

# Flexible coupling and decoupling of distribution networks using power electronics

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# Context

- Deregulation
- Increased DG
- Uncertainty for DNO (planning, operation)
- Flexible network management solutions are needed

# Outline

- Proposed Intelligent Node concept.
- Technology used.
- Research topics and some results:
  - Dis-/connecting grid areas.
  - Control concept
  - 3-Phase and phase-by-phase circuit breakers.
- Conclusions.

# Proposed Intelligent Node concept

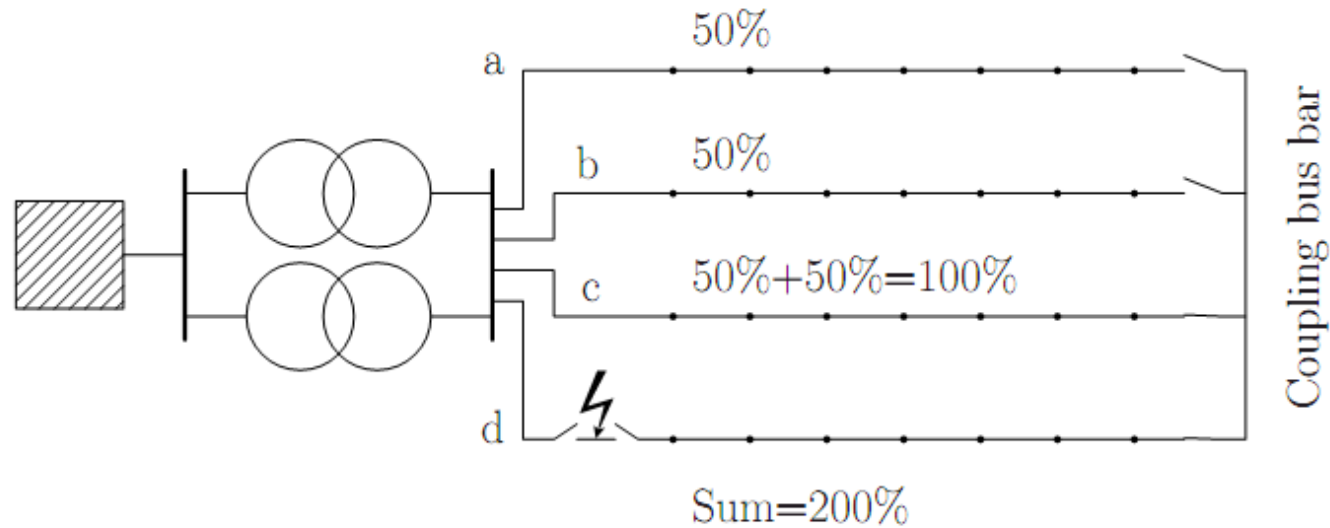
## Intelligent Node

a flexible way of making connections in distribution systems

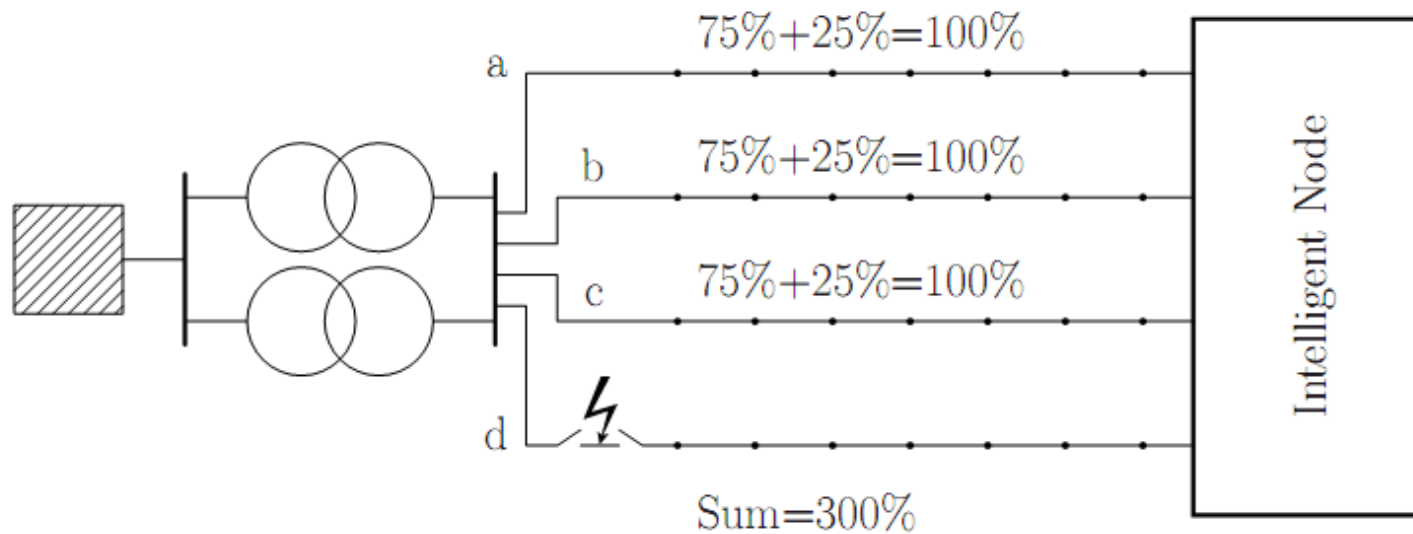
- Two main applications:
  - Redundancy sharing.
  - Coupling of grid areas.
- Other applications, not discussed here:
  - Mitigate harmonics, dips, flicker.
  - Voltage profile control.



