

Regelen en beveiligen in DC netten, problemen of kansen?

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UNIVERSITY OF  
APPLIED SCIENCES



*CaspoC*



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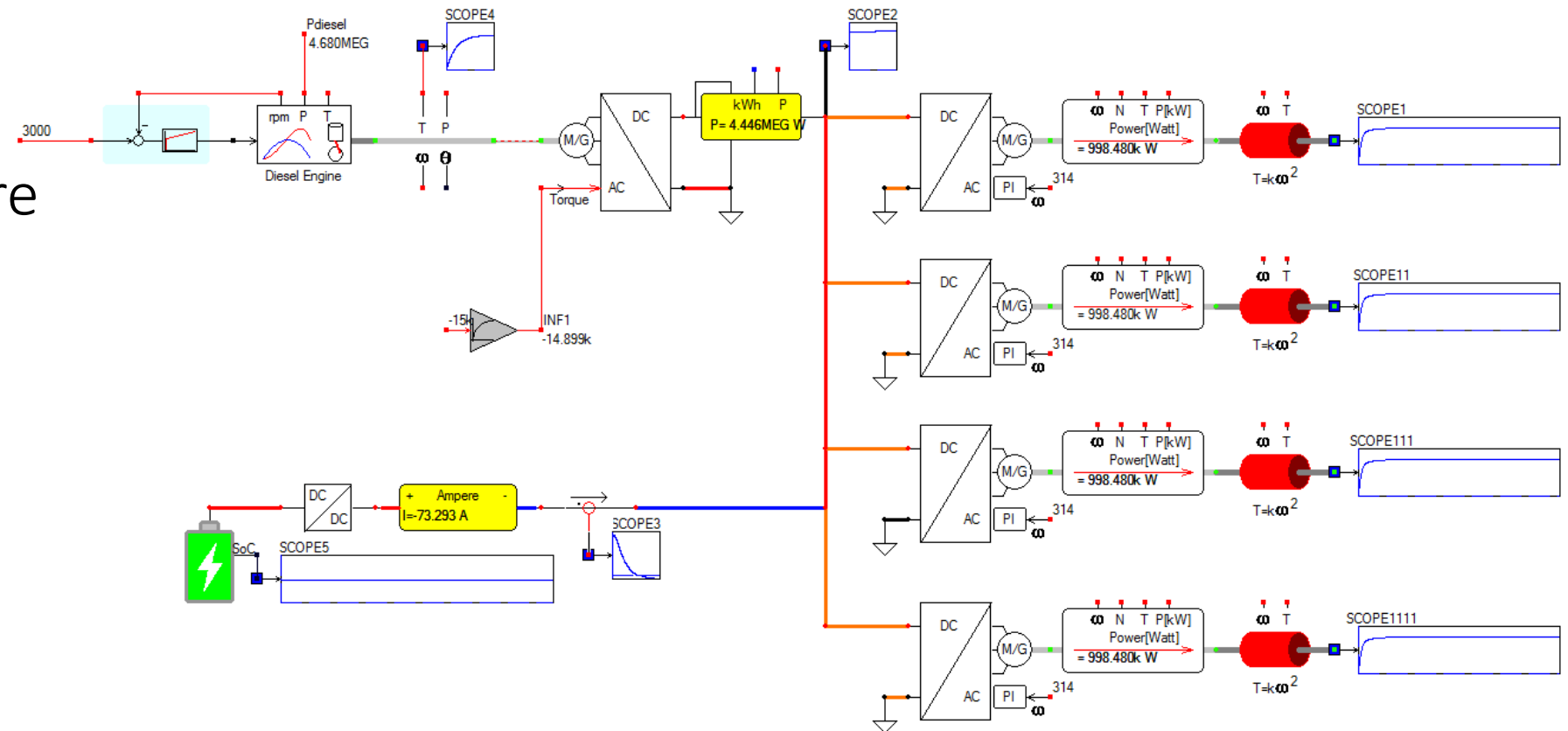
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# Contents

- DC grid structure
- Control
- Switching
- Protection
- Stability



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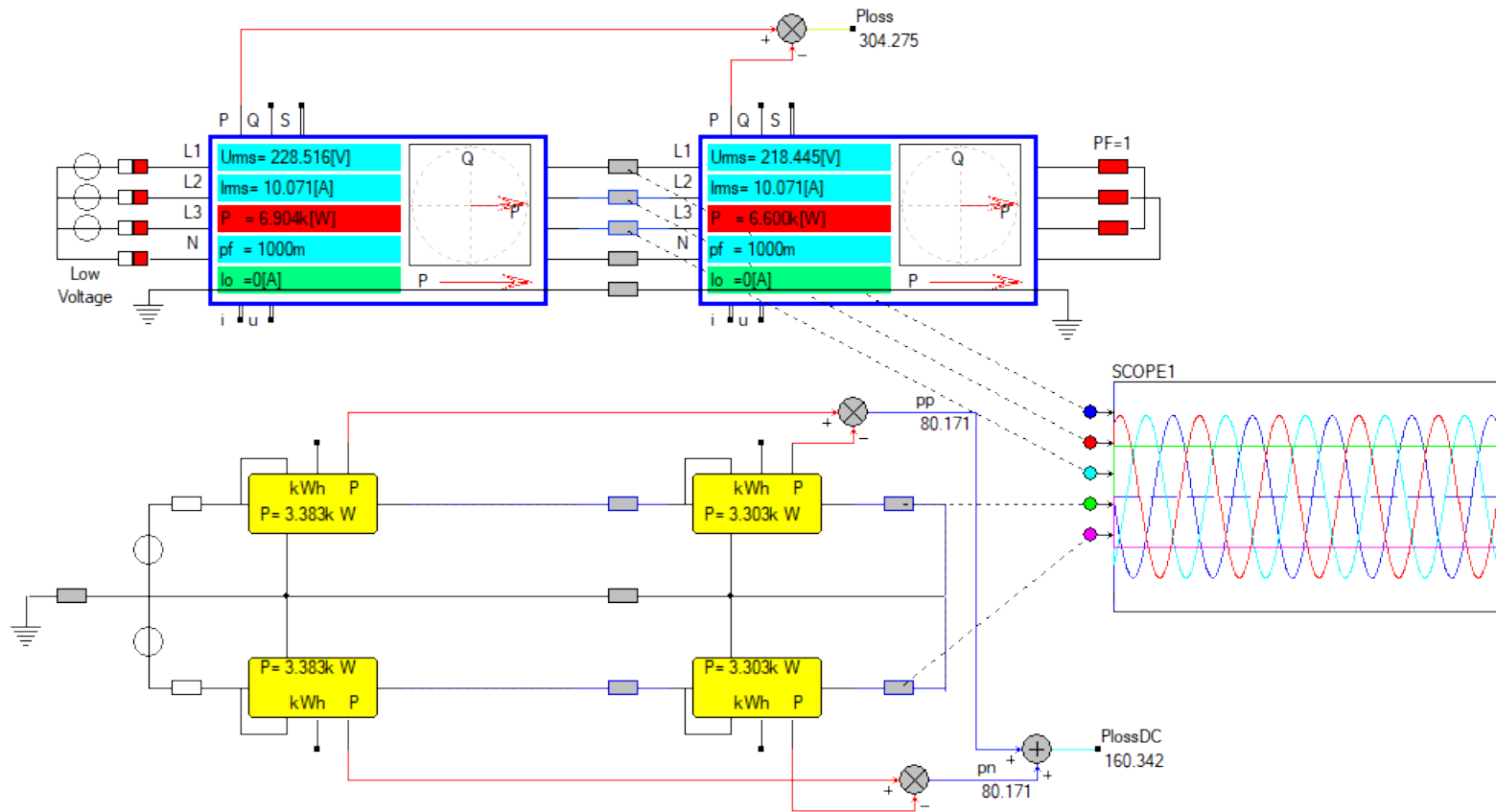
# DC grid structure?

