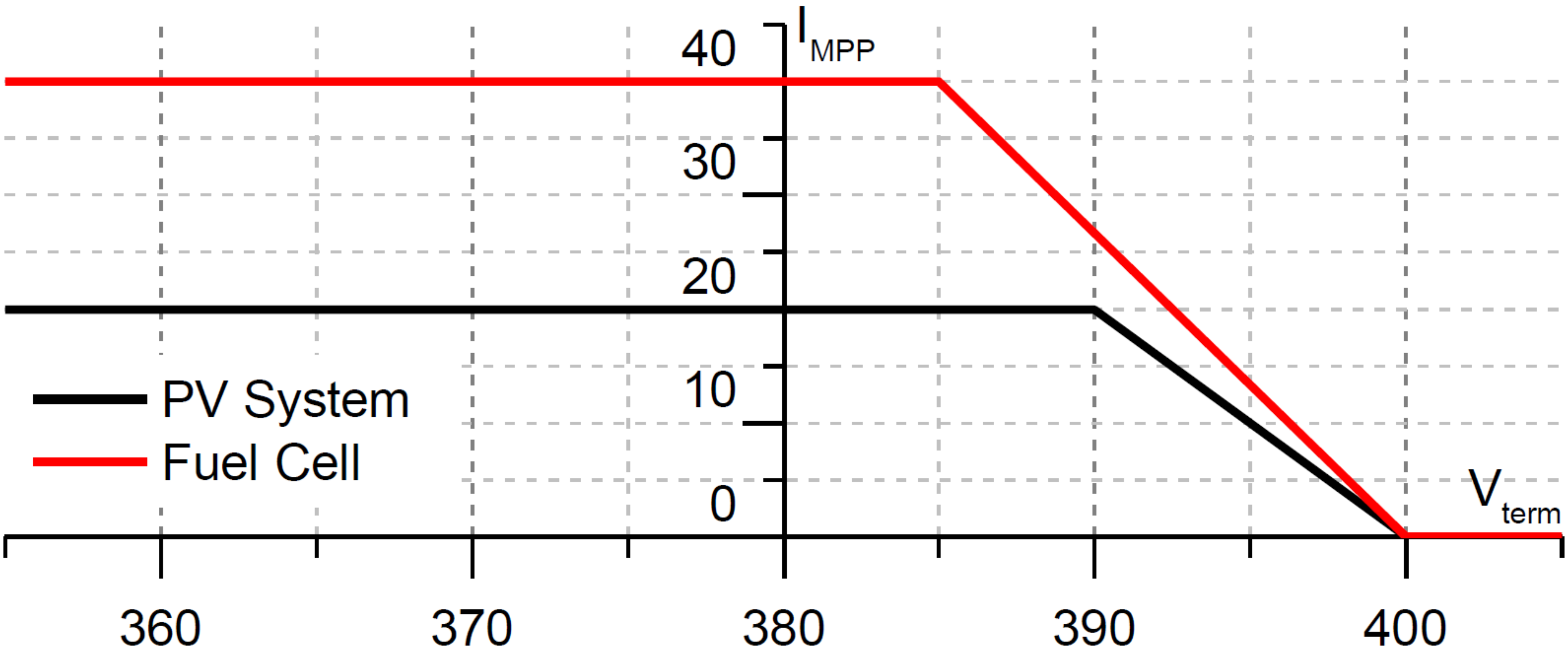
Battery



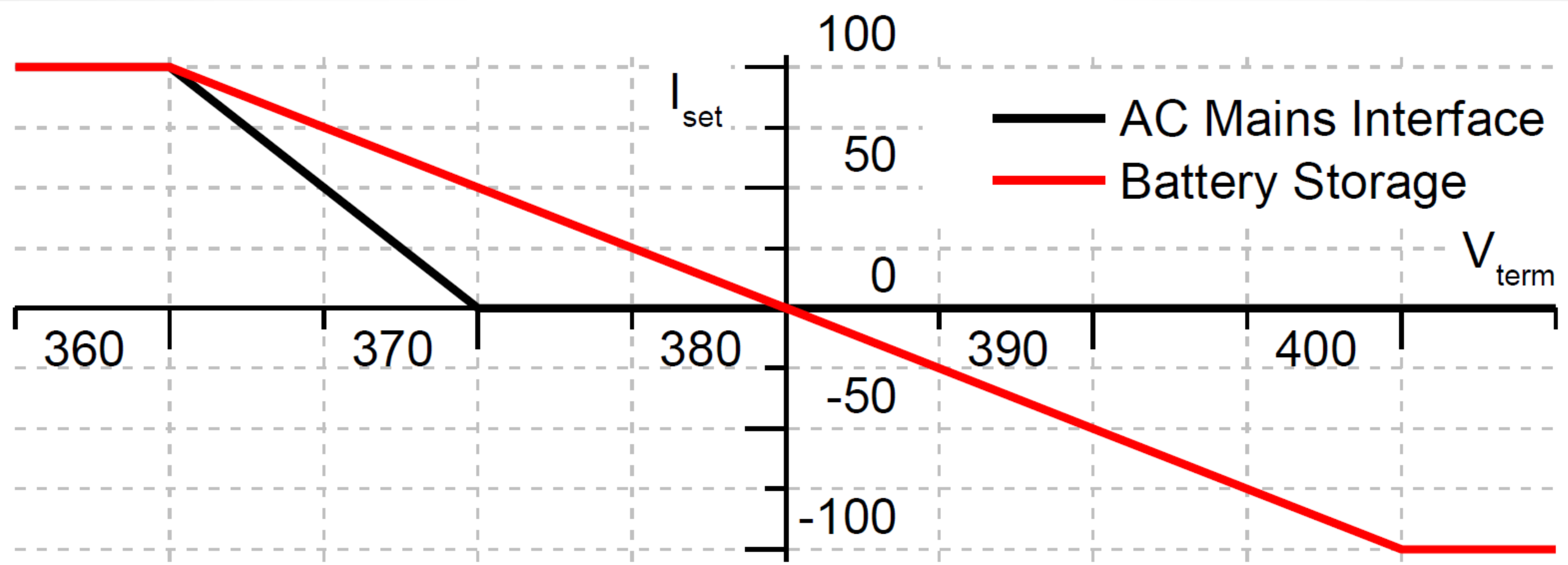
Solar



Solar and other sources

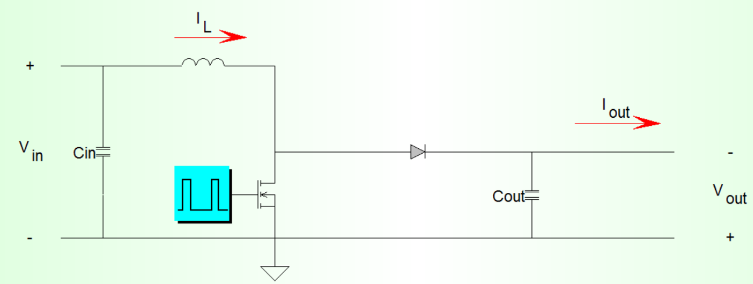


Grid and battery storage



Power Electronics

Caspoc



Input voltage	20	[V]
Output voltage	30	[V]
Output current	0.551	[A]
Inductor current ripple	40	0..100[%]
Output voltag ripple	0.1	0..100[%]
Switching Frequency	57.5	[kHz]
Diode forward voltage drop	0.7	[v]
Use predefined inductor value, (leave 0 for suggestion)	150	[μH]

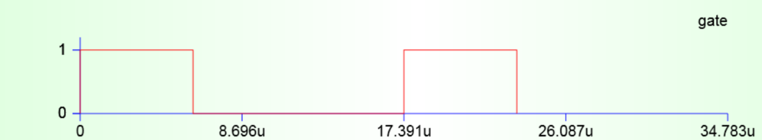
Calculate

Grafiek Outputfields tab3 tab4 tab5

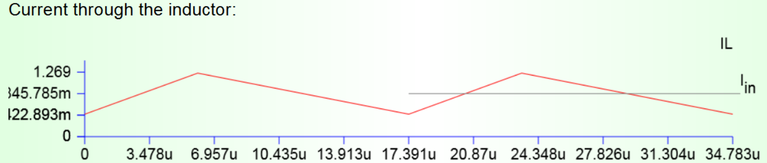
L=150[μH] C=58.56[μF] T_{on}=6.06[μs] T_{off}=17.39[μs] I_{peak}=1.25[A]

i_{ripple}=0.81[A] v_{ripple}=0.03[V] i_{in}=0.85[A]