# Redundancy sharing

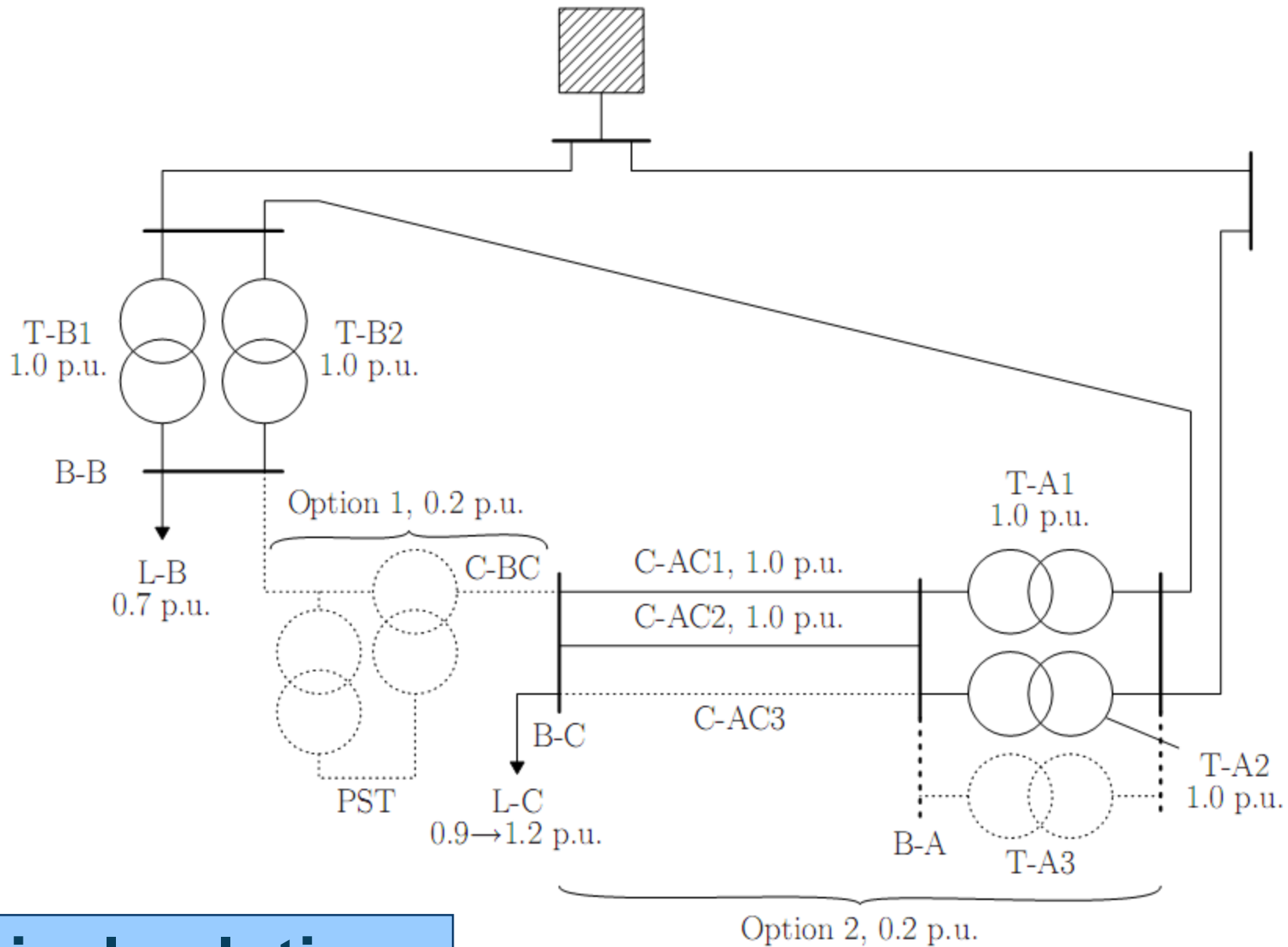


(a) Each feeder can supply the load of an other feeder.



