SCCER – FURIES
Shaping the FUtuRe SwIss Electrical InfraStructure

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation
Innosuisse – Swiss Innovation Agency

DEVELOPMENT OF A SOFT-OPEN POINT FOR CHAPELLE-SUR-MOUDON LV DISTRIBUTION SYSTEM

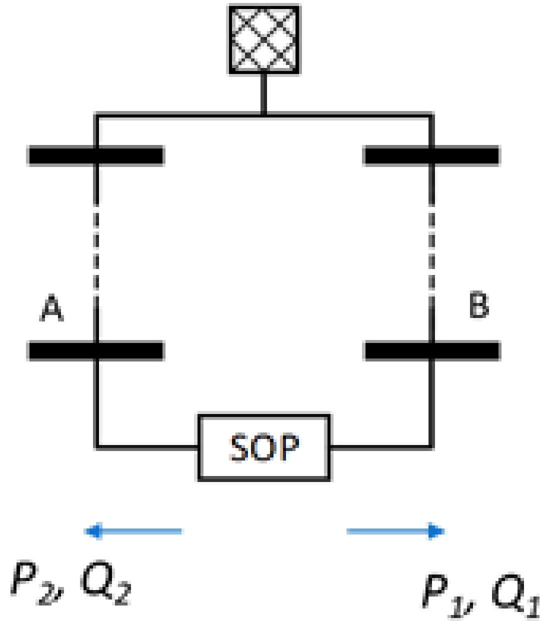
Mauro Carpita, Patrick Favre-Perrod
University of applied sciences and arts western Switzerland

2020 SCCER-FURIES Annual Conference
28 October 2020, Virtual

Hes·so
Haute Ecole Spécialisée de Suisse occidentale
Fachhochschule Westschweiz
University of Applied Sciences Western Switzerland

The SOP principle

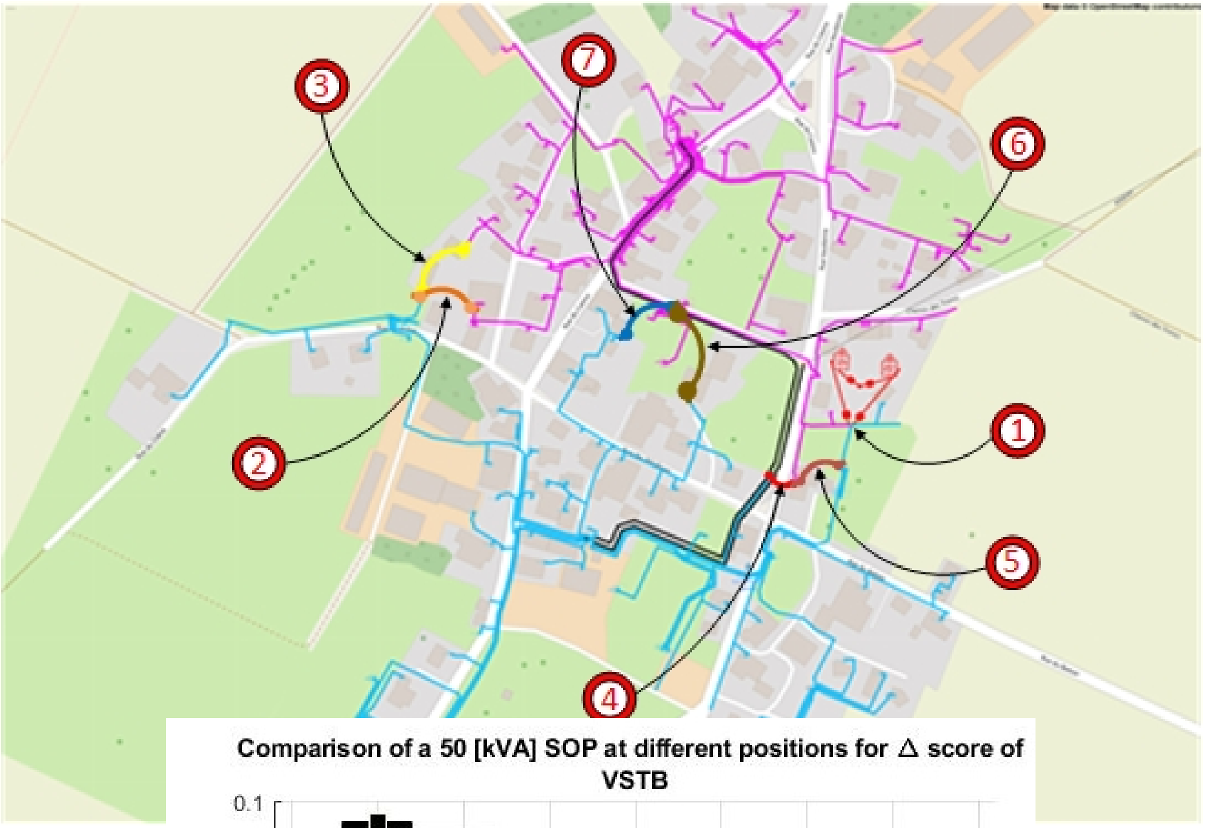
- The SOP is a way to decouple load flows and fault currents:
  - It is (or can be) closed in normal conditions
    ➔ meshed/loop network topology
  - It opens in fault condition
    ➔ radial network topology
- Advantages:
  - The SOP increases the operational flexibility with minimal influence on existing protection and automation systems
  - The RES hosting capacity can increase
- Application area: MV and LV networks