## Structure of the DC Grid



# Why do we need a DC Grid?

## Lower losses is not the reason why we choose DC!

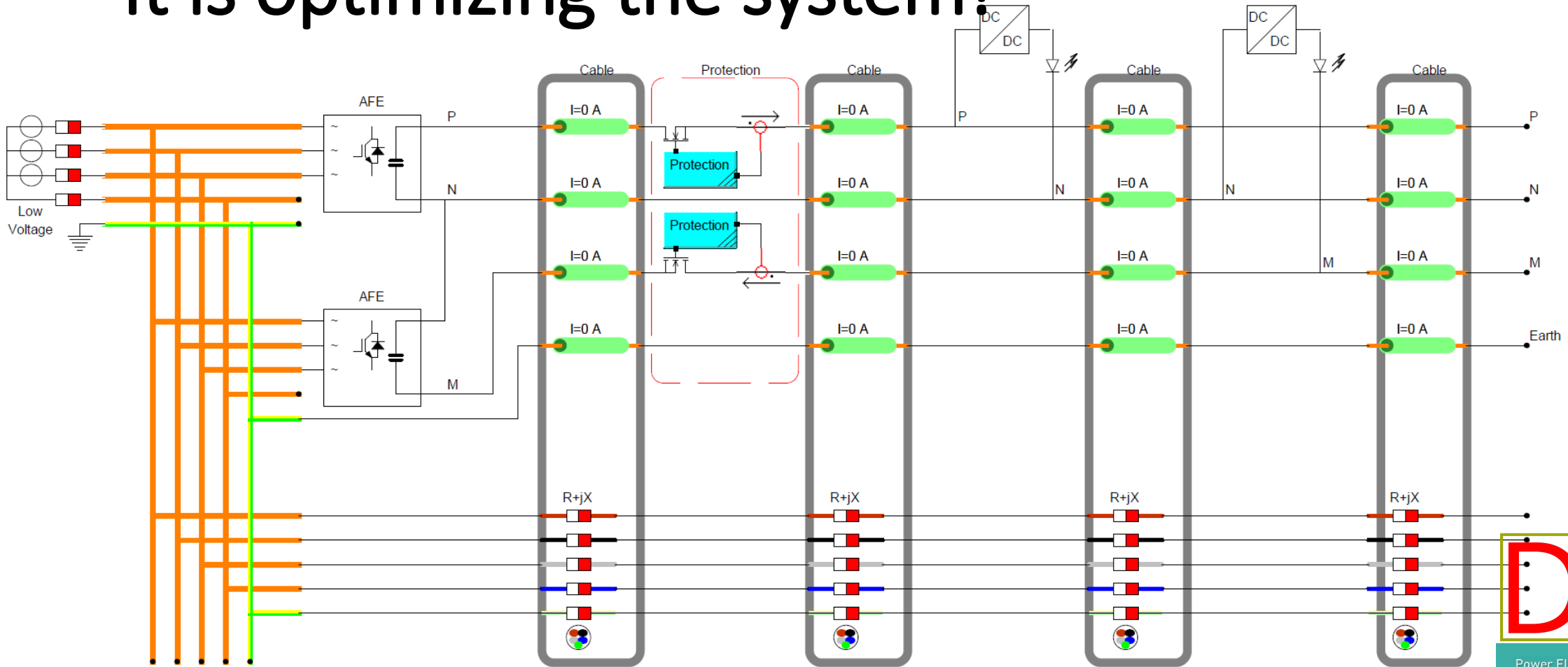


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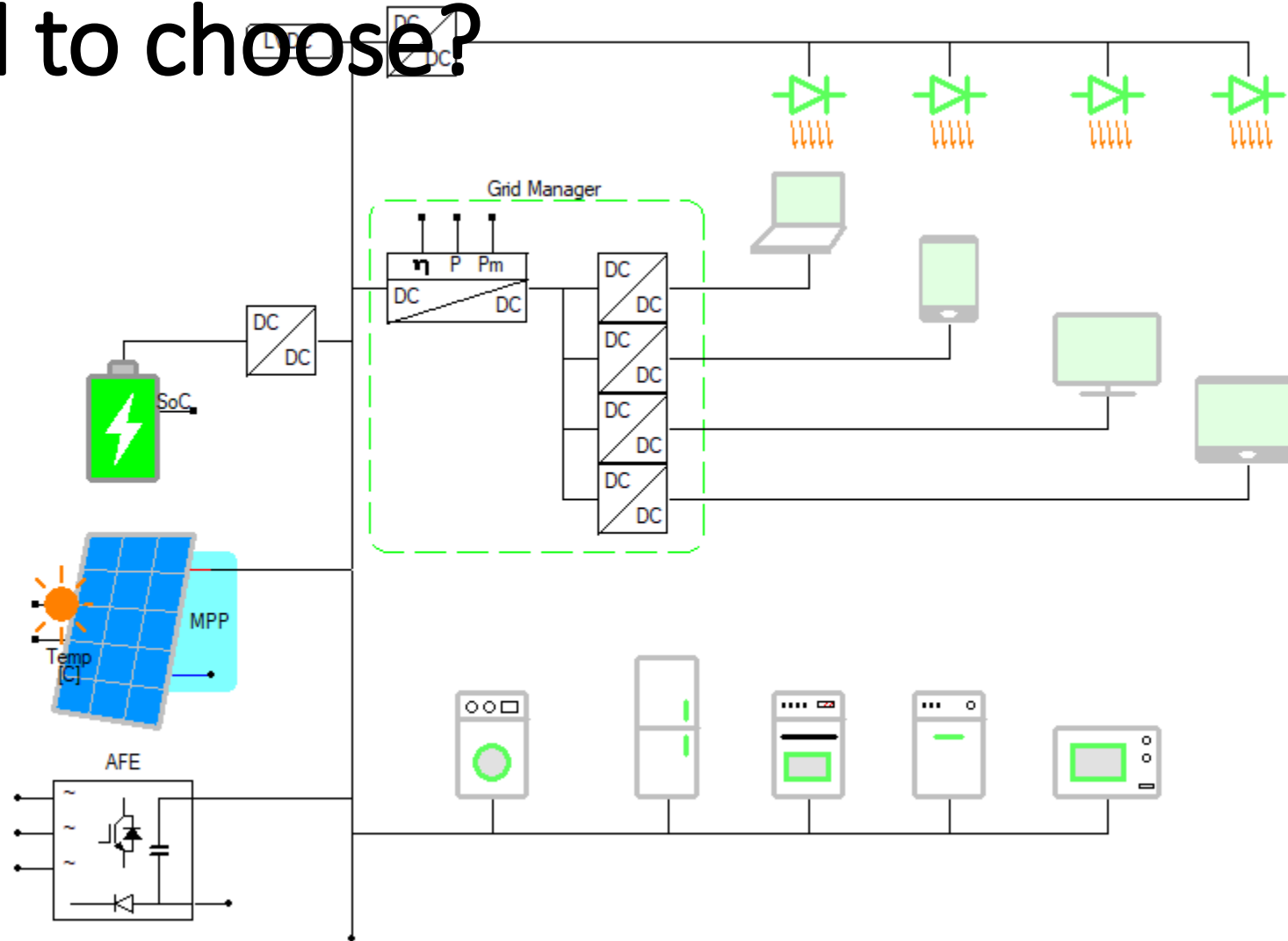
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# It is not about optimizing components It is optimizing the system!



# Which grid to choose?

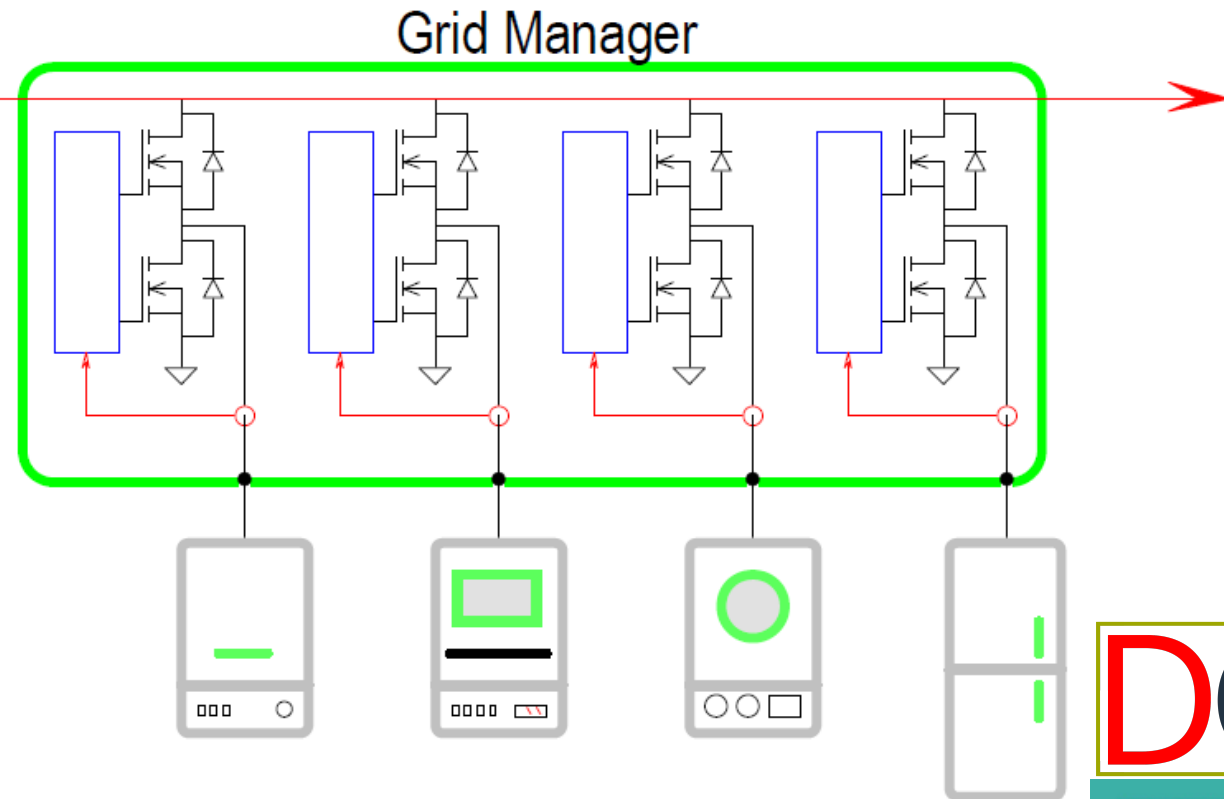
- Centralized
- Decentralized



# Centralized DC Grid with Grid Manager

- All control in one device
- Control of Power
- Breaker
- Inrush limiter

LVDC



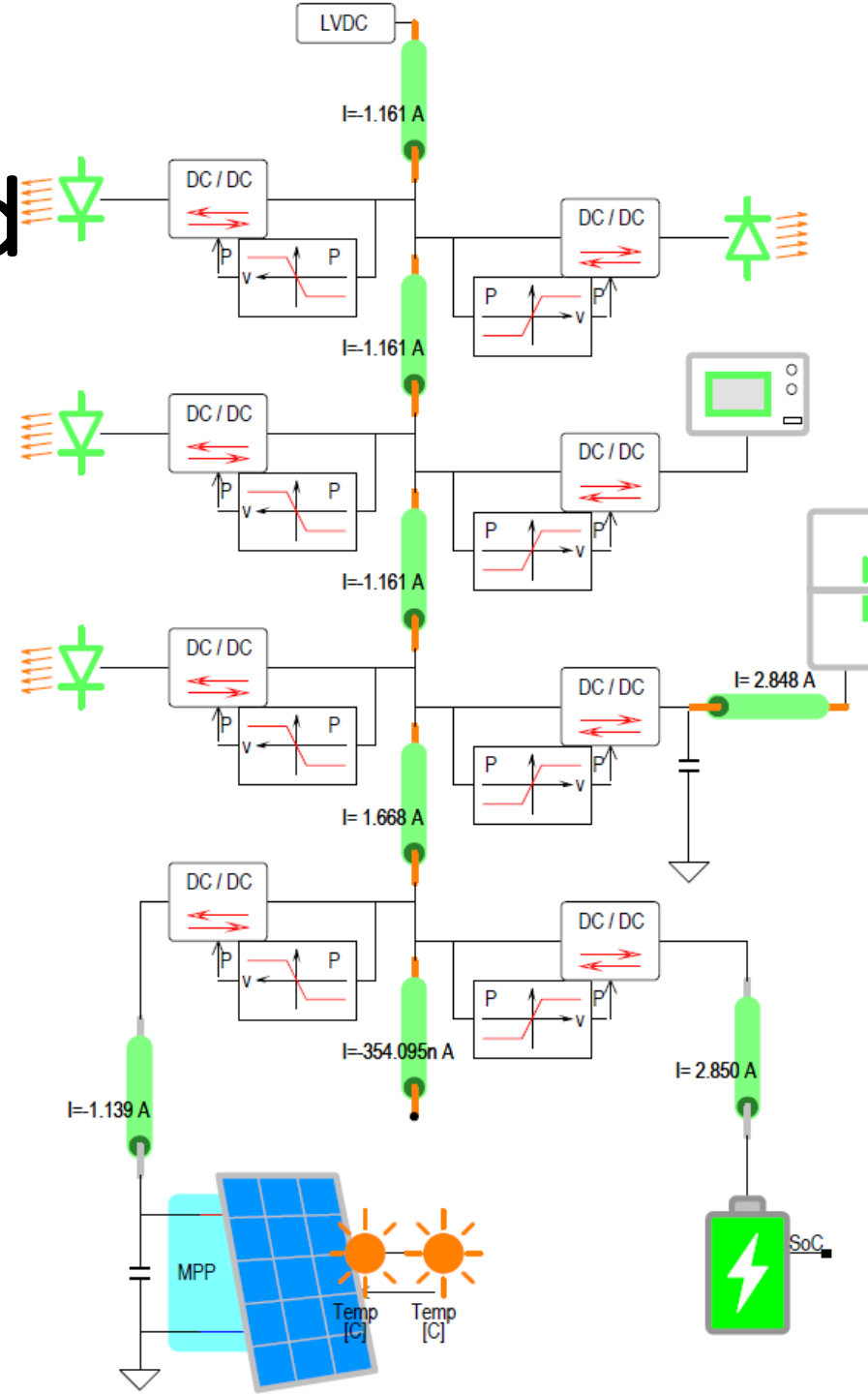
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# Decentralized DC Grid