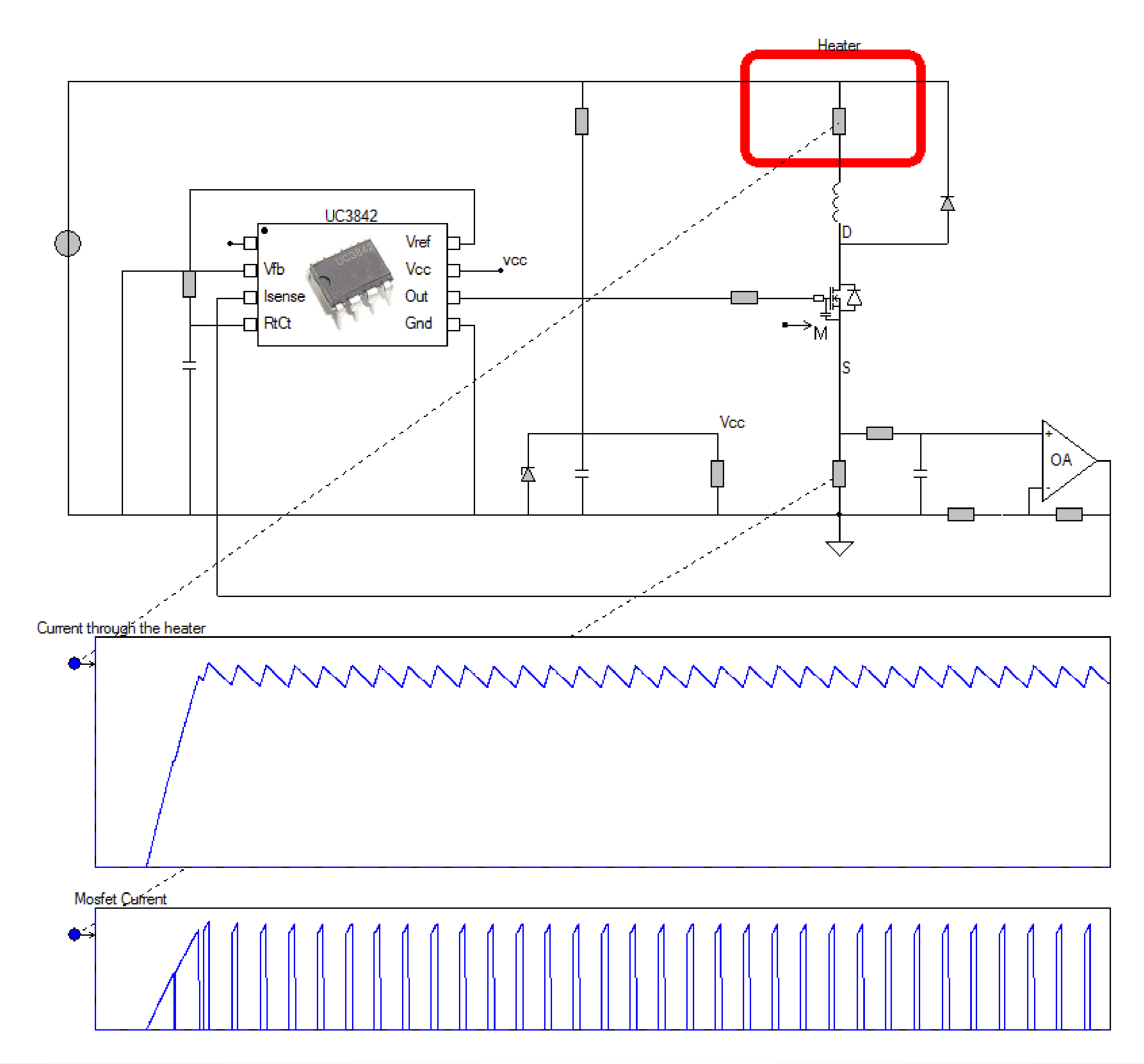
Gate signal for the Mosfet:



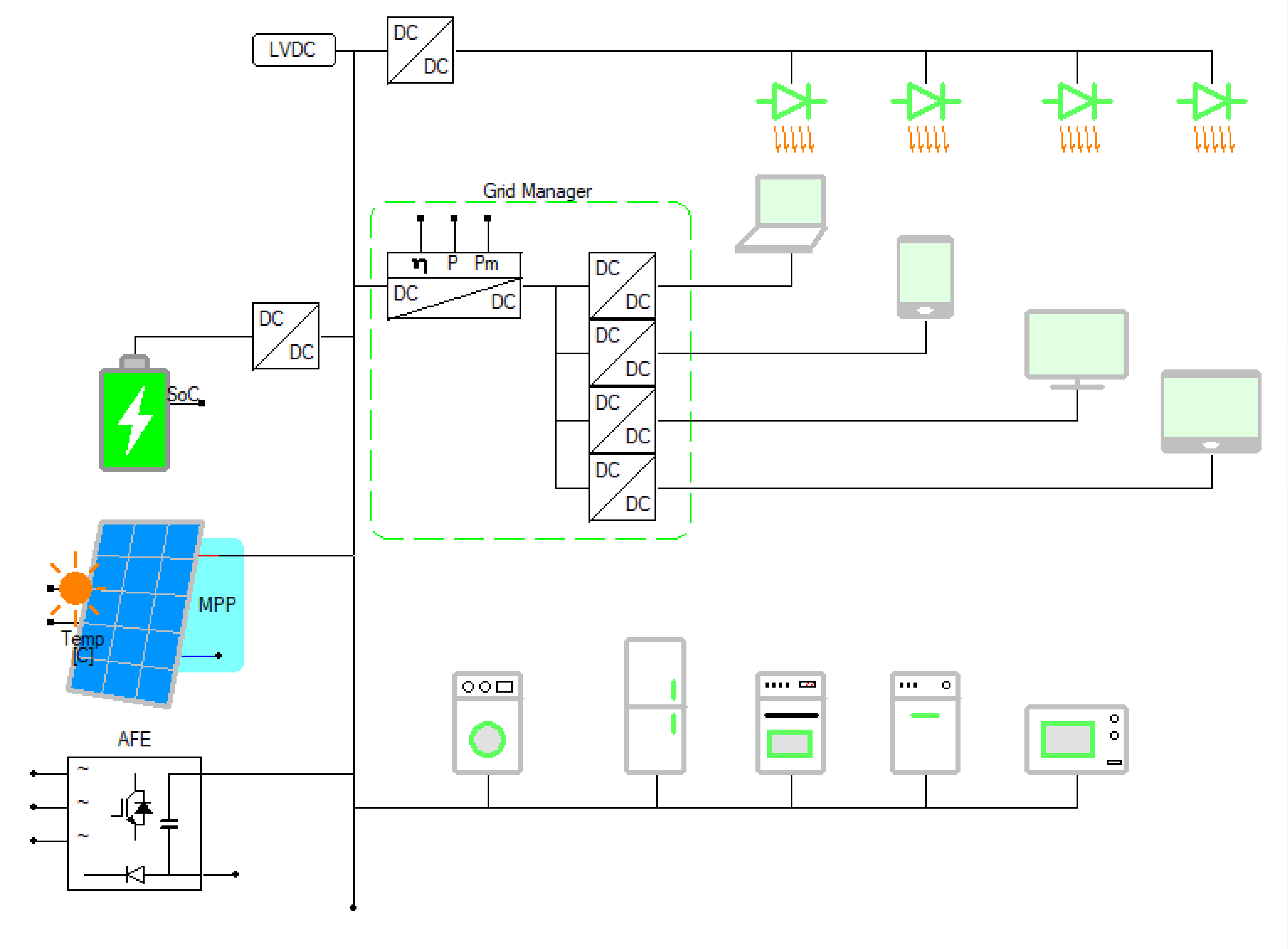
Current through the inductor:



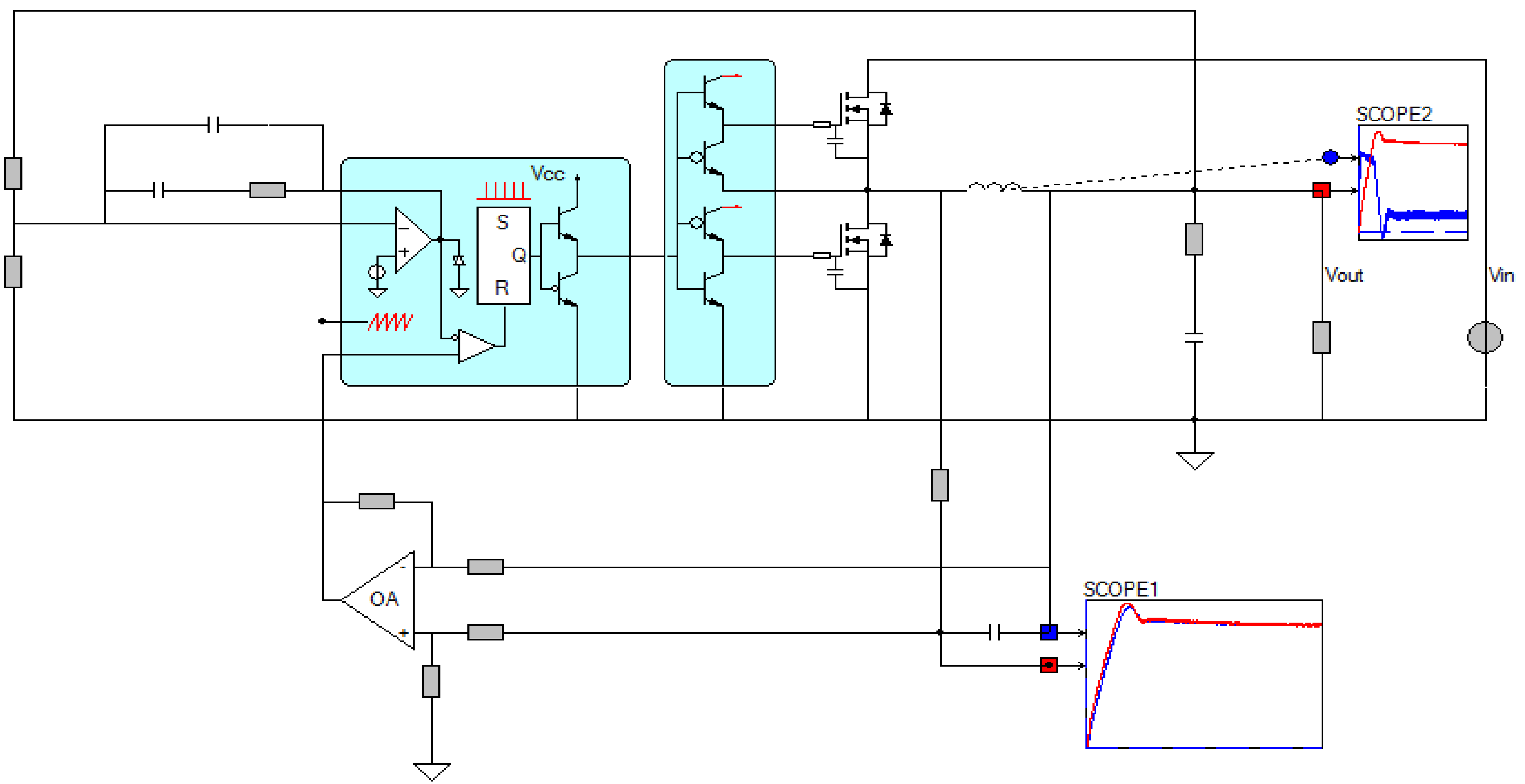
No common ground!