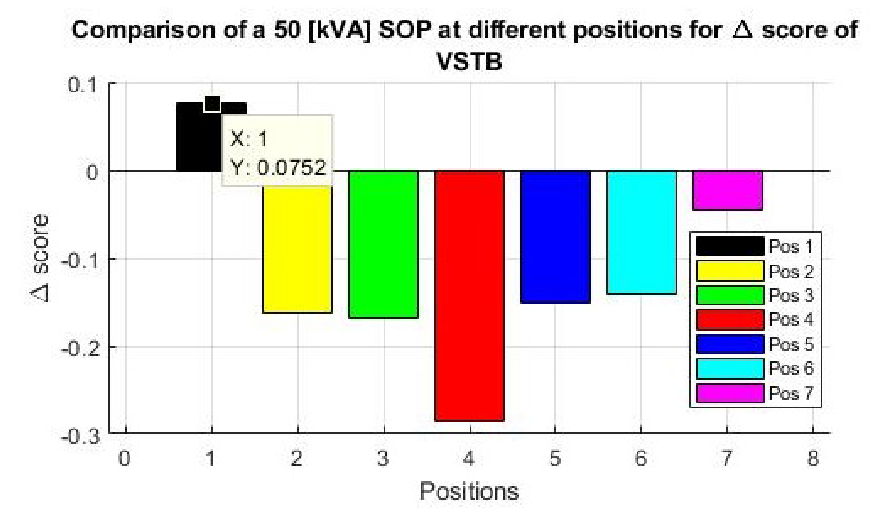


Performance criteria:
- Component loading
- Voltage variation over time
- Network losses
- (Increase in RES hosting capacity)