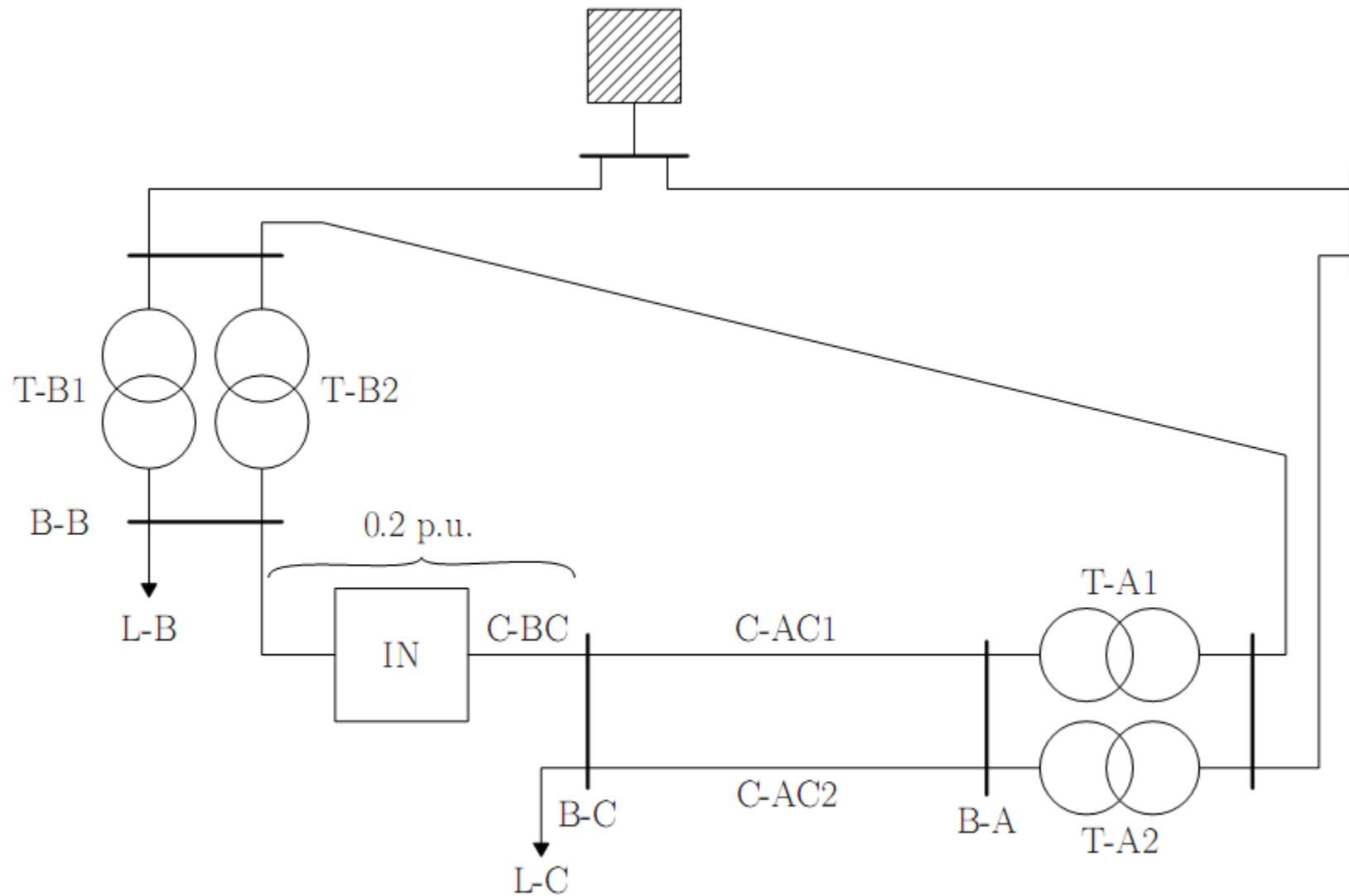
(b) All feeders share the load of the affected feeder.