Grid manager

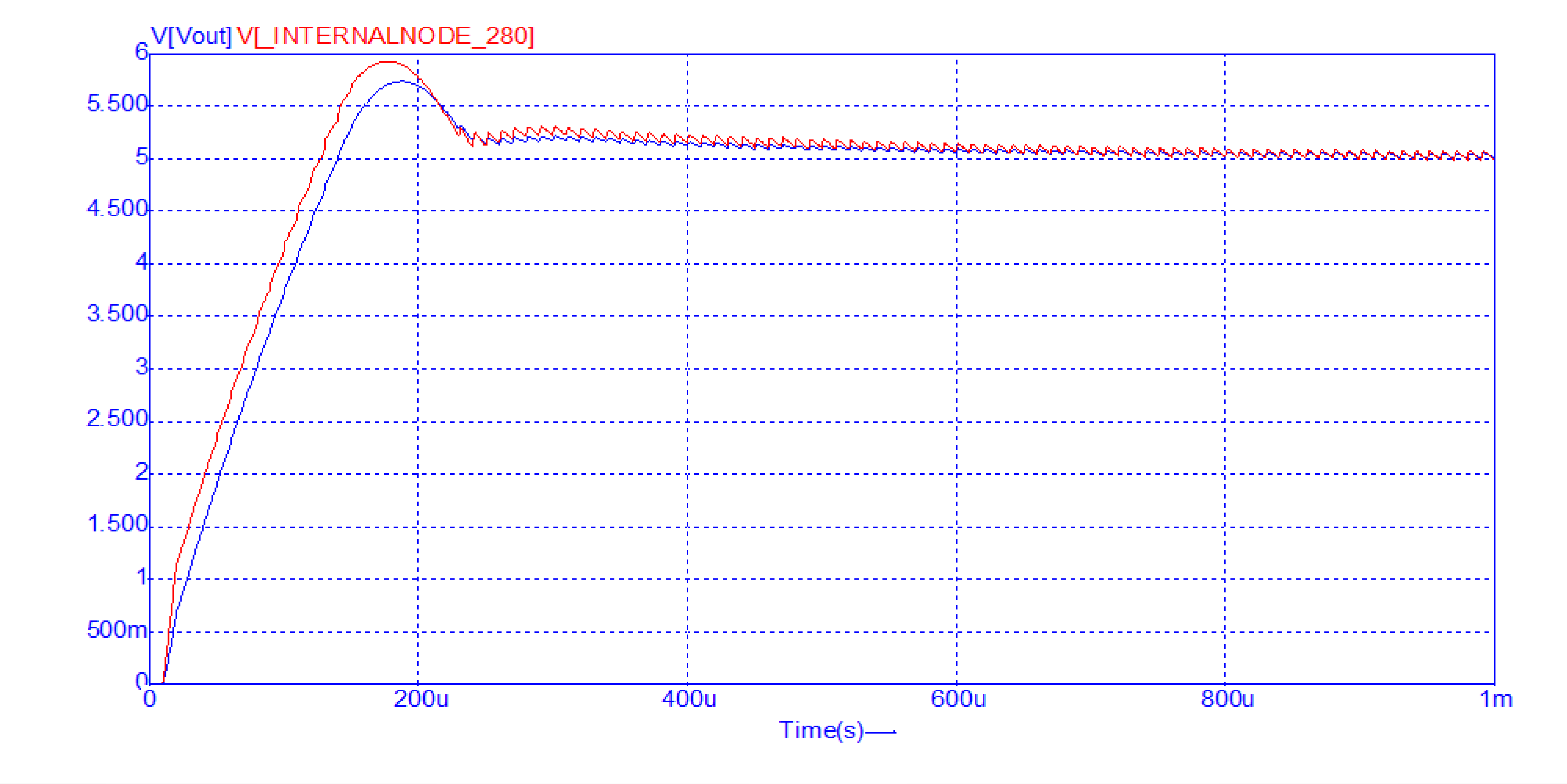


Synchronous Buck converter



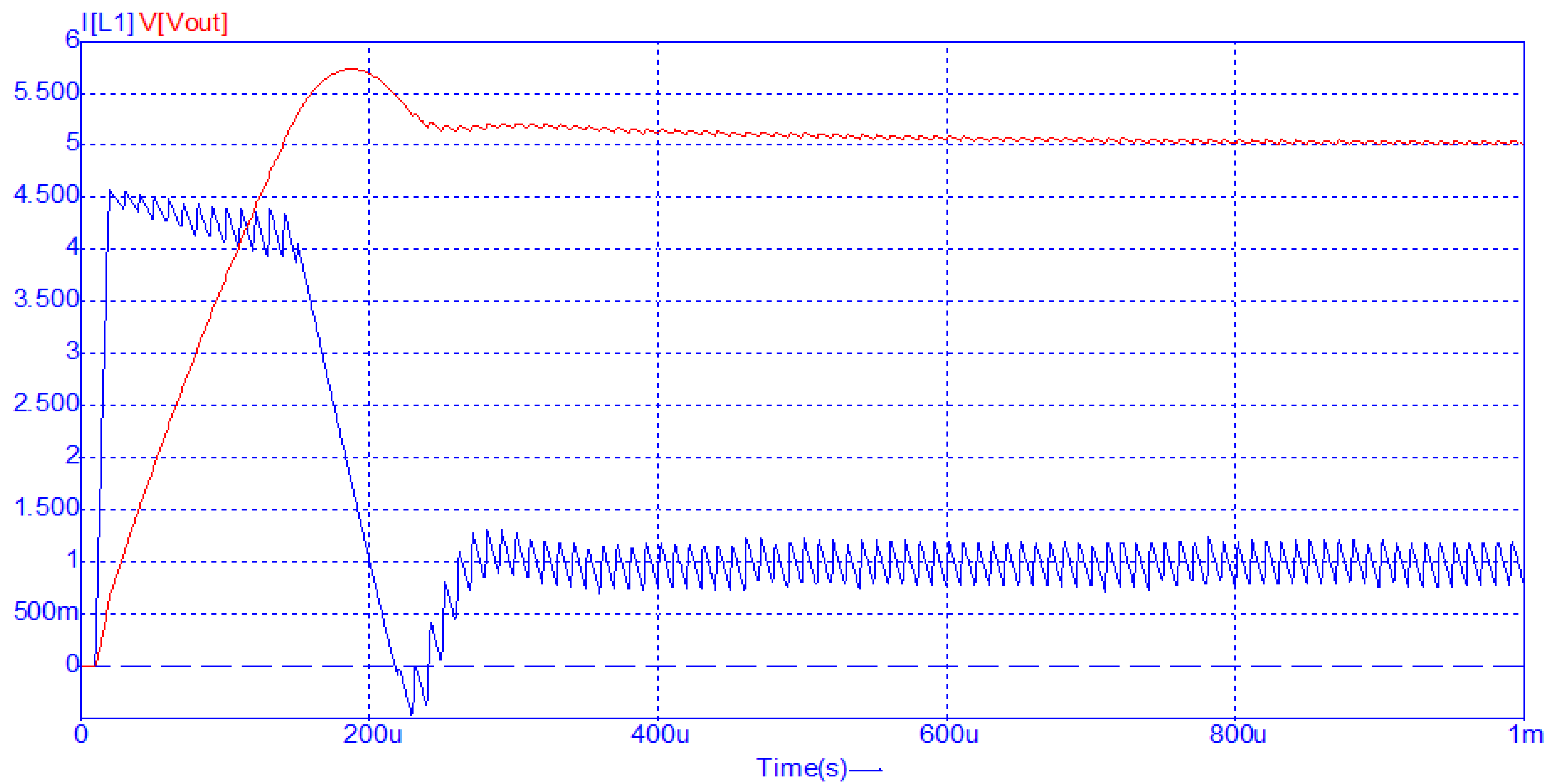
Current measurement

- Current is measured as:
  - Differential voltage over a shunt resistor!
  - Shunt resistor: Series resistance of inductor!