- Droop control per appliance
- DCDC converter per appliance



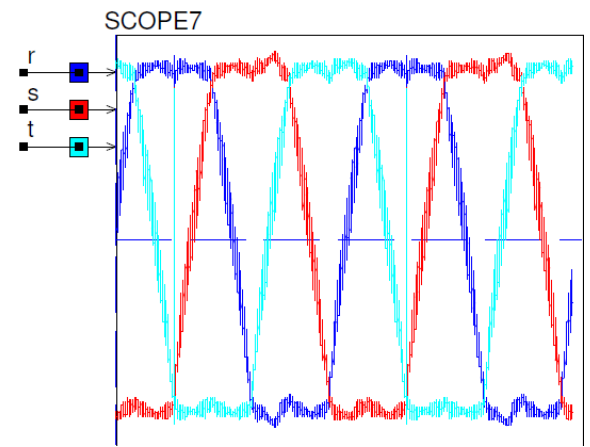
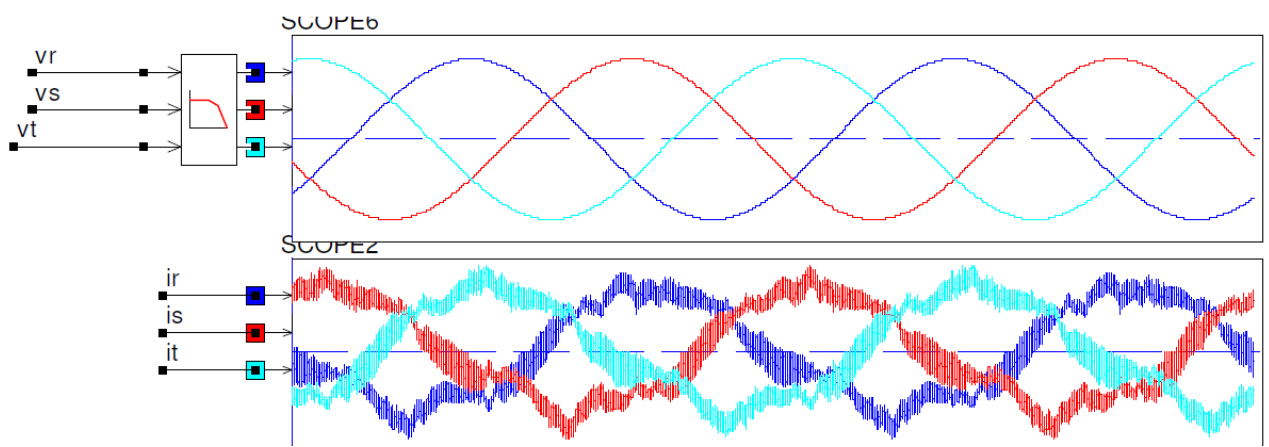
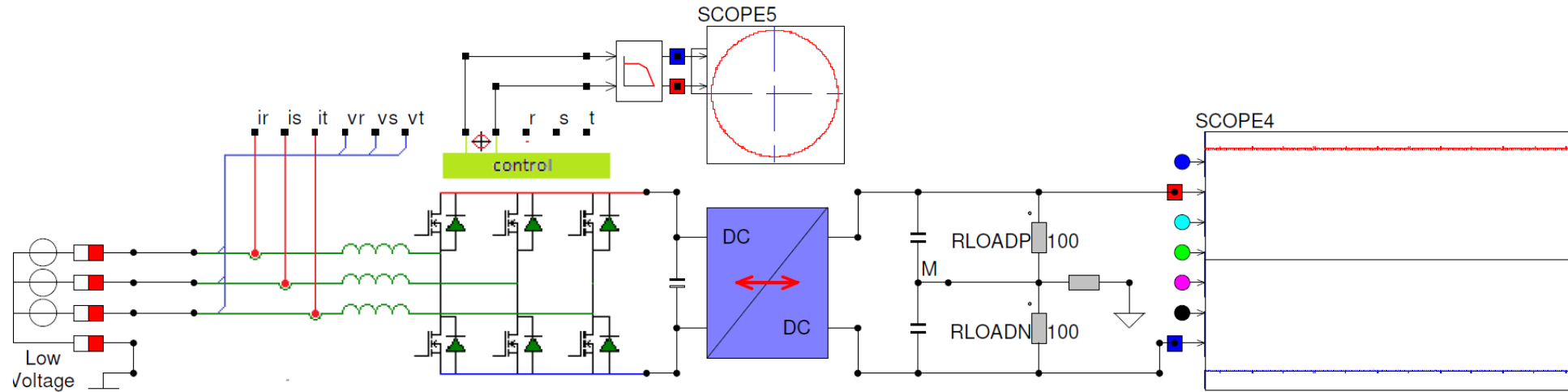
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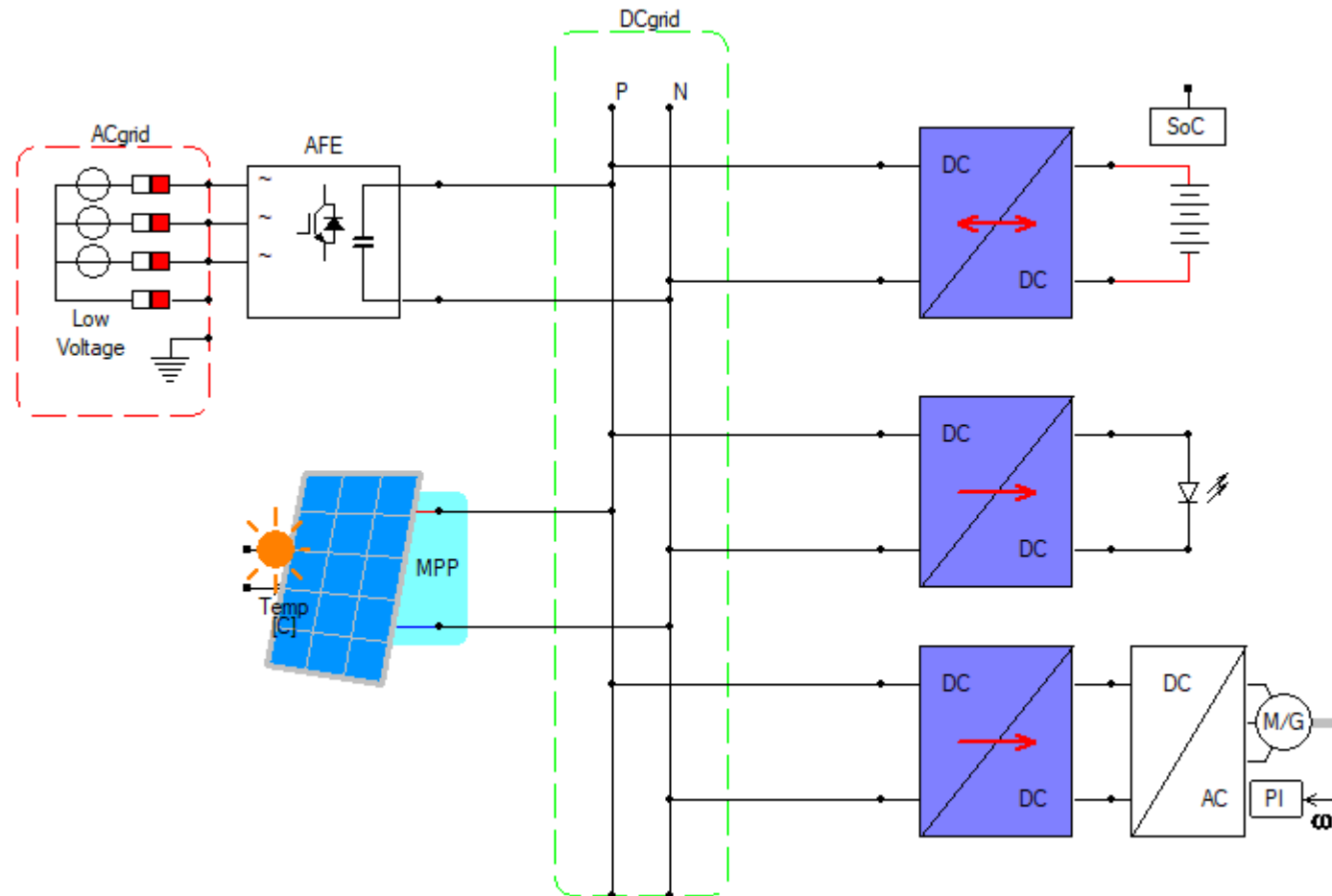