# Coupling grid areas 1/2



**Classical solutions**

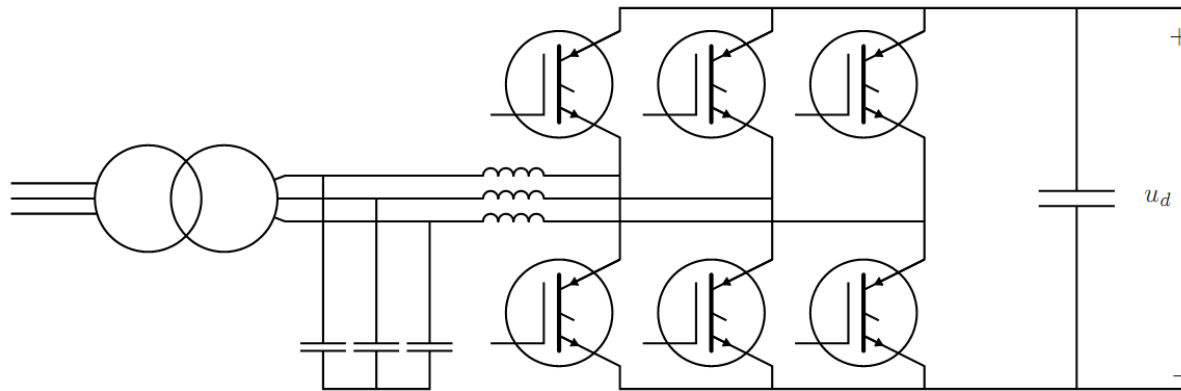
# Coupling grid areas 2/2



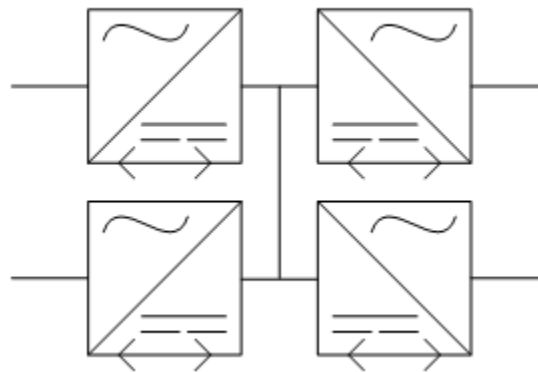
**Intelligent Node**

# Technology used

- Voltage source converters



- $n$ -Back-to-back configuration

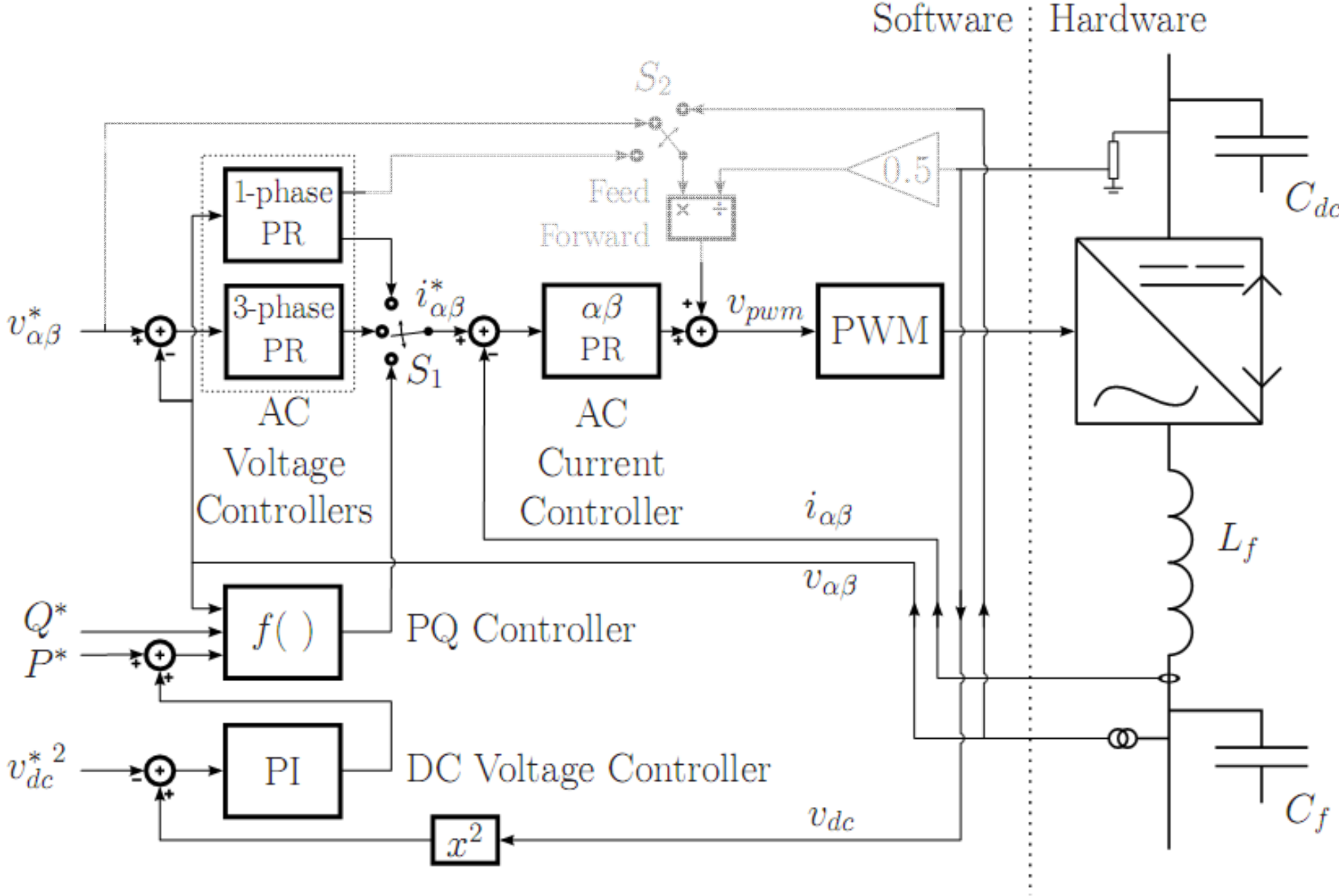