Placement of the SOP

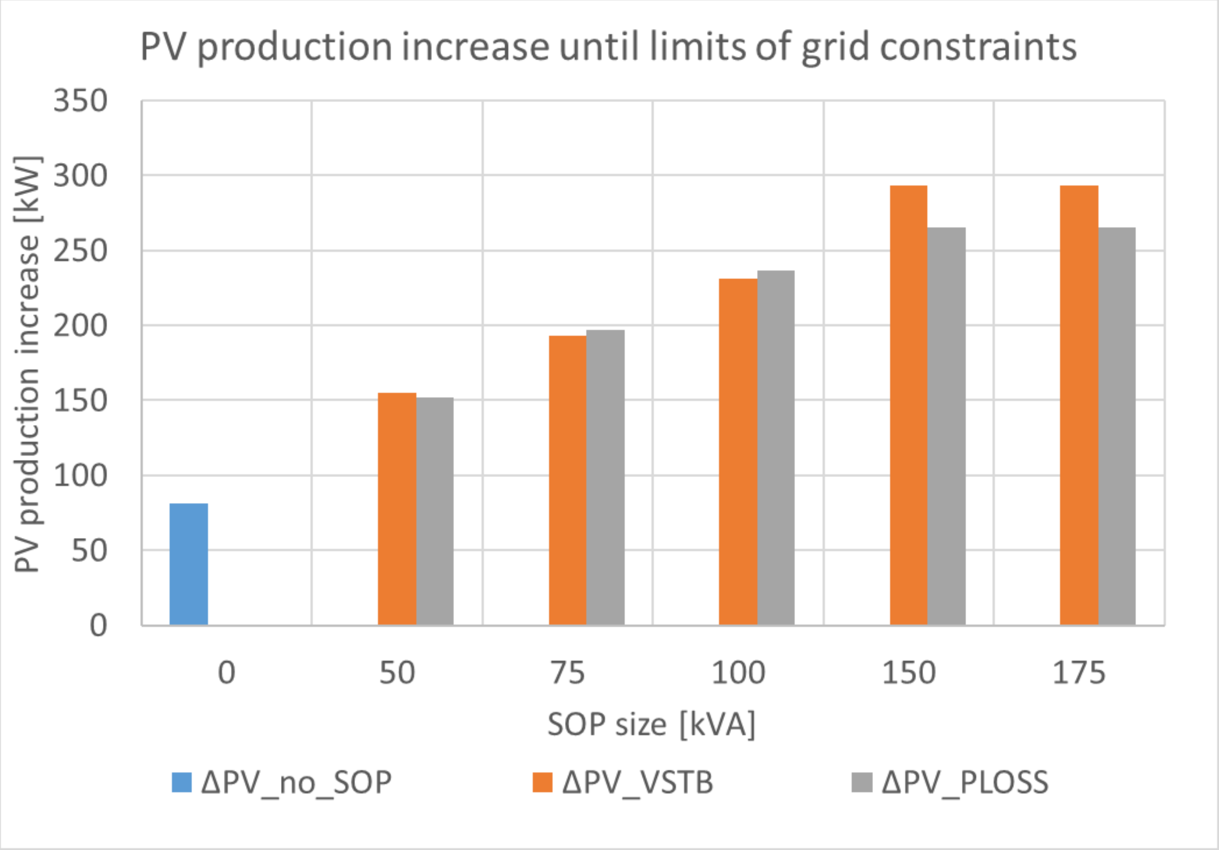
- LV modelling approach established
- 7 candidate locations identified
- Simulations based on load snapshots → comparison with status quo
- Space / planning permission checked in a second step → OK for best variant





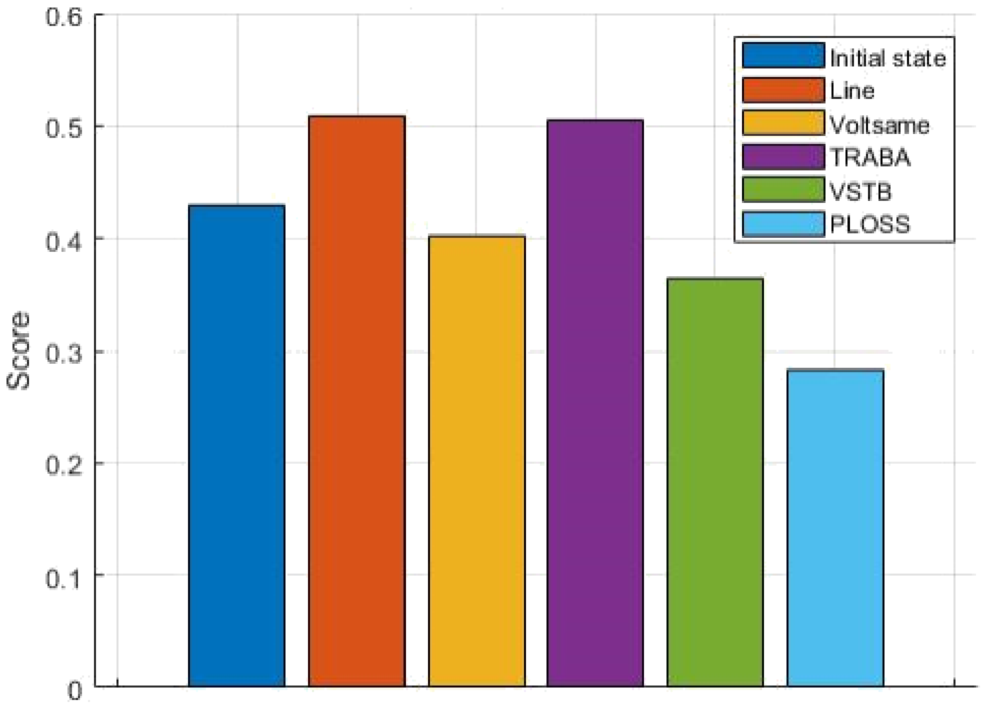
Sizing of the SOP

- Evaluation of PV hosting capacity with no SOP
- Determination of the incremental possible addition of PV for SOP of different sizes (no other network reinforcement)
- 50 kVA selected