# Connection to existing AC Grid?



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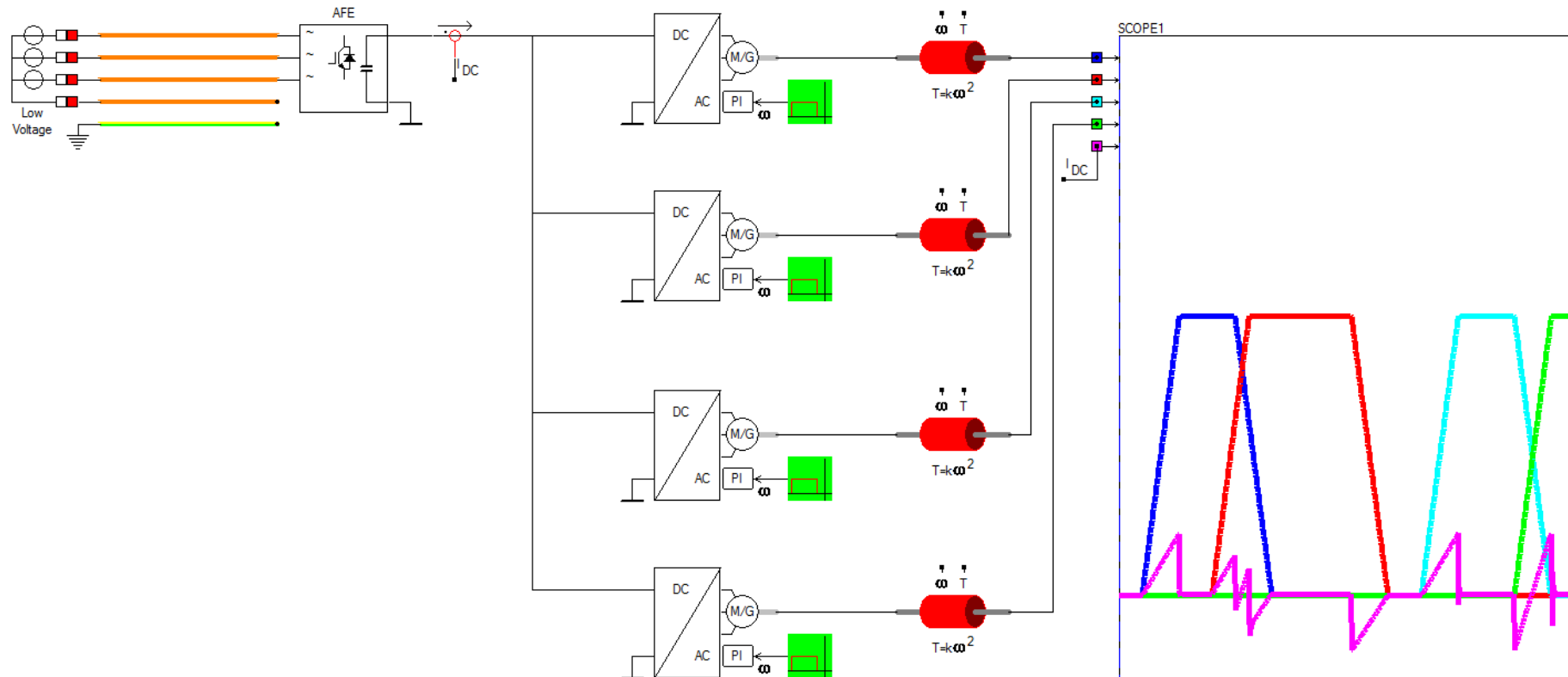
# Producers and Consumers are directly coupled



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# Exchange of Drive and Brake Energy



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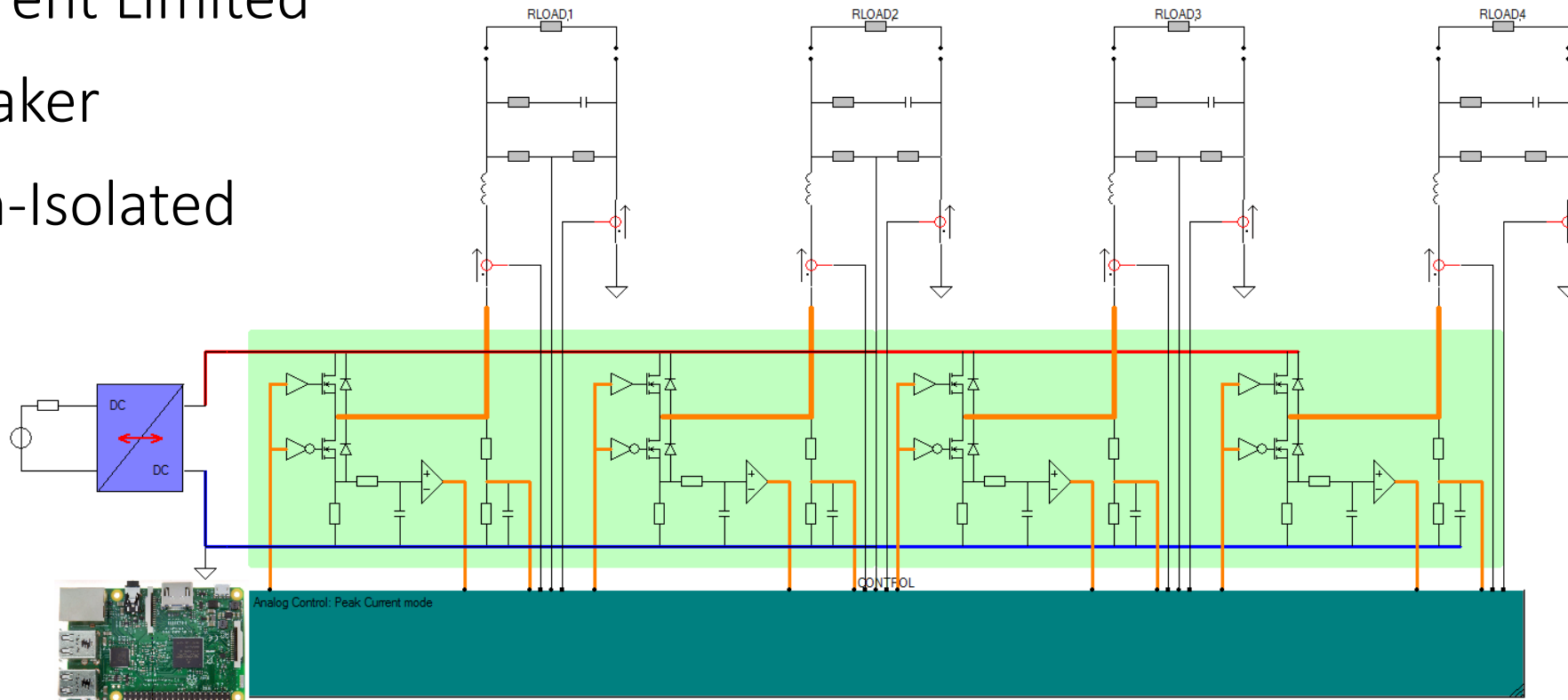
# Switching in the DC grid?

What type of switches do exist,  
if they do exist at all?