# Research area

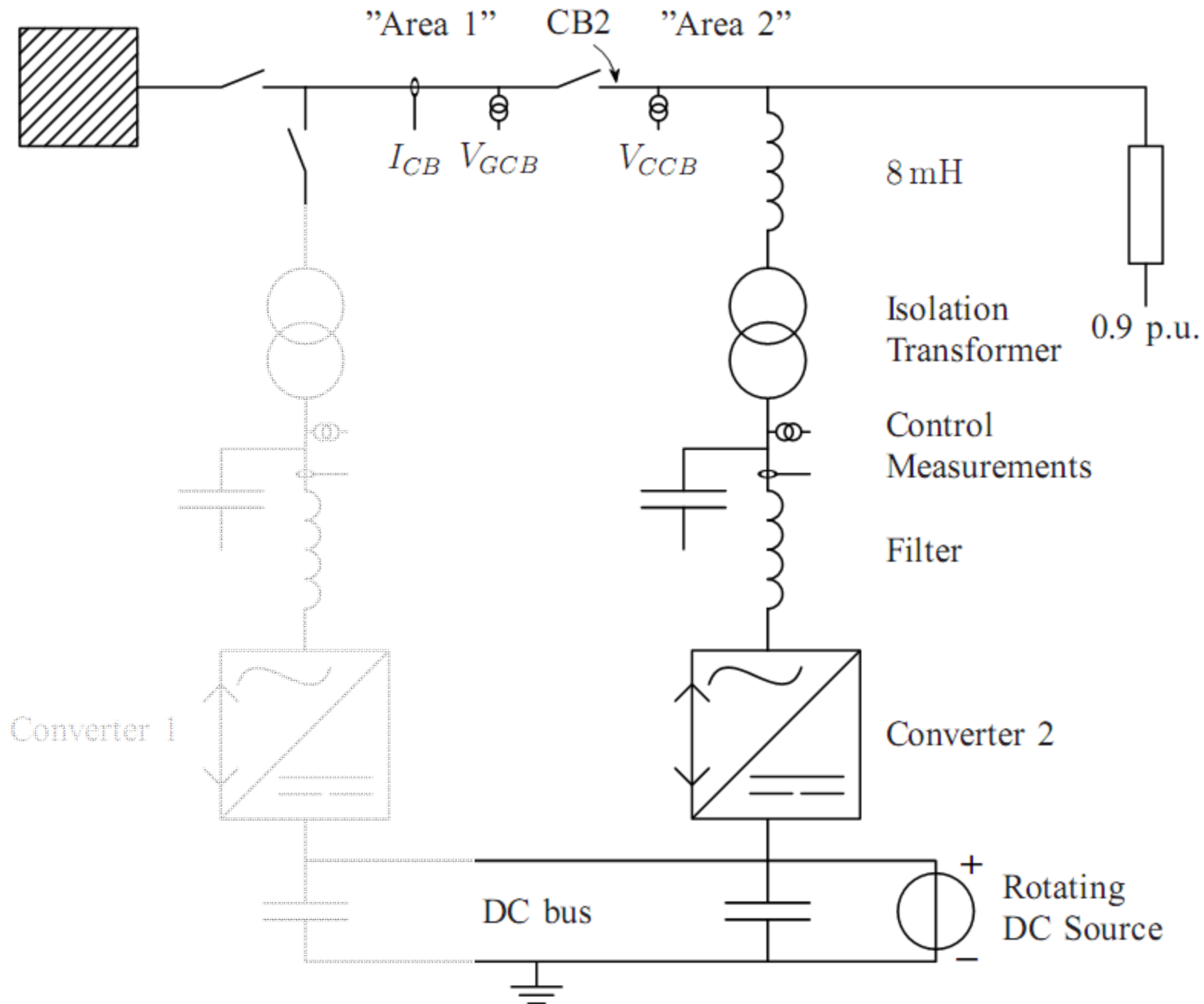
- Control system
- Connecting and disconnecting without interruption
- 3-phase and phase-by-phase circuit breaker operation



# Development of control system

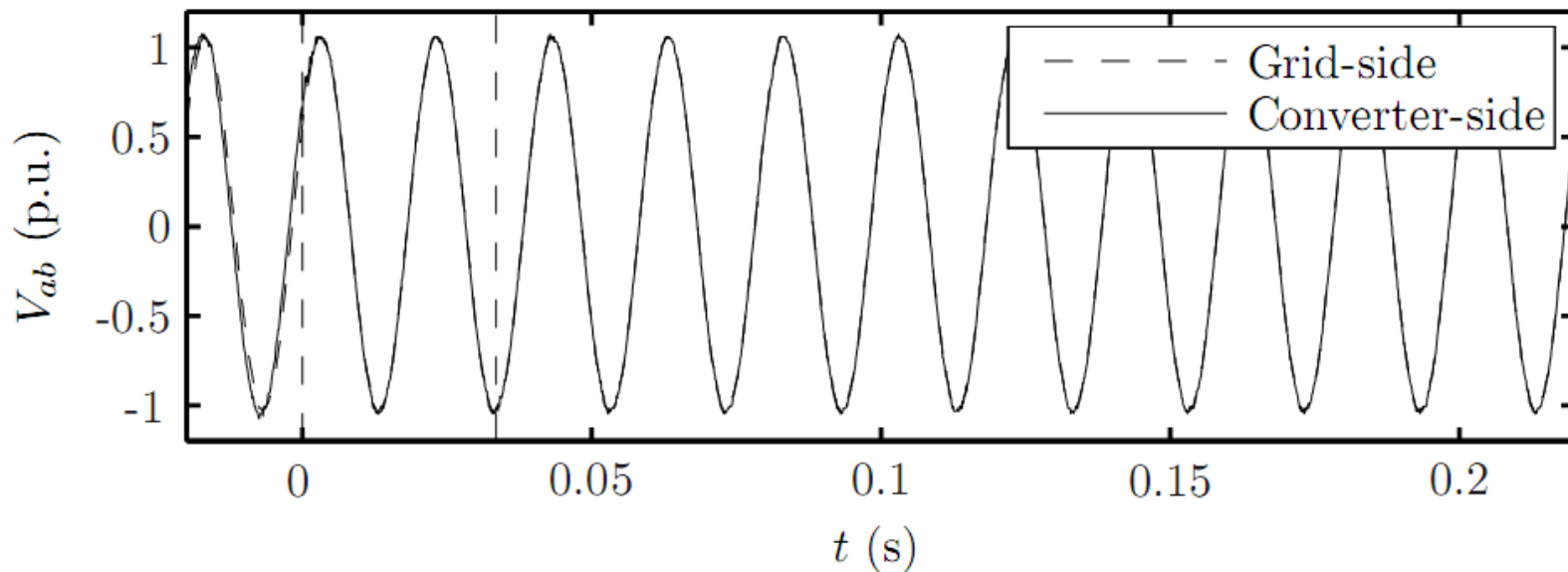
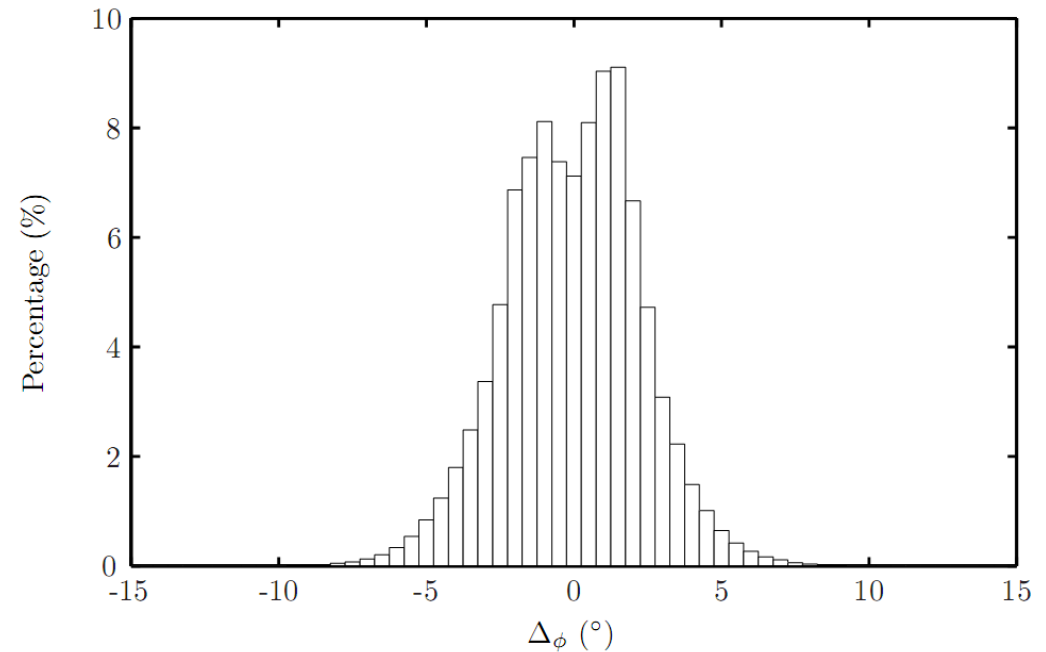