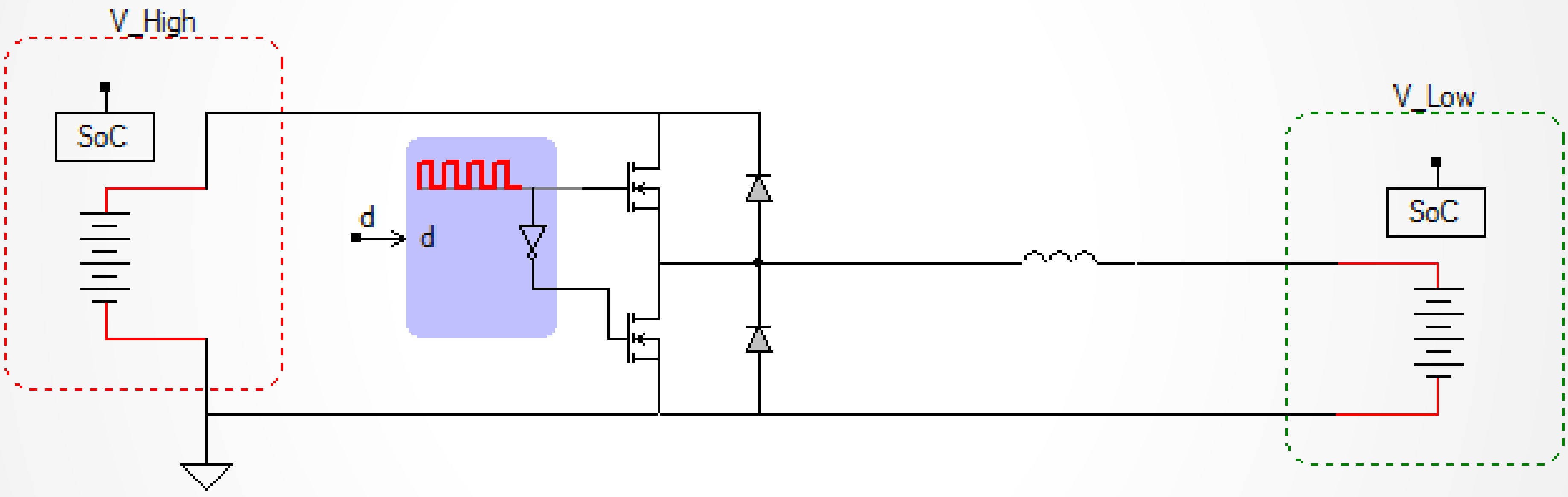


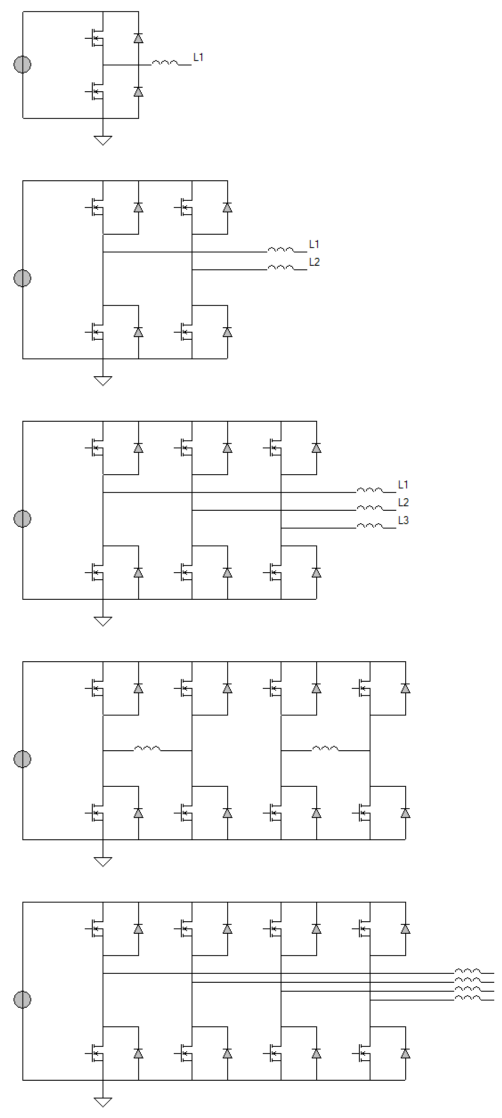
Current is controlled!

- Only current through inductor can be controlled!