# Grid Manager contains multiple Synchronous Buck Converters

- power flow
- Current Limited
- Breaker
- Non-Isolated

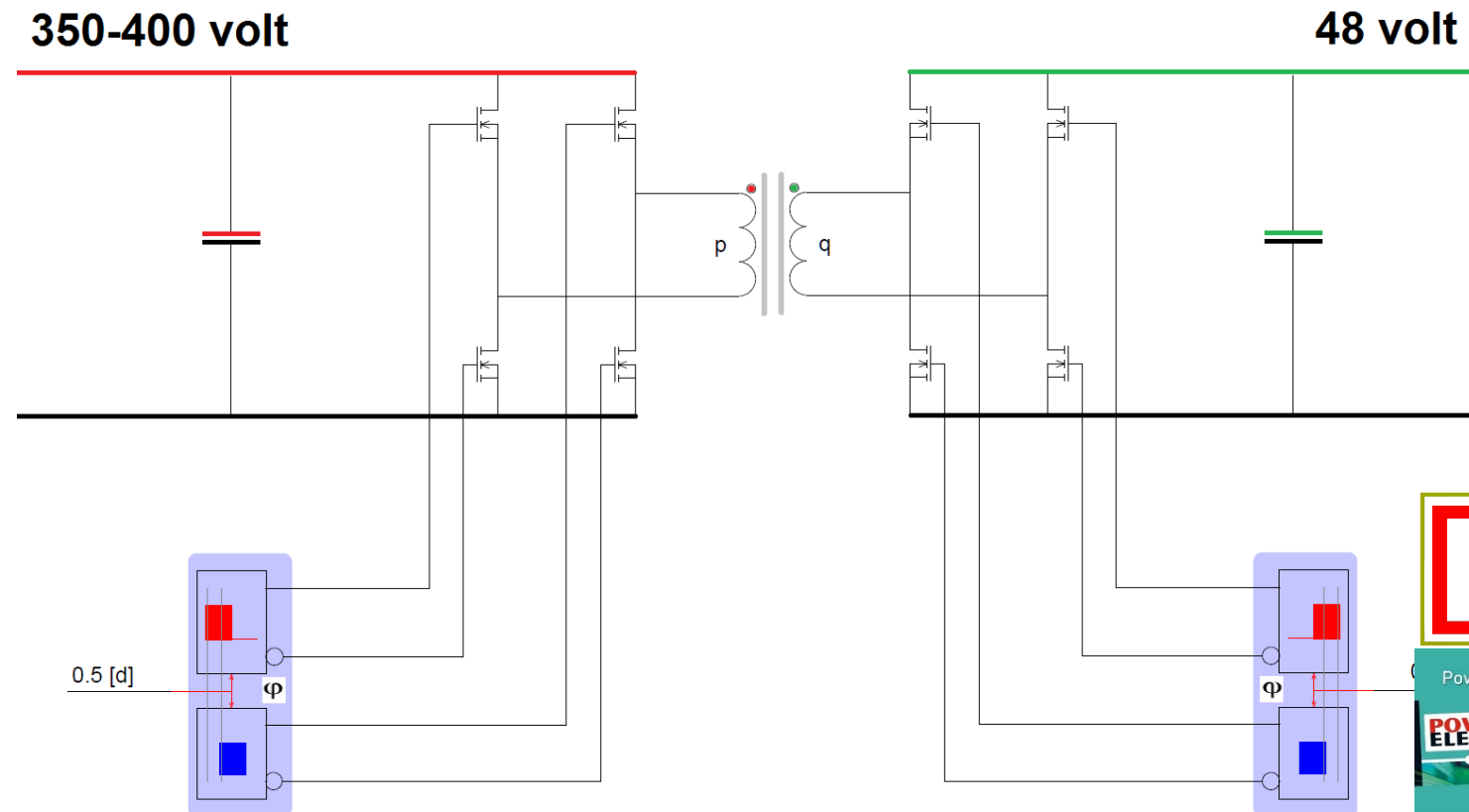


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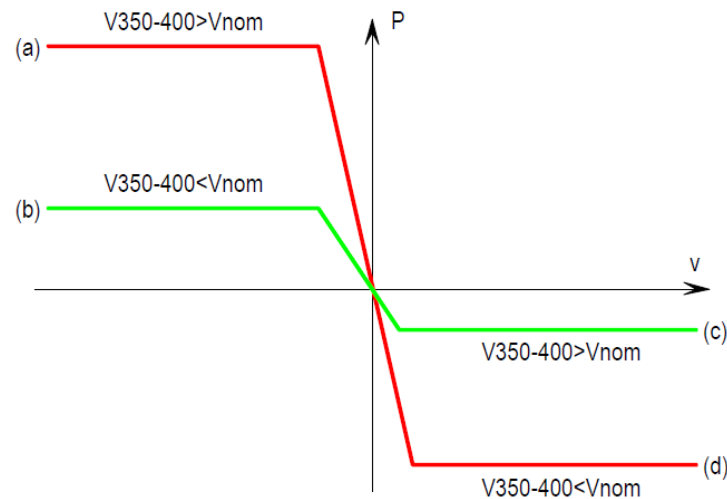
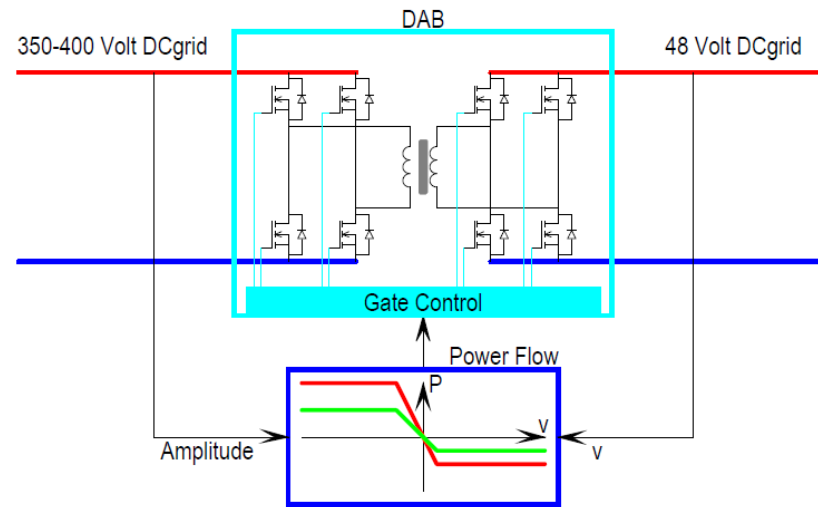


# Dual Active Bridge is Isolated

- Bidirectional power flow
- Current Limited
- Breaker
- Isolated
- DC transformer



# Connecting two DC grid with different voltage levels



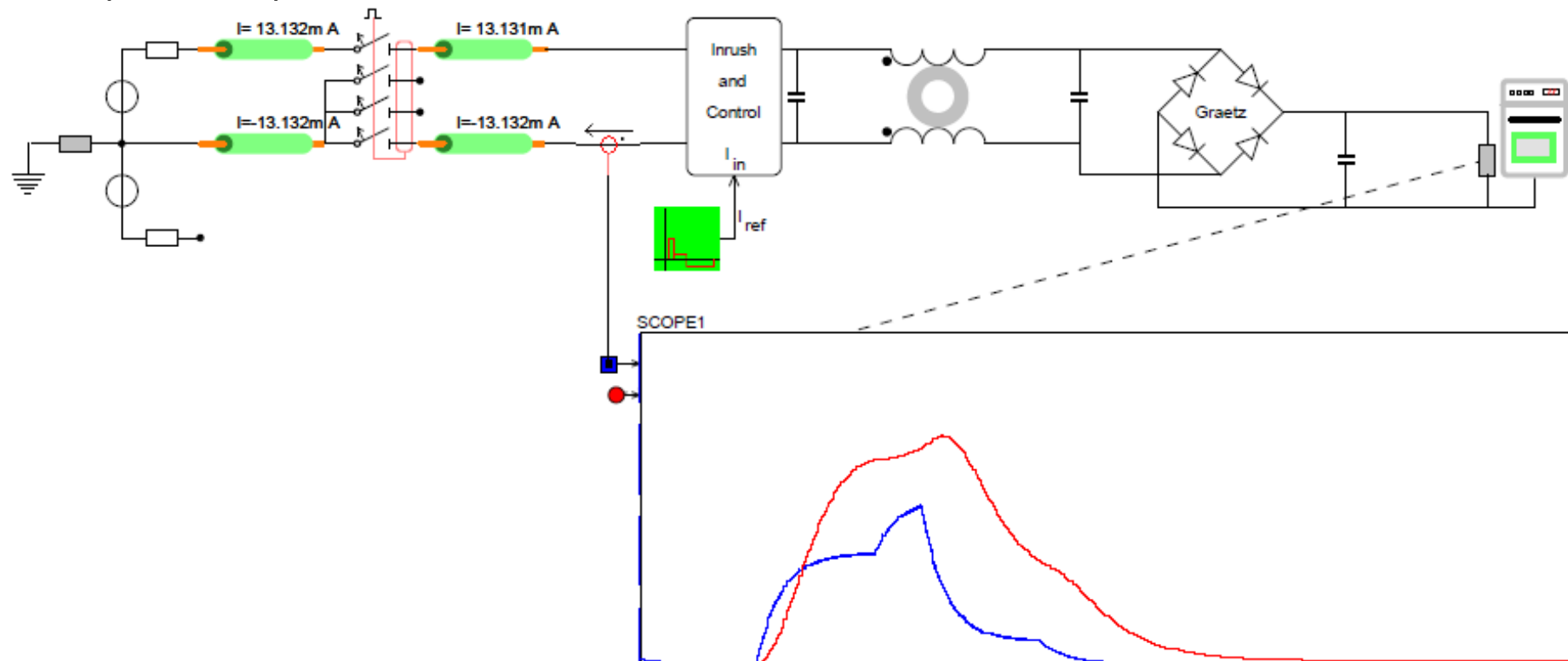
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# Inrush protection using a Sepic converter

- Controlled current flow
- Input Impedance is controlled



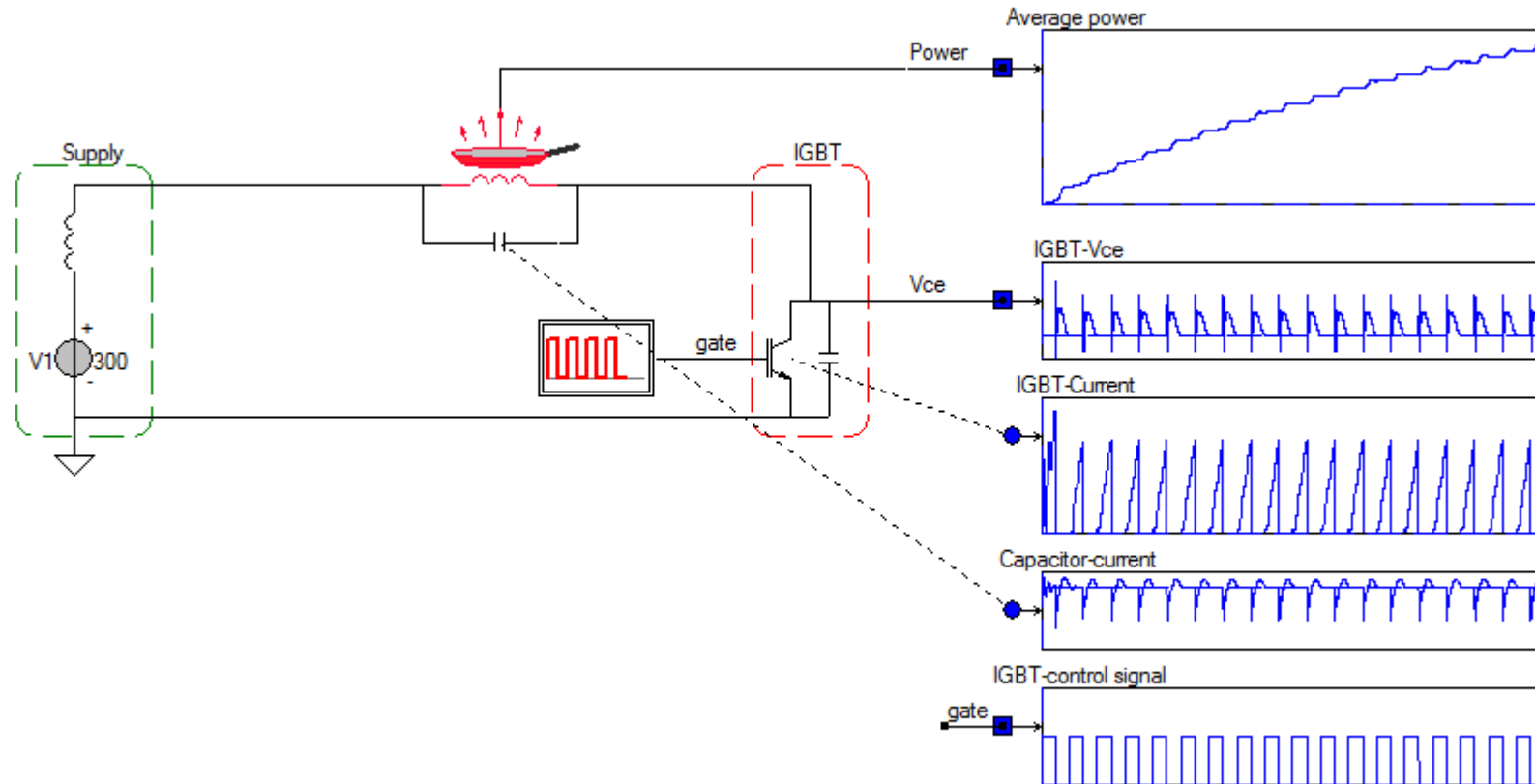
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# Switching Inrush protection

## Low side mosfet for inrush protection



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# DC grid control?