# Laboratory-scale demonstration



# Connecting 3-phase

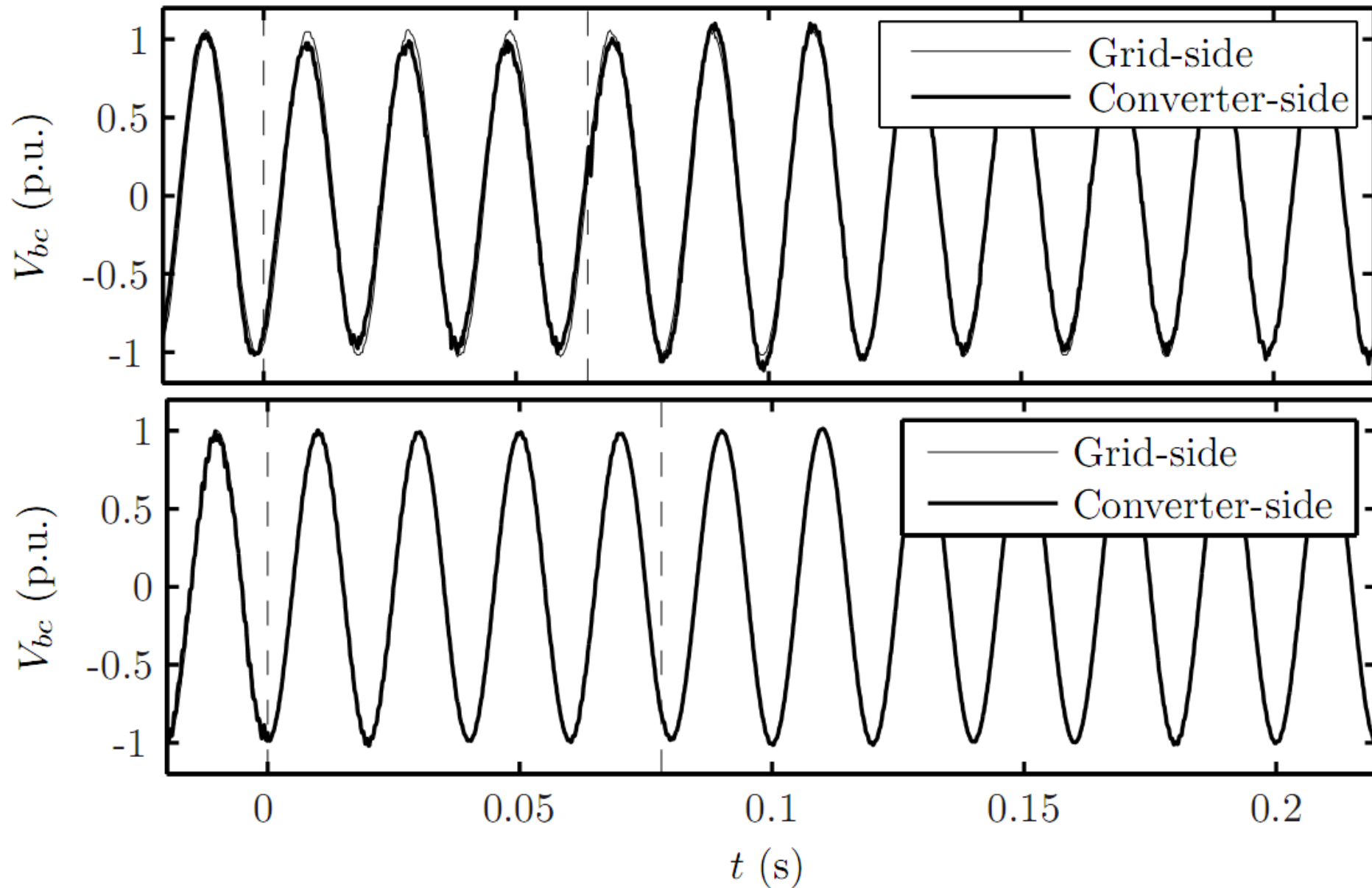
- 1) Synchronize →
- 2) Connect
- 3) Detect (over current)
- 4) Change operating mode