Control of the SOP

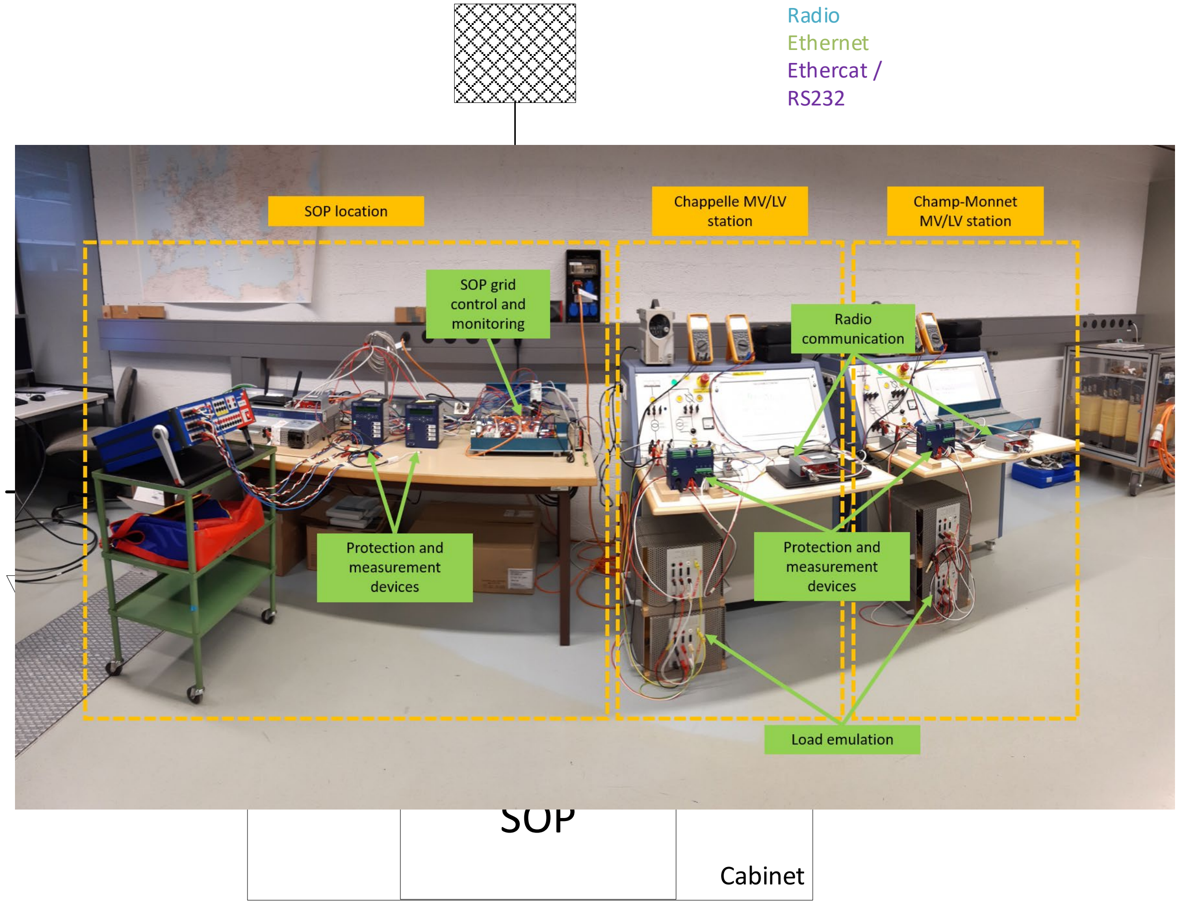
- Requirements:
  - Independent system with optional interlink to other systems
  - Simple system
- Candidate "basic" control schemes:
  - TRABA (Transformer Balancing):balance the loading of the two distribution transformers
  - VSTB (Voltage profile adjustment & transformer balancing): reduce a combination of the loading difference between the two distribution transformers and to reduce the voltage difference between the two connection points of the SOP.
  - VOLTSAME: reduce the voltage drop between the transformers and the SOP connection points.
  - PLOSS: OPF for minimal network losses
- Comparison + measurement requirements → VSTB was chosen



NB: low score is better

The 50 kVA prototype for Chapelle-sur-Moudon: Protection, control and communication