## Control and Power Congestion Management in the DC Grid



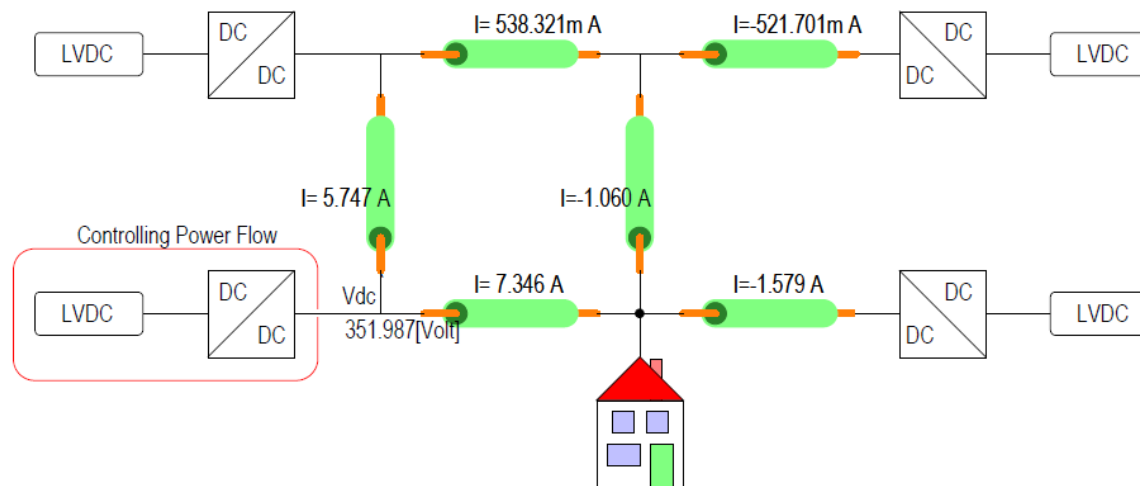
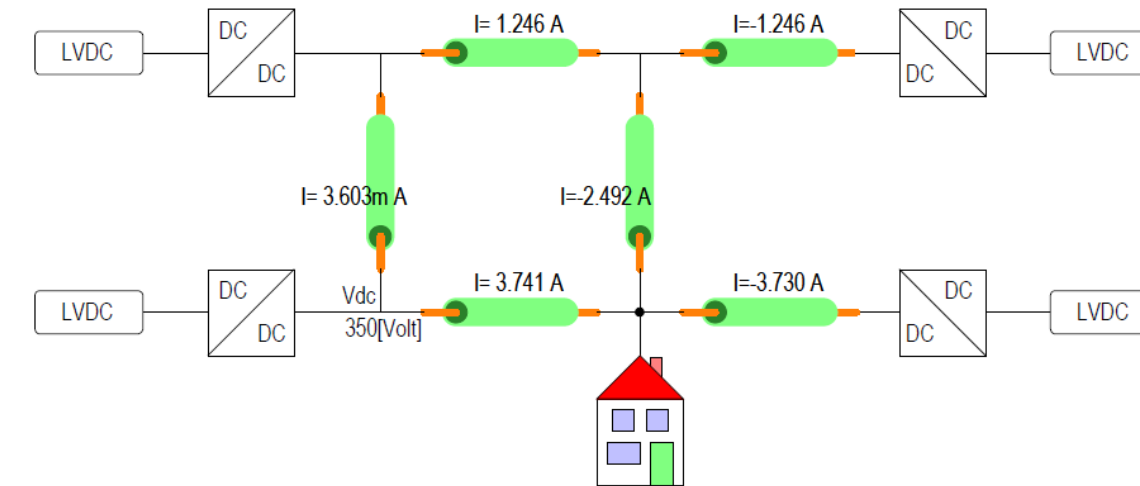
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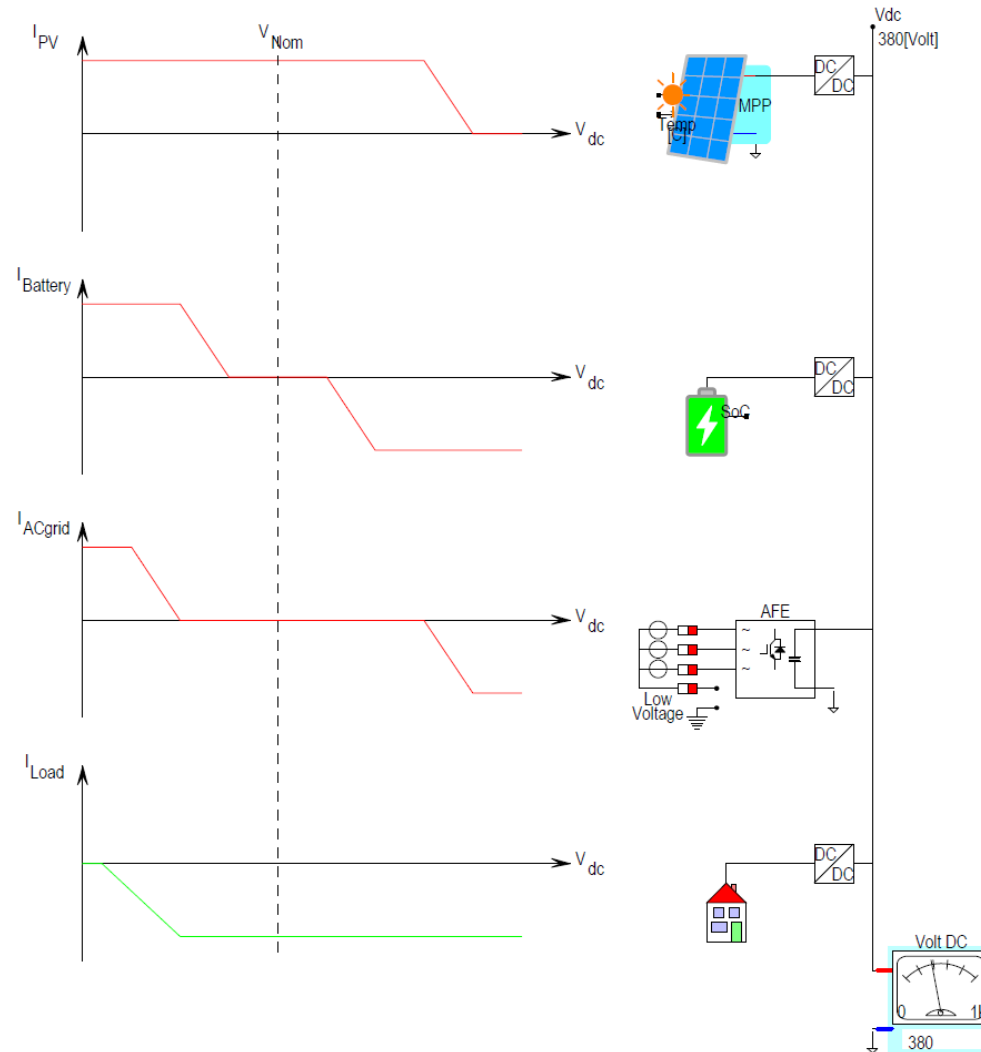
# Control the current in a Meshed grid

- Nodal voltage defines current flow
- DCDC converters have losses



# Droop Control regulates in a decentralized grid

- Controlled current flow per appliance
- Islanding operation
- No communication required



# DC grid selectivity and protection?

Protection and/or selectivity  
in the DC Grid?