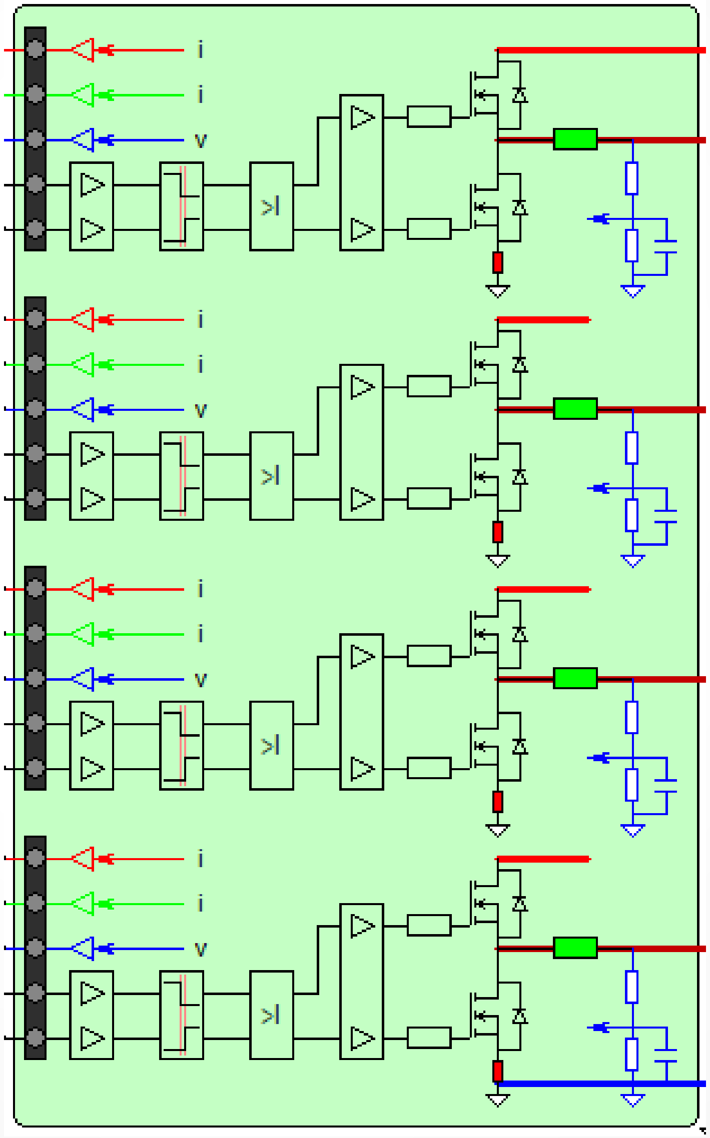


Bidirectional DCDC converter

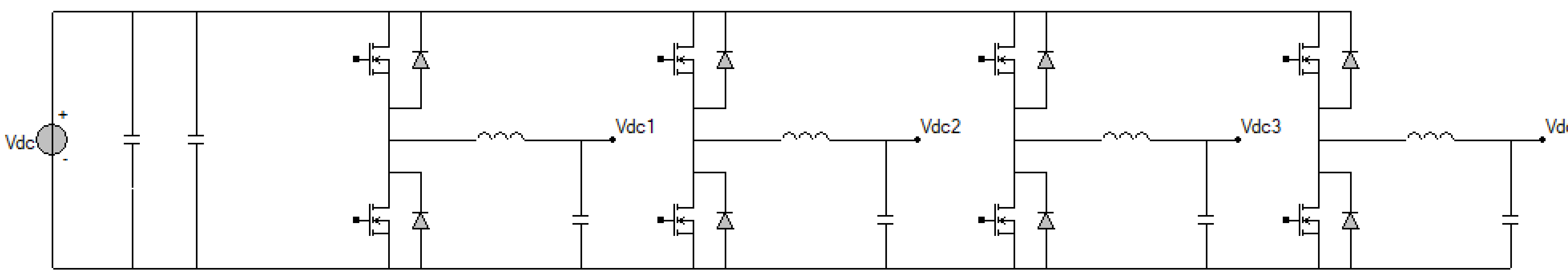


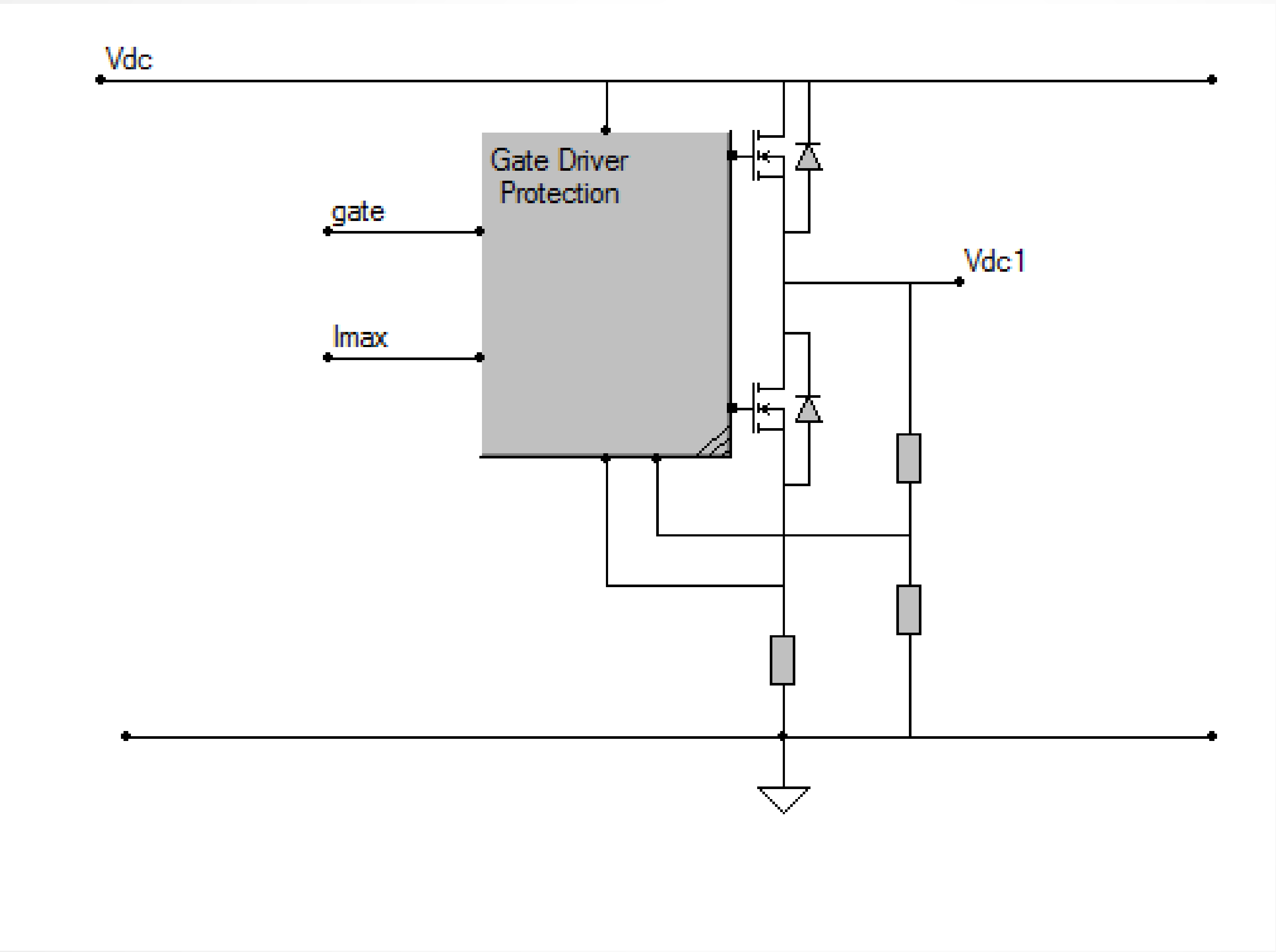


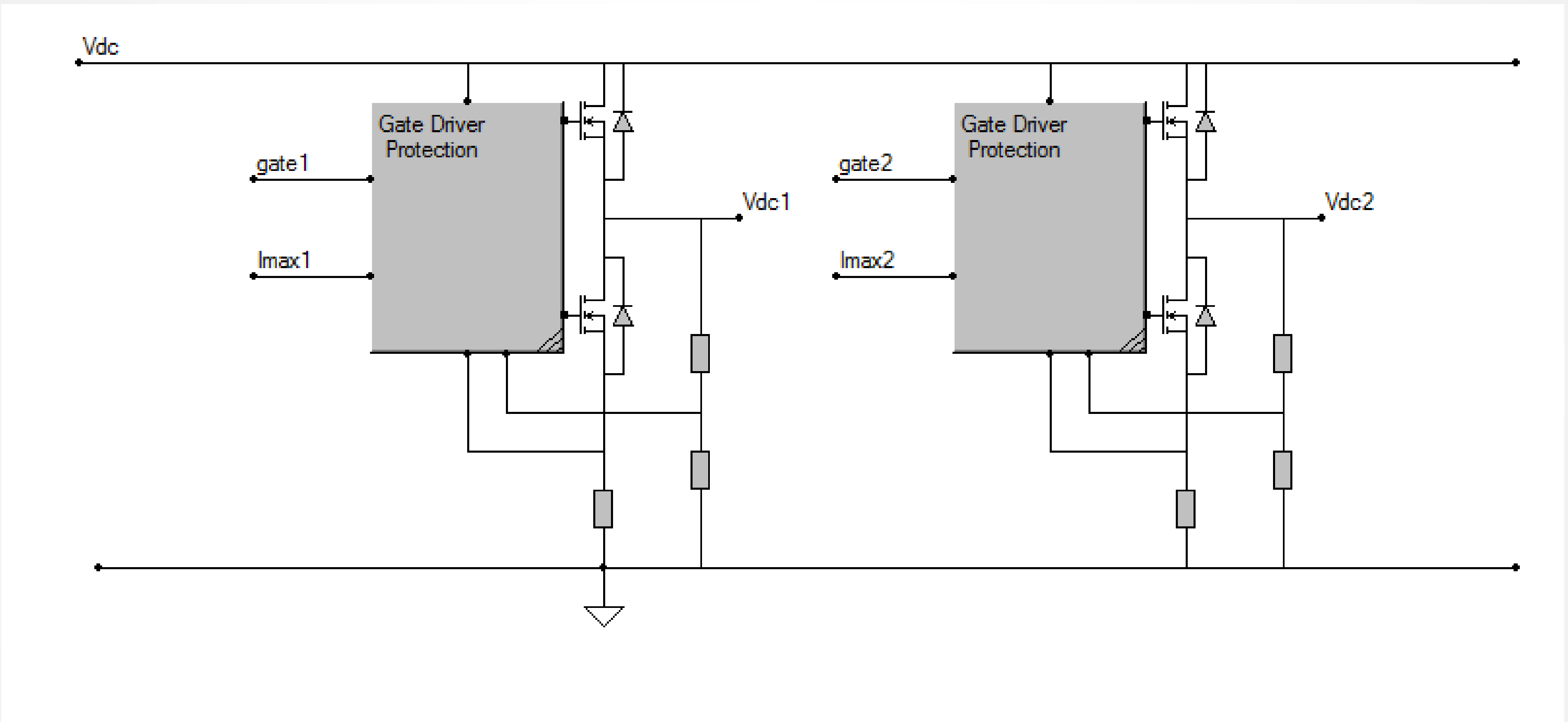
L1
L1
L2
L1
L2
L3



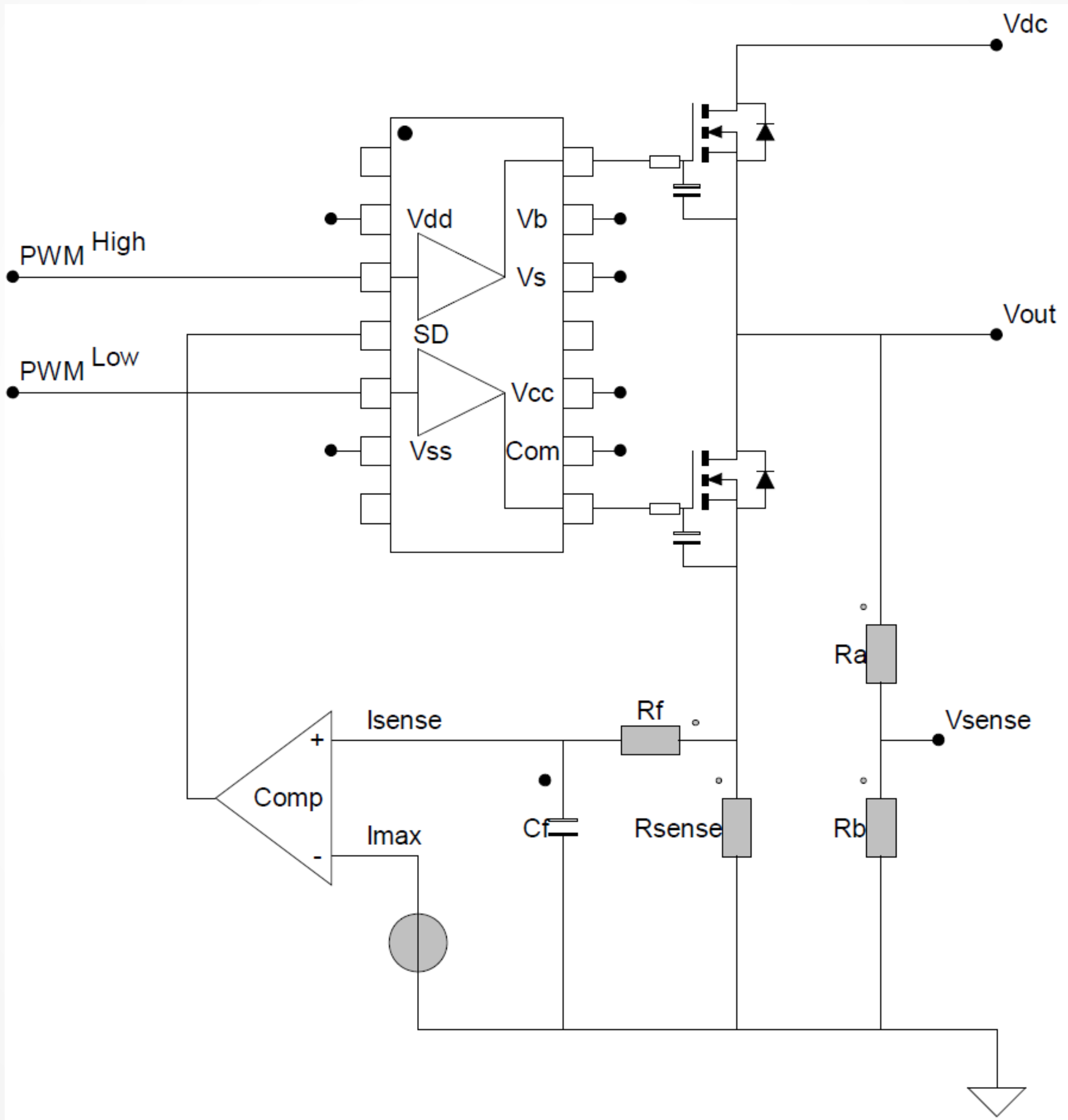
i
i
v
i
i
v
i
i
v
i
i
v


Vdc
+
-
Vdc1
Vdc2
Vdc3