# Connecting phase-by-phase 1/2

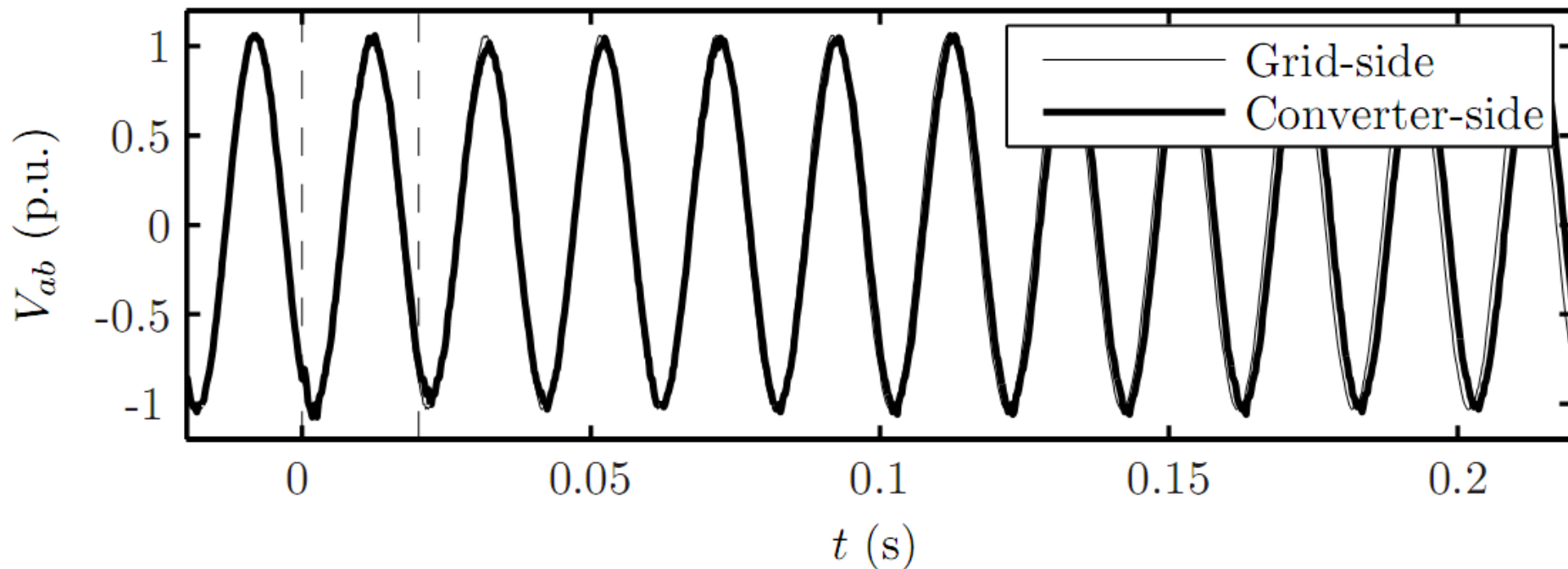
- 1) Synchronize
- 2) Connect phase A (nothing happens)
- 3) Connect phase B
- 4) Detect (current unbalance/over current)
- 5) Change operating mode
- 6) Connect phase C
- 7) Detect (over current)
- 8) Change operating mode