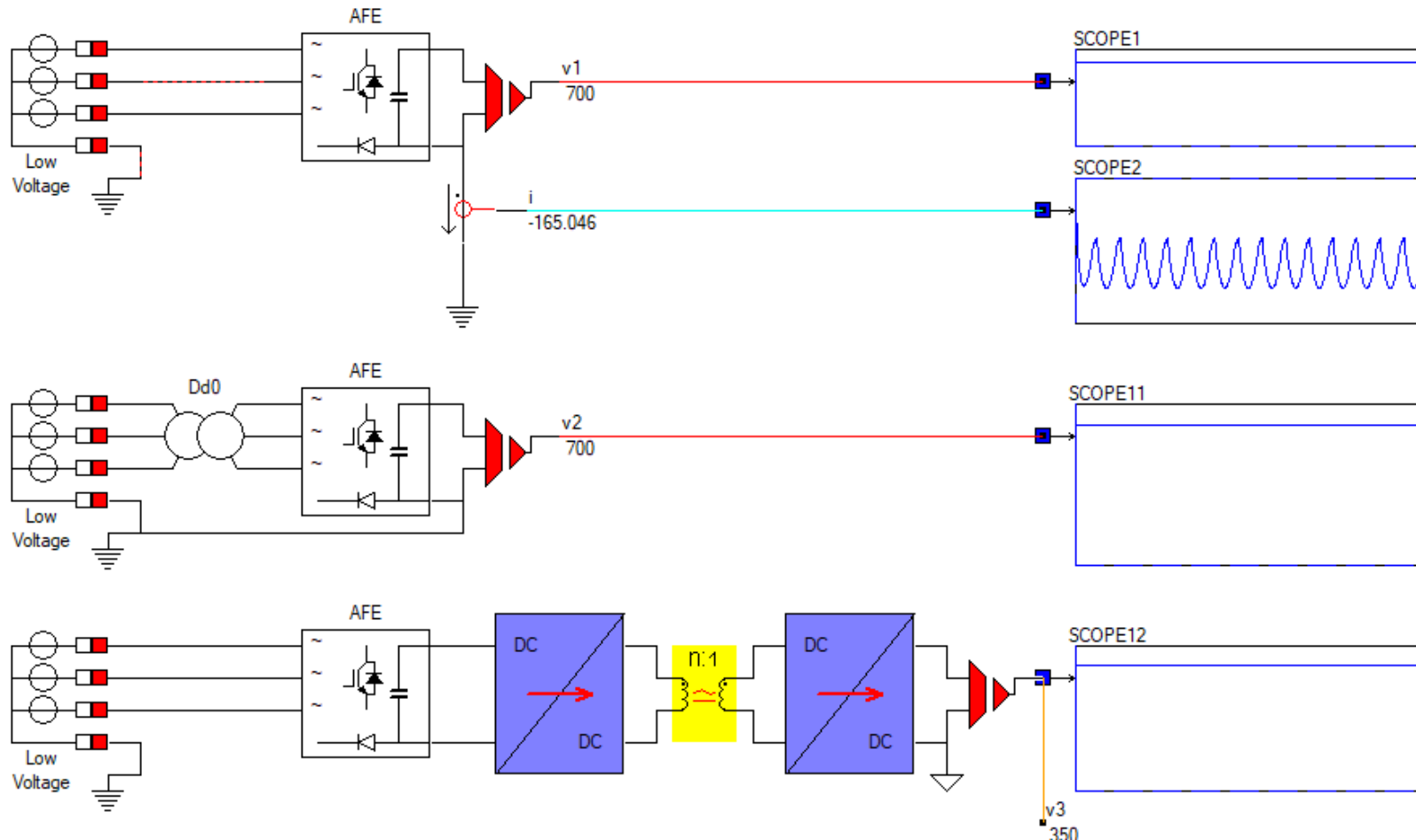


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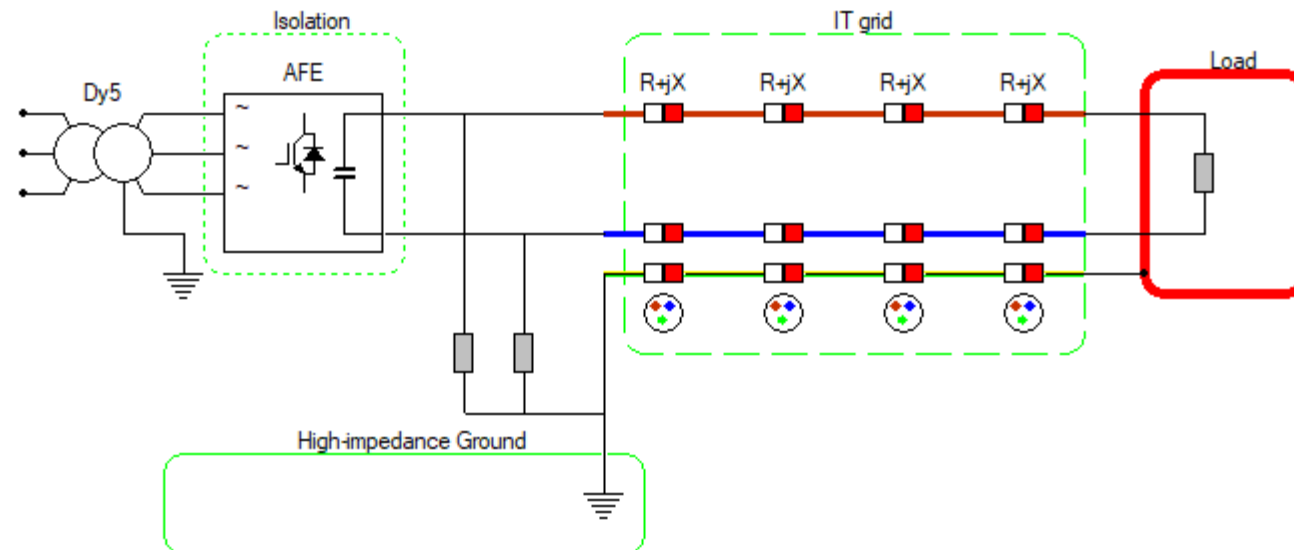
# When grounding, the DC grid has to be isolated from the AC grid



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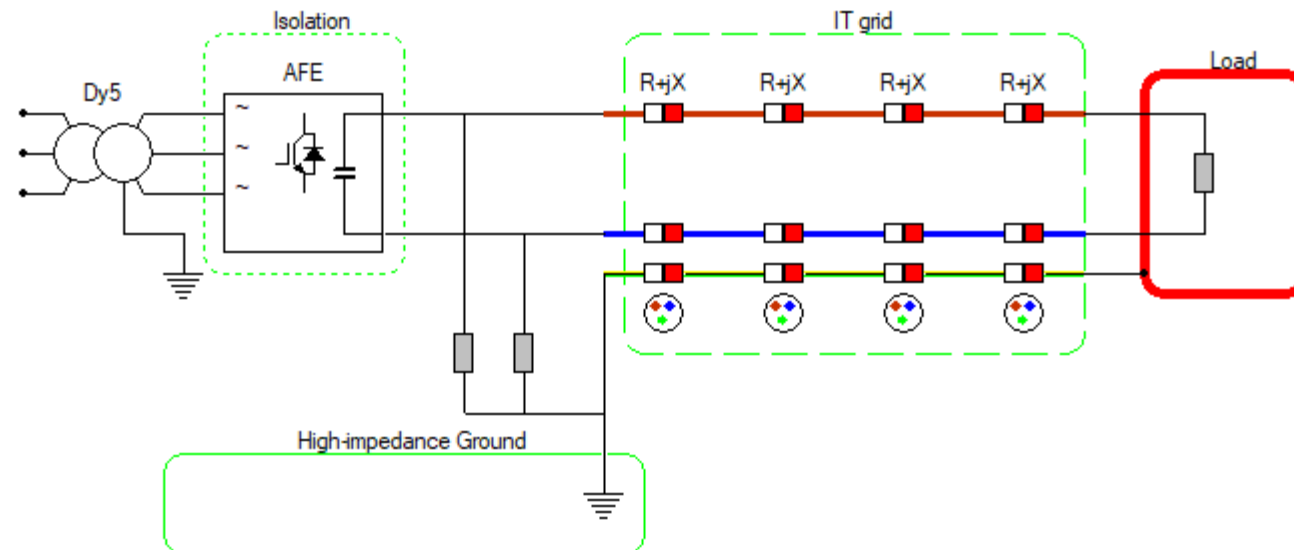
# Grid system?

- You can choose an isolated Grid IT to implement earth leakage detection,
- but your grid is floating!



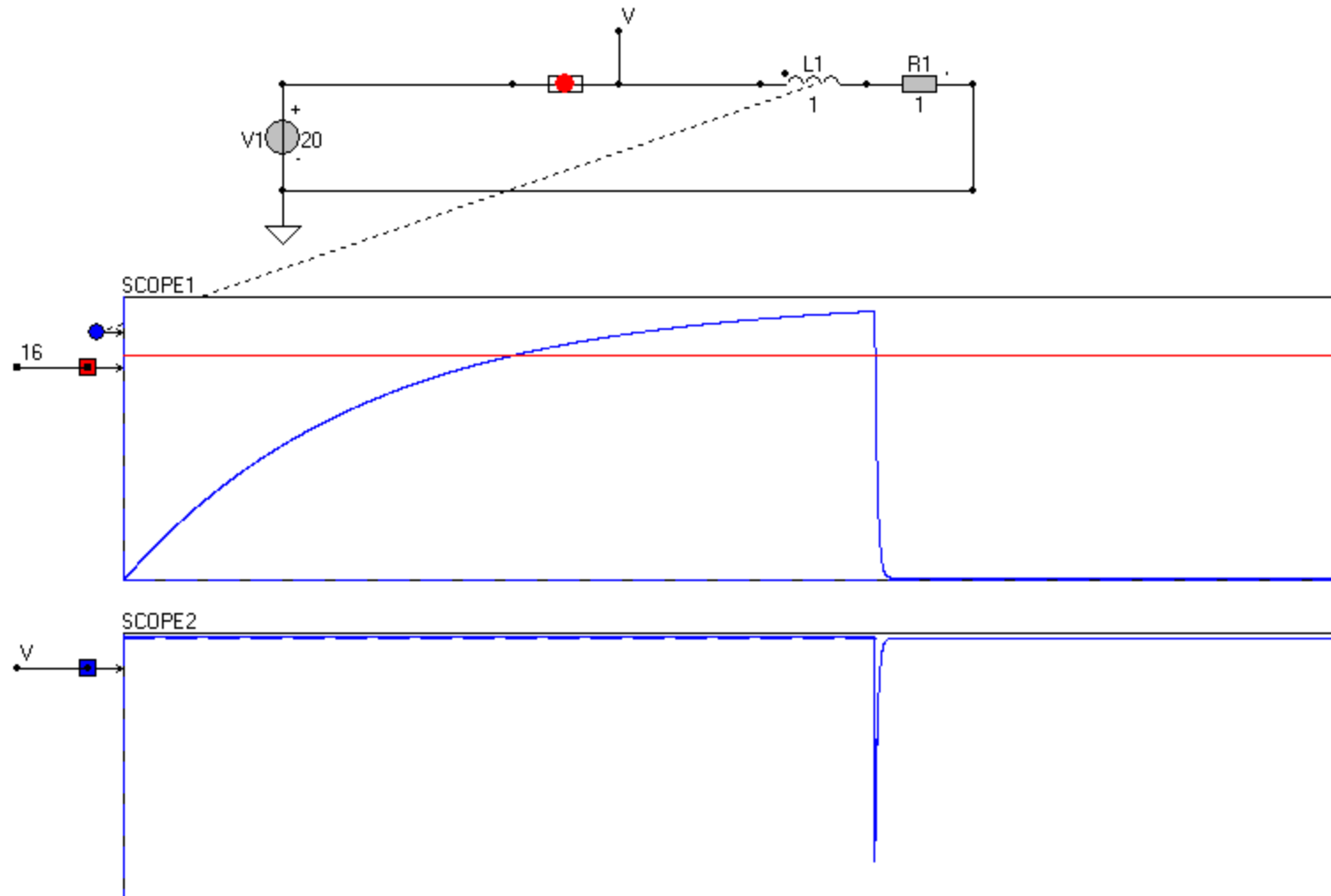
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# Fuse?