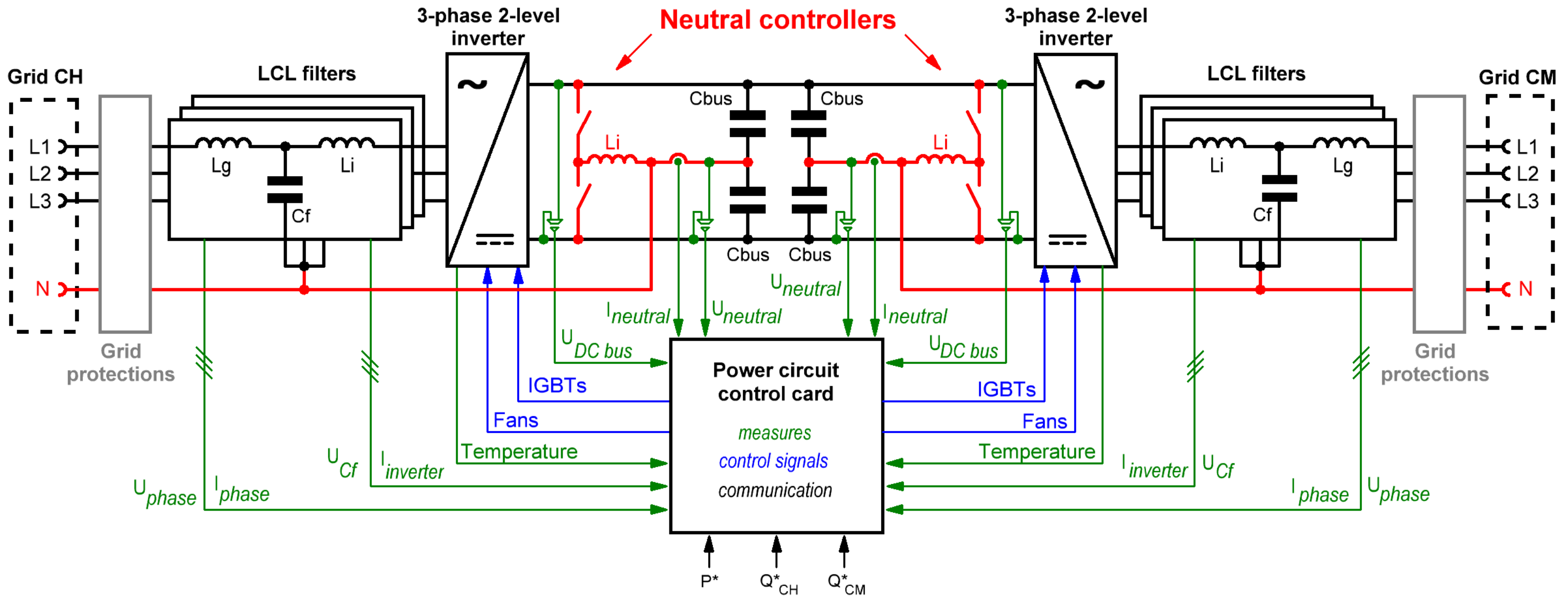
- Communication between sites
  - IEC 61850 GOOSE
  - Radio link
- Protection
  - U< / I> based short-circuit detection
  - Transfer tripping
- Control
  - Remote U/I measurements at MV/LV stations
  - Integration with Depsys GridEye system



The 50 kVA prototype for Chapelle-sur-Moudon: Power circuit principle

- Power part:
  - Inverters in back to back
  - LCL filter on each phase
  - Protections for each grid
  - Neutral controllers

- Control part:
  - Control card with 2 DSP
  - Measures (current, voltage and temperature)
  - Inverters control
  - Communication with P-Q calculator