Vdc4


Vdc
Gate Driver
Protection
gate
Imax
Vdc1

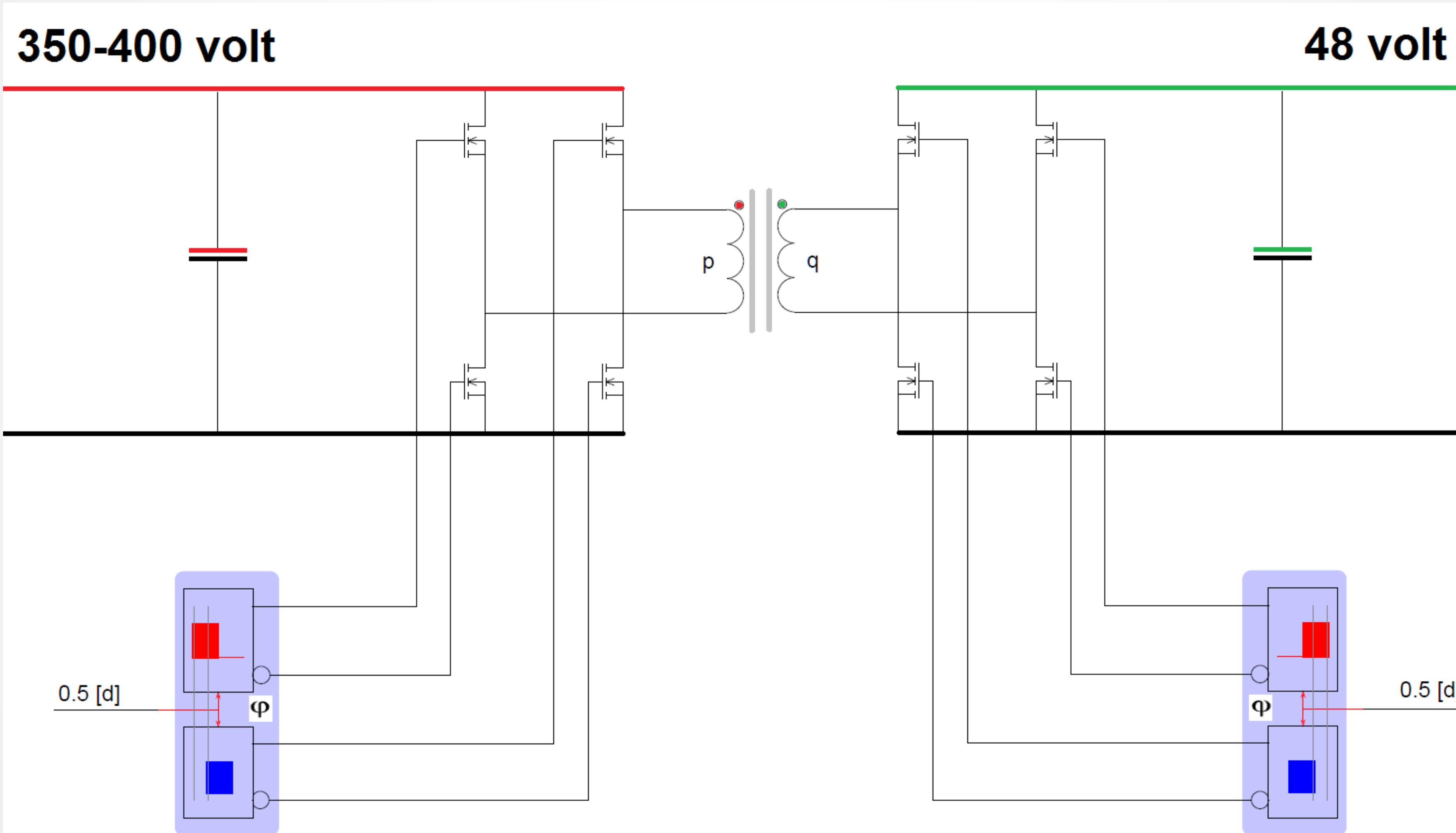


Vdc
Gate Driver
Protection
gate1
Imax1
Vdc1
Gate Driver
Protection
gate2
Imax2
Vdc2

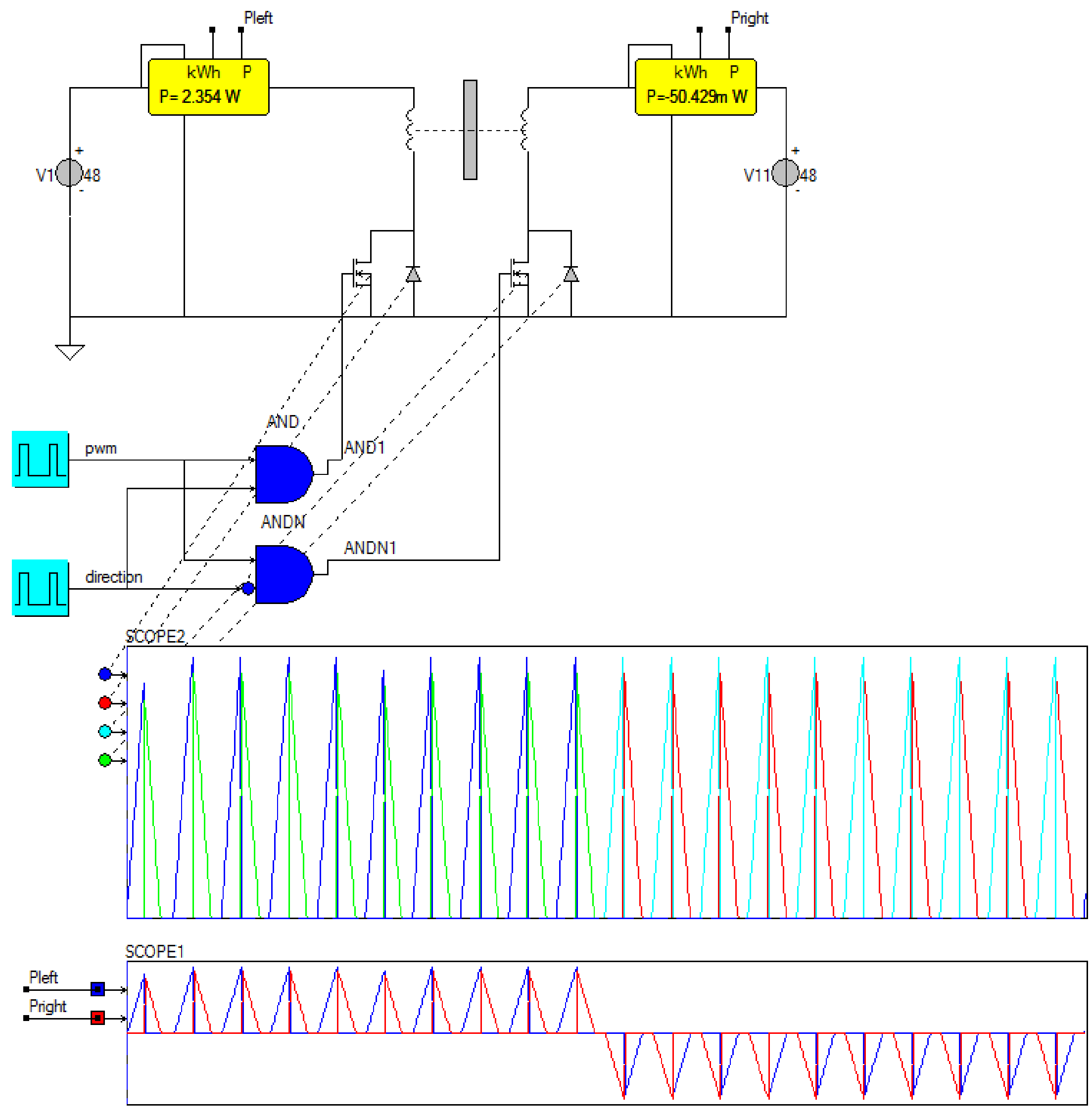

Vdc
Vdd
Vb
PWM High
Vs
Vout
SD
PWM Low
Vcc
Vss
Com
Ra
Isense
Rf
Vsense
Comp
Imax
Cf
Rsense
Rb