# Connecting phase-by-phase 2/2



# Disconnecting 3-phase

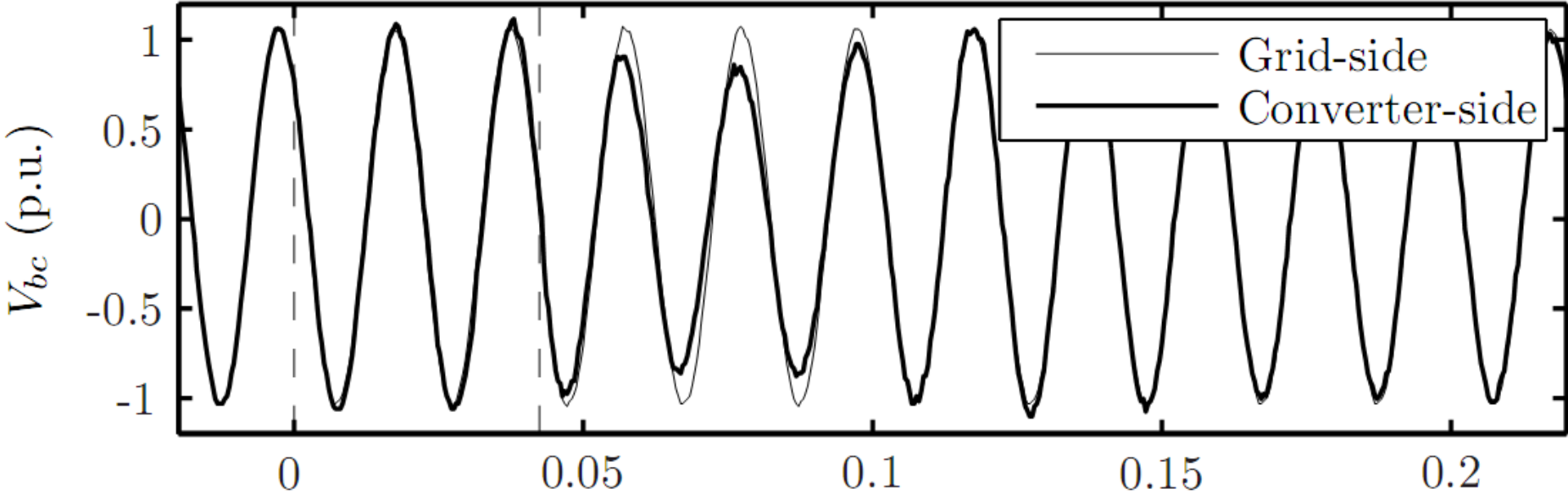
- 1) Disconnect
- 2) Detect (frequency)
- 3) Change operating mode



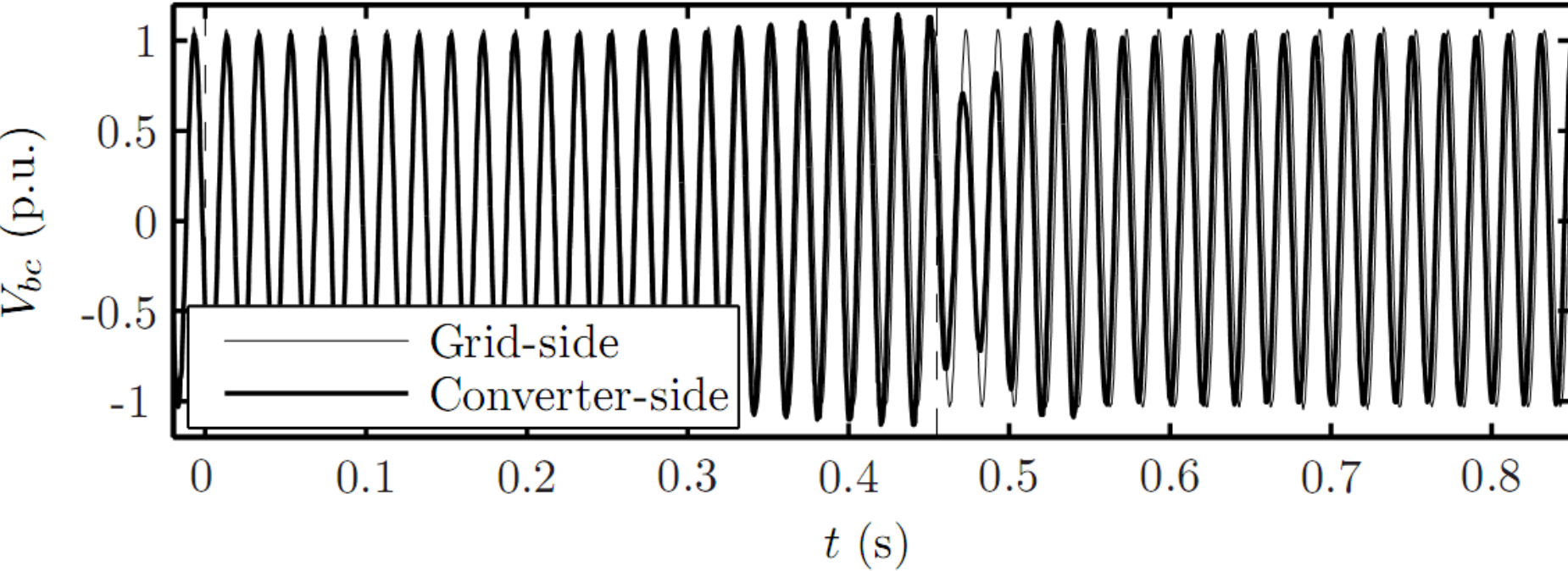
# Disconnecting phase-by-phase 1/2

- 1) Disconnect phase C
- 2) Detect (current unbalance)
- 3) Change operating mode
  
- 4) Disconnect phase B
- 5) Detect (voltage amplitude)
- 6) Change operating mode
  
- 7) Disconnect phase A (nothing happens)

# Disconnecting phase-by-phase 2/2



C



B

# Conclusions

- Intelligent Node concept:
  - Redundance sharing
  - Coupling of grids
  - Based on voltage source converters
- Control concept for
  - 3-Phase and
  - Phase-by-phase circuit breaker operation
- Experimental results laboratory-scale demonstration



Thank you for your attention.

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