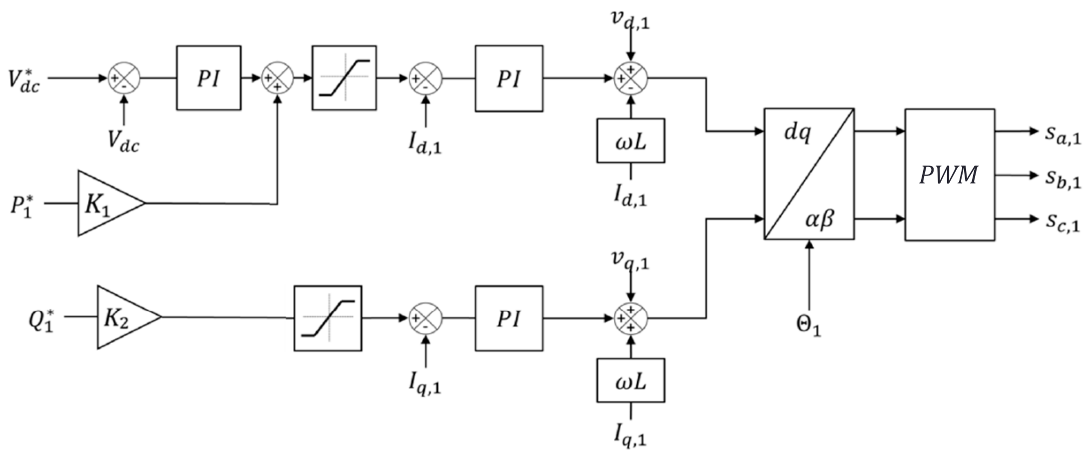


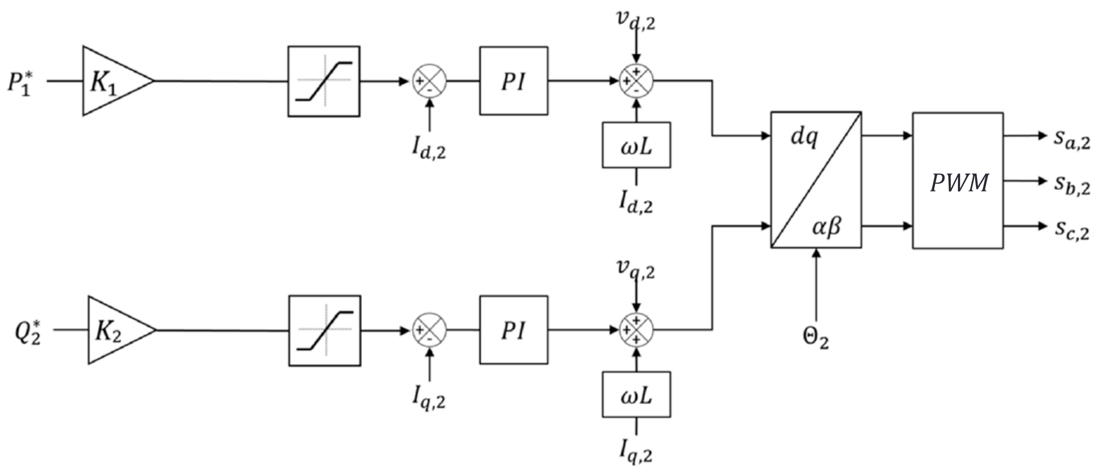
The 50 kVA prototype for Chapelle-sur-Moudon: Power circuit control

- Control strategy for inverter 1 (principle, adapted to LCL filter):
  - External regulation loop with PI corrector on U_{DC} and Q_1
    => current setpoints in d-q frame
  - Regulation loop with PI corrector on $I_{d,1}$ and $I_{q,1}$

Interchangeable

- Control strategy for inverter 2 (principle):
  - External regulation loop with PI corrector on P_1 and Q_2
    => current setpoints in d-q frame
  - Regulation loop with PI corrector on $I_{d,2}$ and $I_{q,2}$