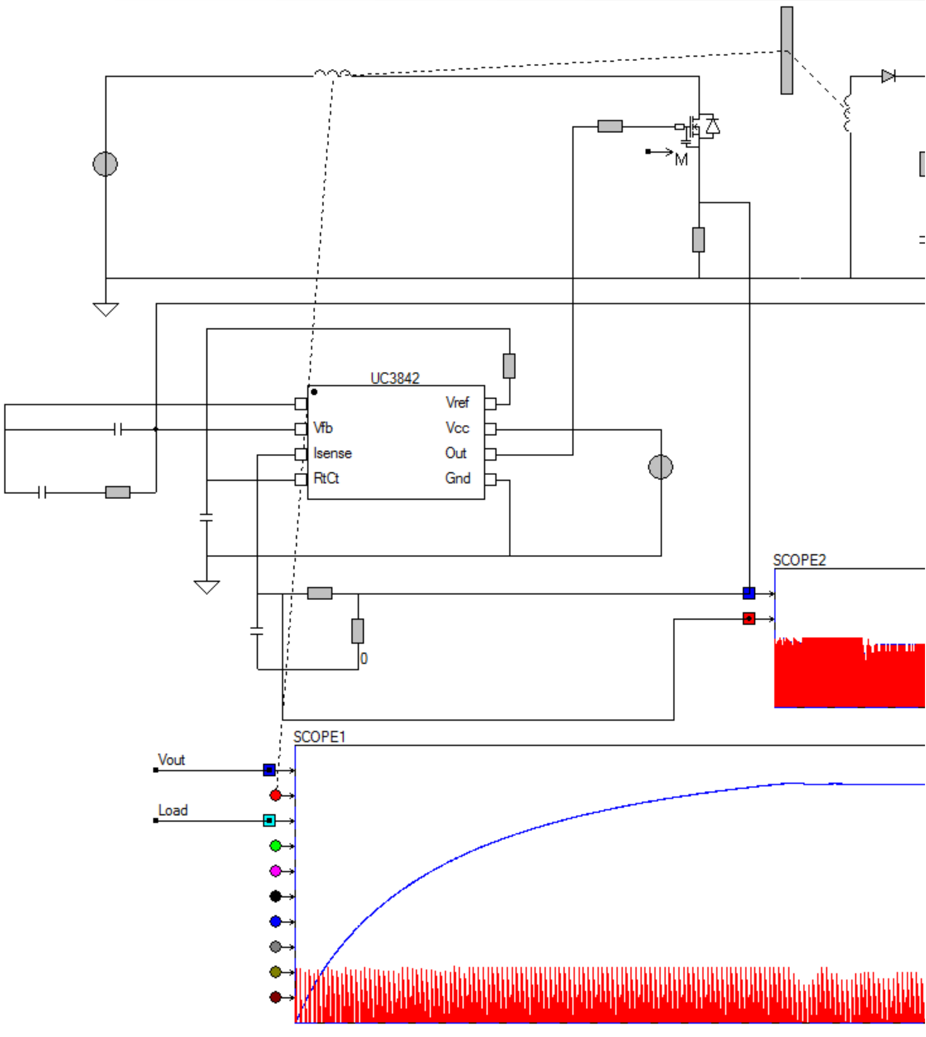
Fraunhofer Grid Manager

Bidirectional converter
Dual Active Bridge

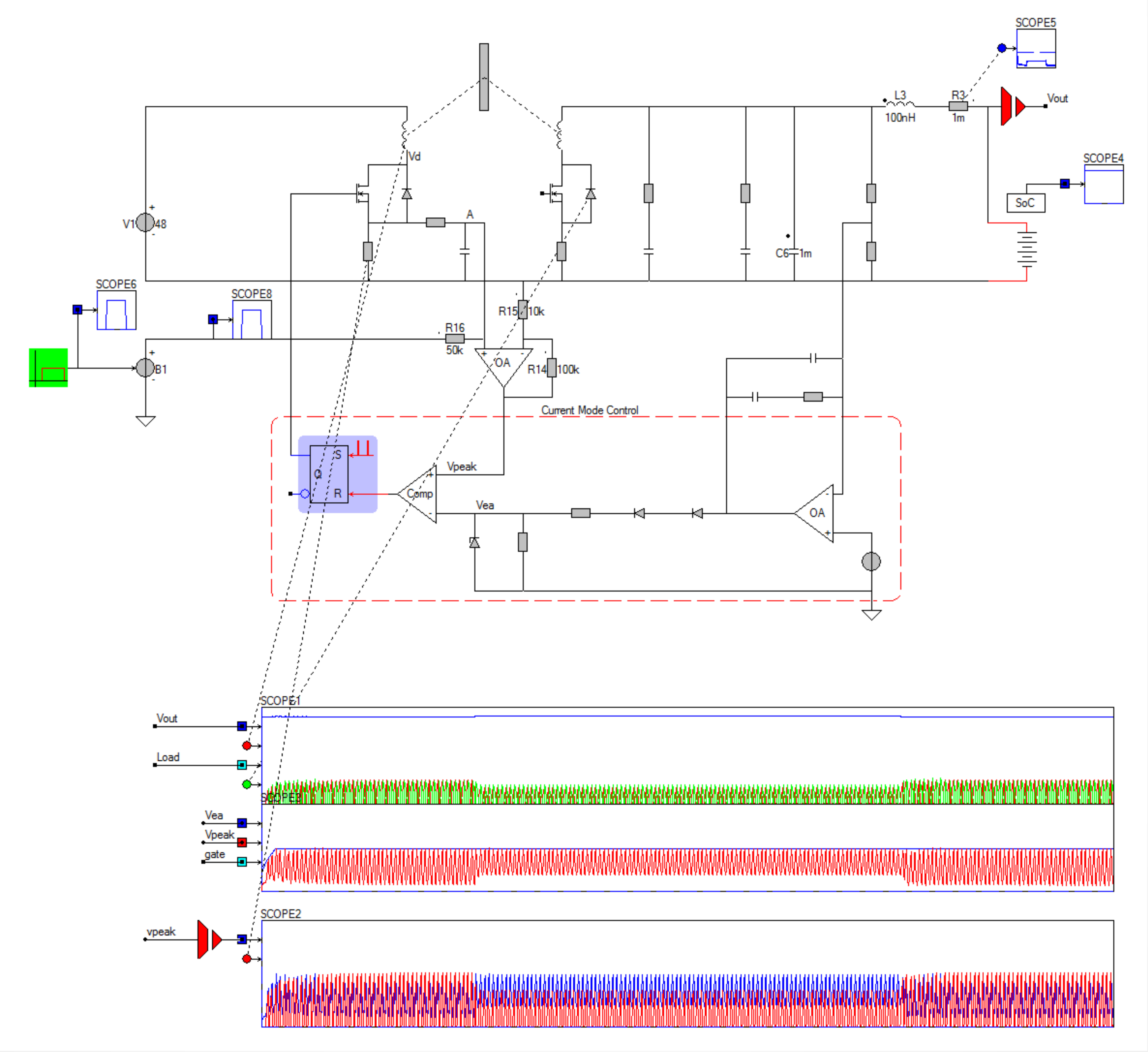


Bidirectional Flyback

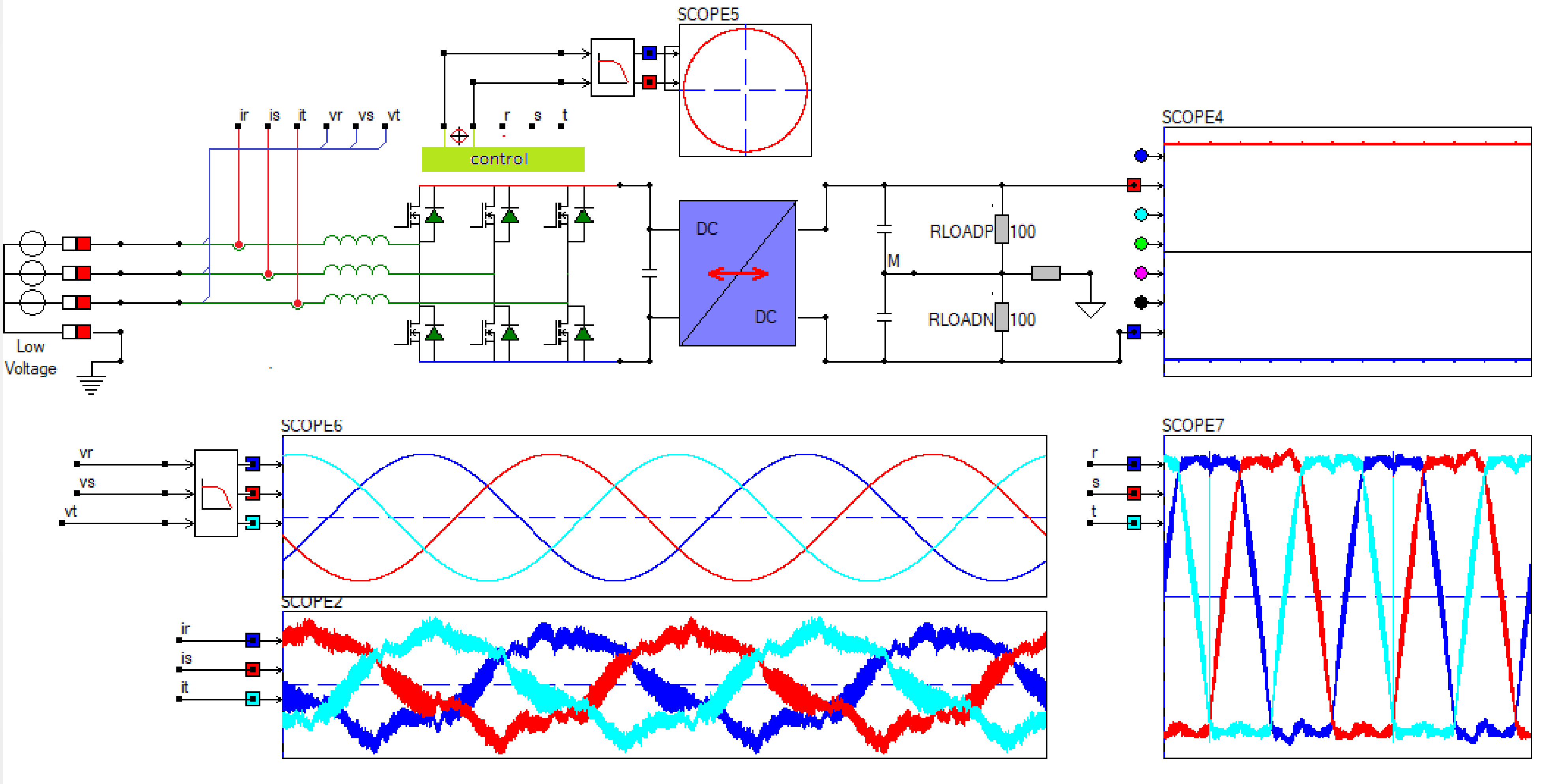




Flyback battery droop control

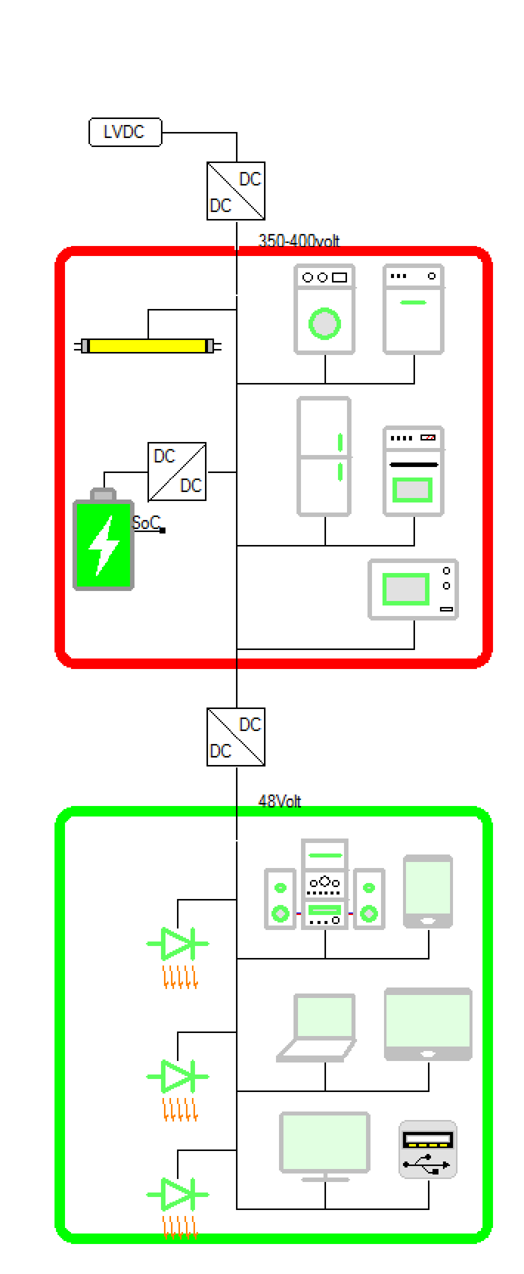


Interfacing AC and DC Bidirectional : Active Front End

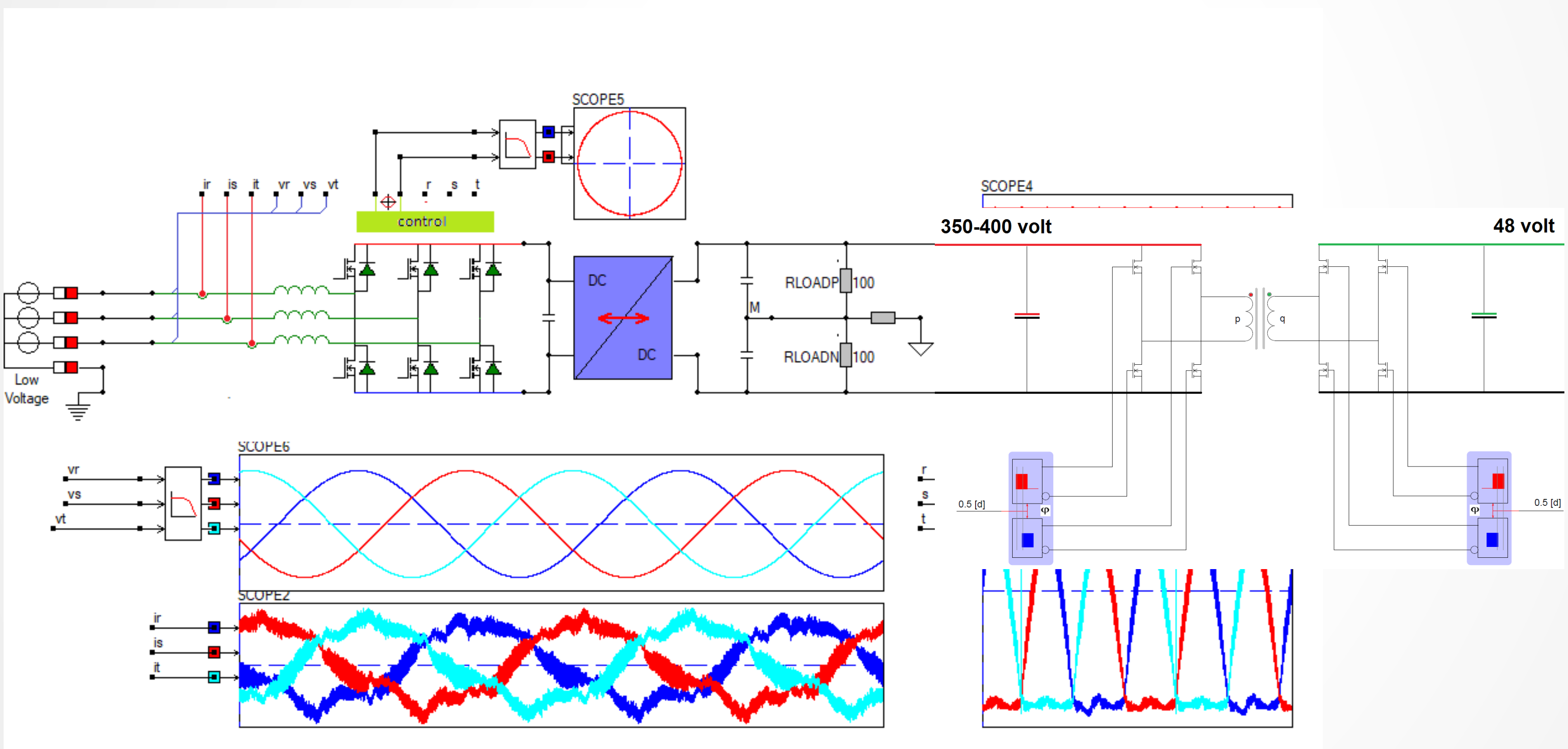