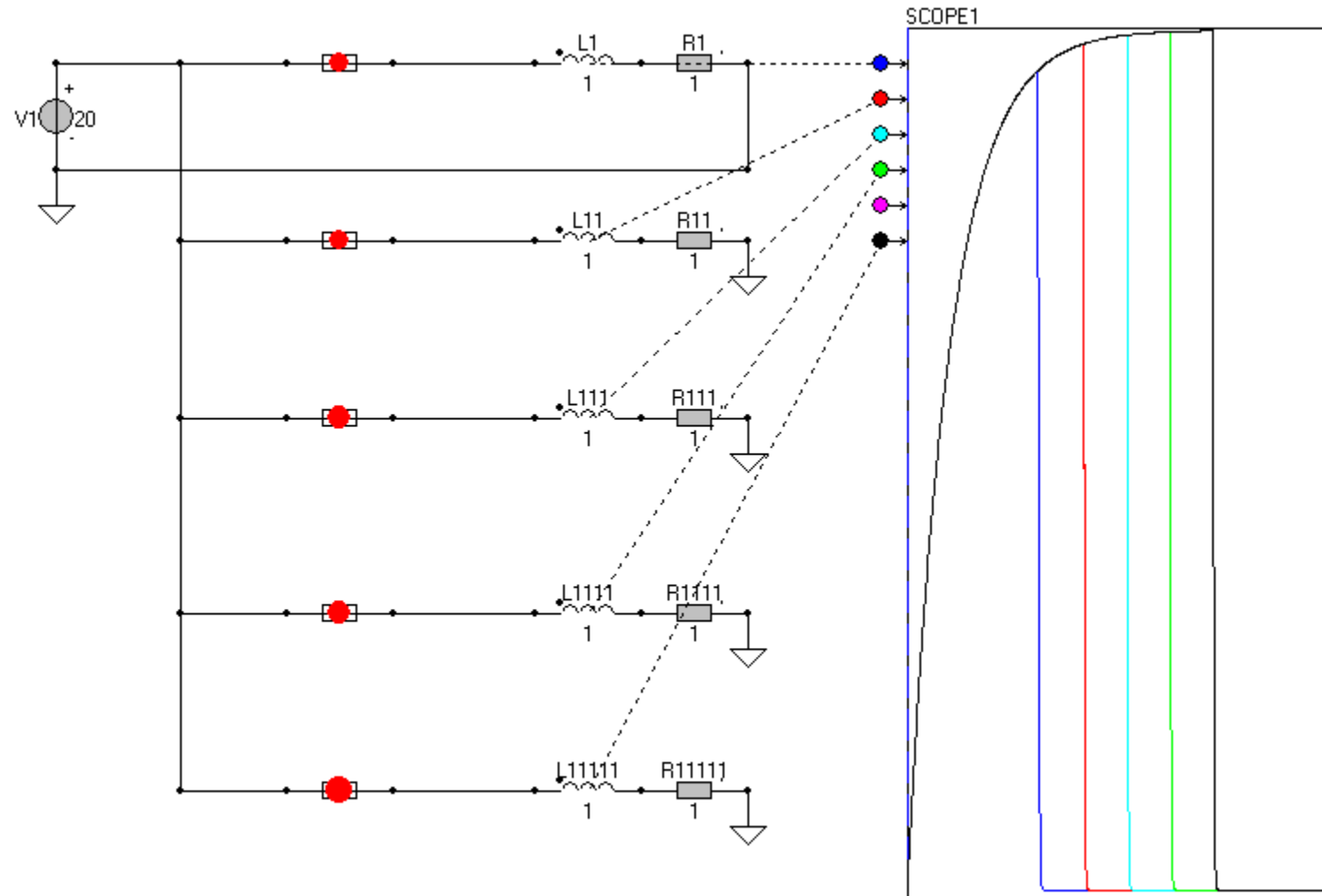


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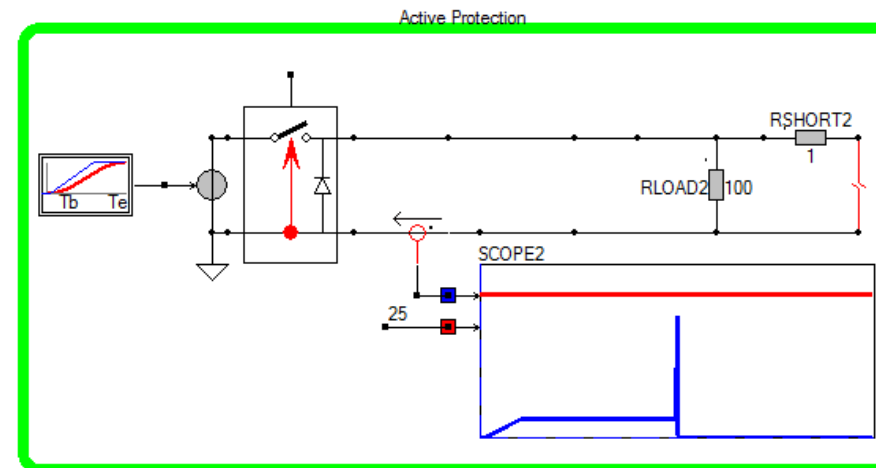
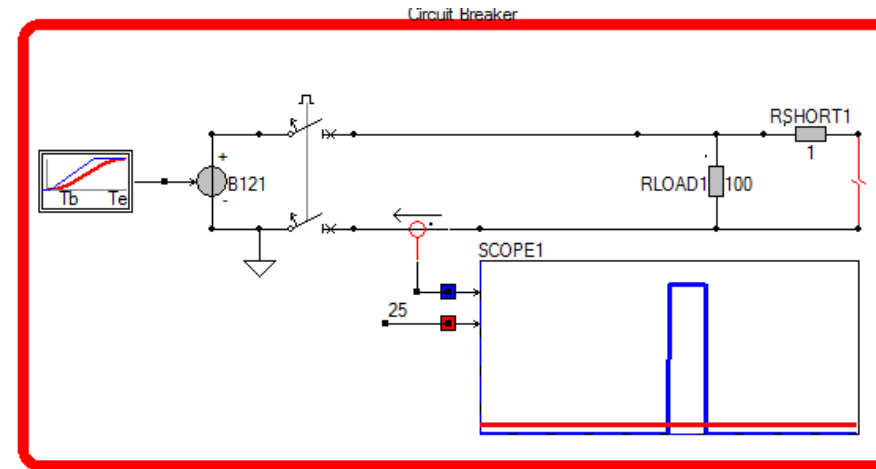
# Fuse?



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# RoCoC Rate of Change of Current



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# DC grid stability?

How to predict and ensure stability in the  
DC Grid



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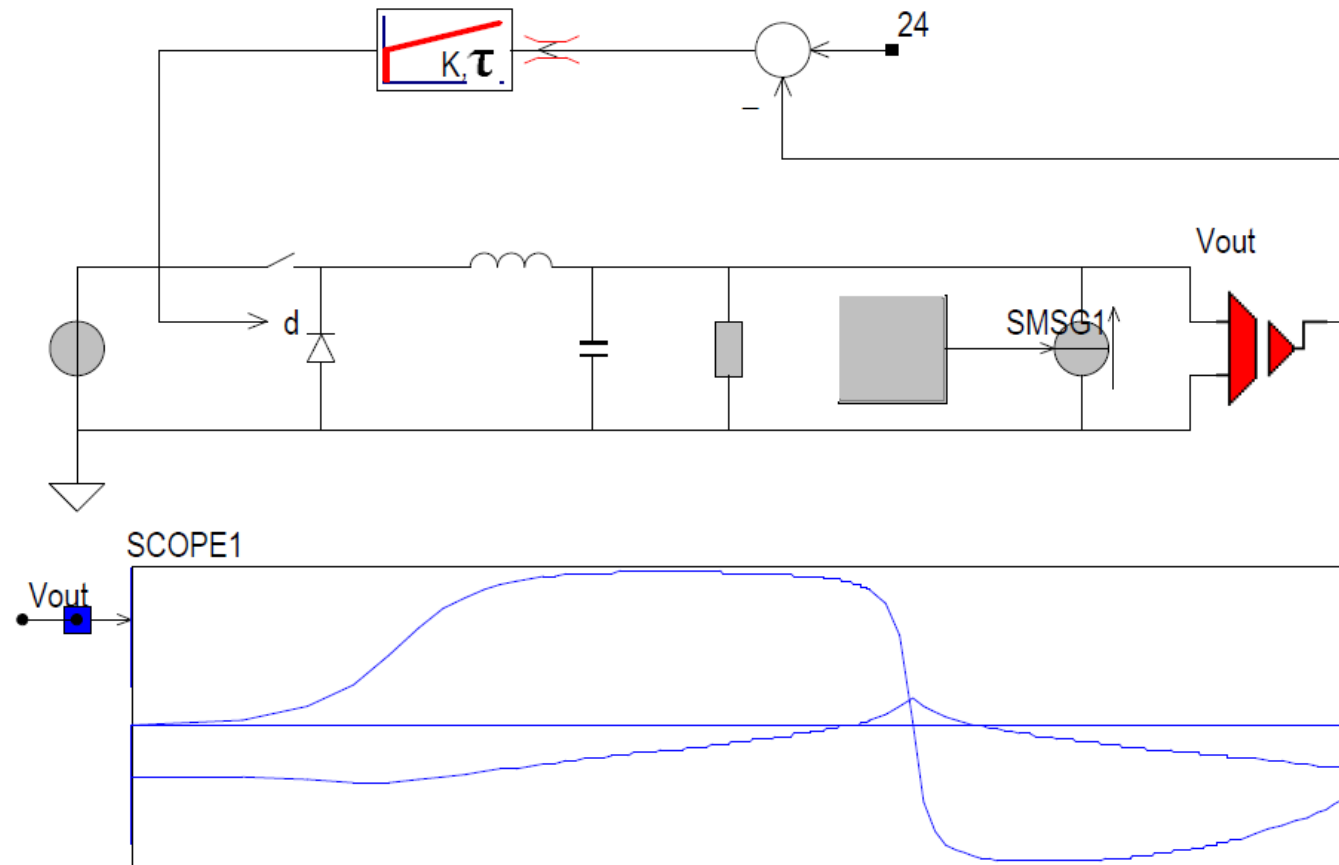


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# Dynamic stability depends on input and output impedance

- $Z_{out} < Z_{in}$
- Middlebrooks Stability Criterion



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# DC Grid: Protect or Control?

- Centralized or Decentralized
- Control
- Protection
- Stability

Thanks for your attention!



# Conclusion: DC Grid: Protect or Control?

- Centralized or Decentralized
- Control
- Protection
- Stability



Thanks for your attention!

[www.dc-lab.org](http://www.dc-lab.org)