Connecting two DC grids

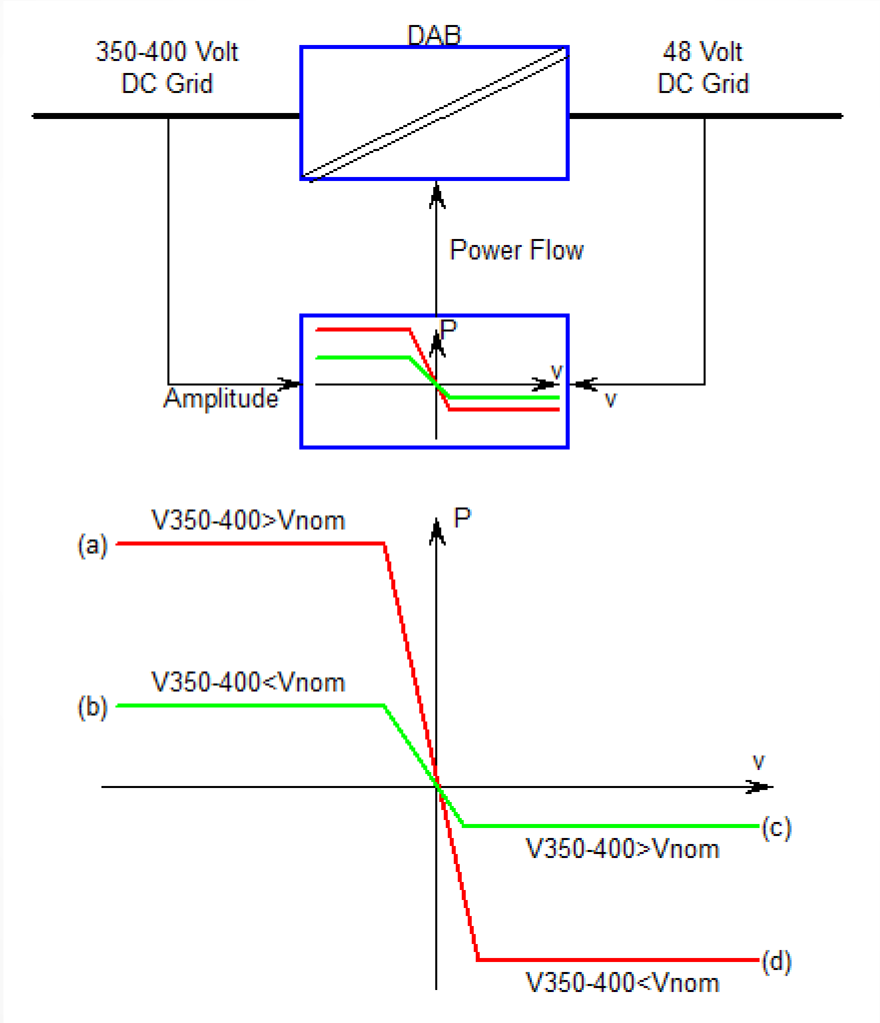
- High power 350-400volt grid
- Low power 48 volt grid



AFE & Dual Active Bridge



Droop control



Conclusion

- Control
  - With communication?
  - Without communication

- Droop control
  - D bus voltage
  - Power Electronics
  - Congestion Management

Questions?

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