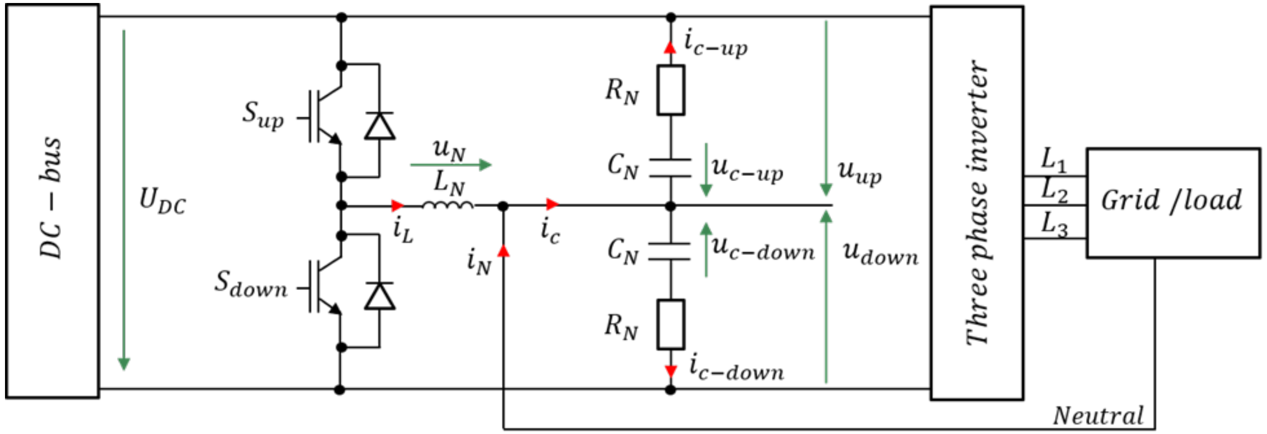




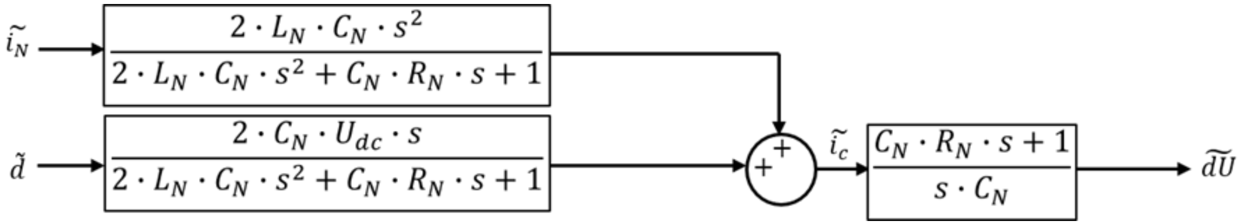
The 50 kVA prototype for Chapelle-sur-Moudon: Power circuit control

Neutral control:

- Principle schematic

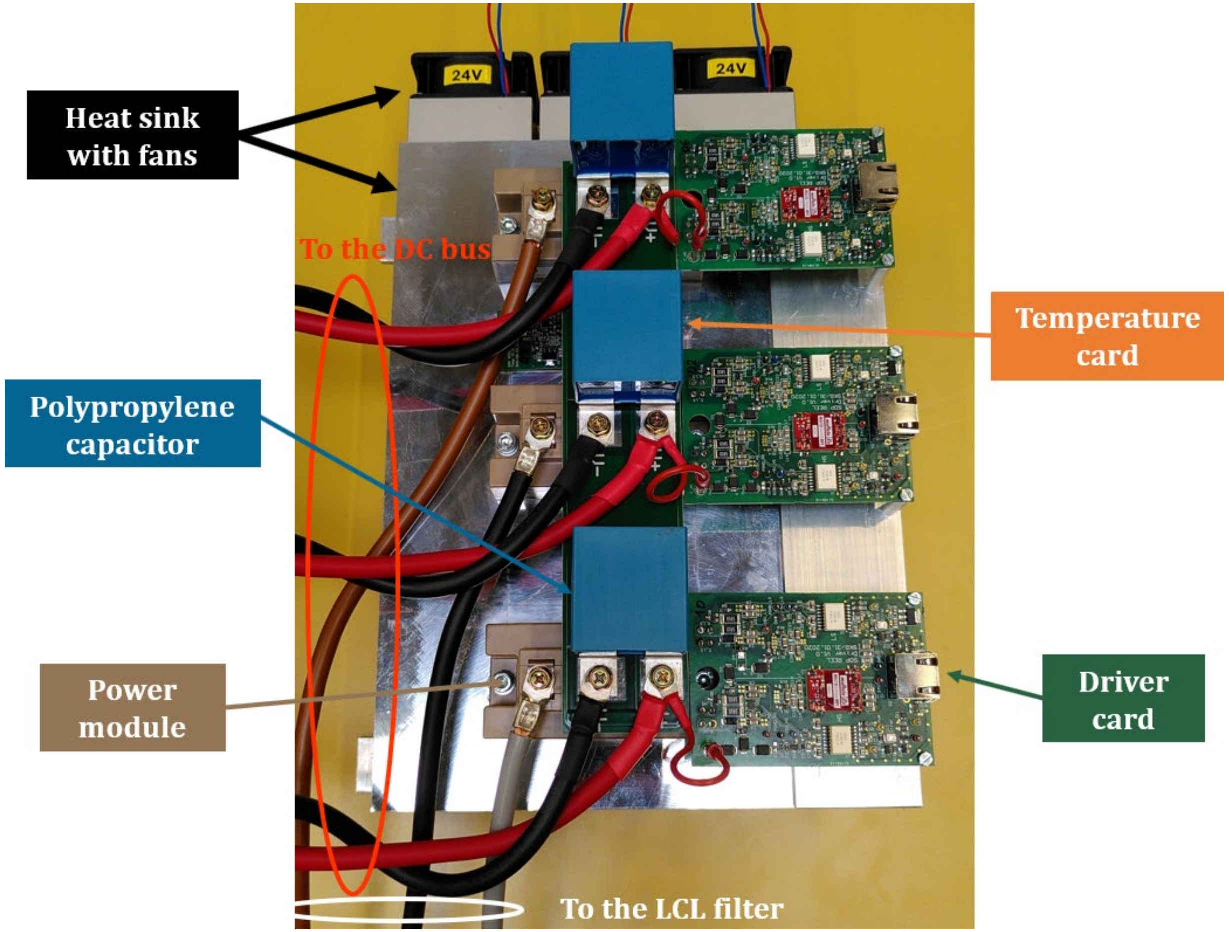


- State space model: linearized for small variations around steady state conditions



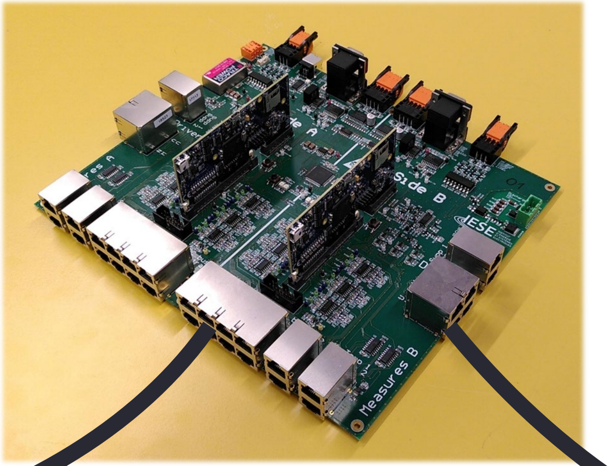
The 50 kVA prototype for Chapelle-sur-Moudon: Power circuit design

- Power modules (ref: 2MSI200VAB-120-53)
  2 IGBTs arm:
  $$\begin{cases} U_{nom} = 1200 \text{ V} \\ I_{nom} = 200 \text{ A} \end{cases}$$
- LCL filter optimised values:
  $$\begin{cases} L_{inverter} = 330 \ \mu\text{H} \\ C_{filter} = 47 \ \mu\text{F} \\ L_{grid} = 150 \ \mu\text{H} \end{cases}$$
- DC link:
  $$\begin{cases} C_{DCbus} = 23{,}1 \text{ mF} \\ U_{DCbus_{nom}} = 800 \text{ V} \end{cases}$$

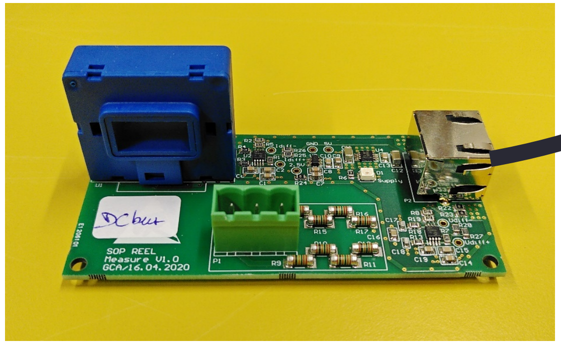


SOP REEL inverter

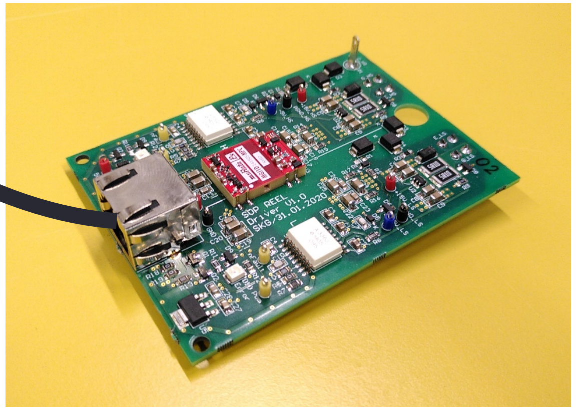
The 50 kVA prototype for Chapelle-sur-Moudon: Control circuit design



Control card



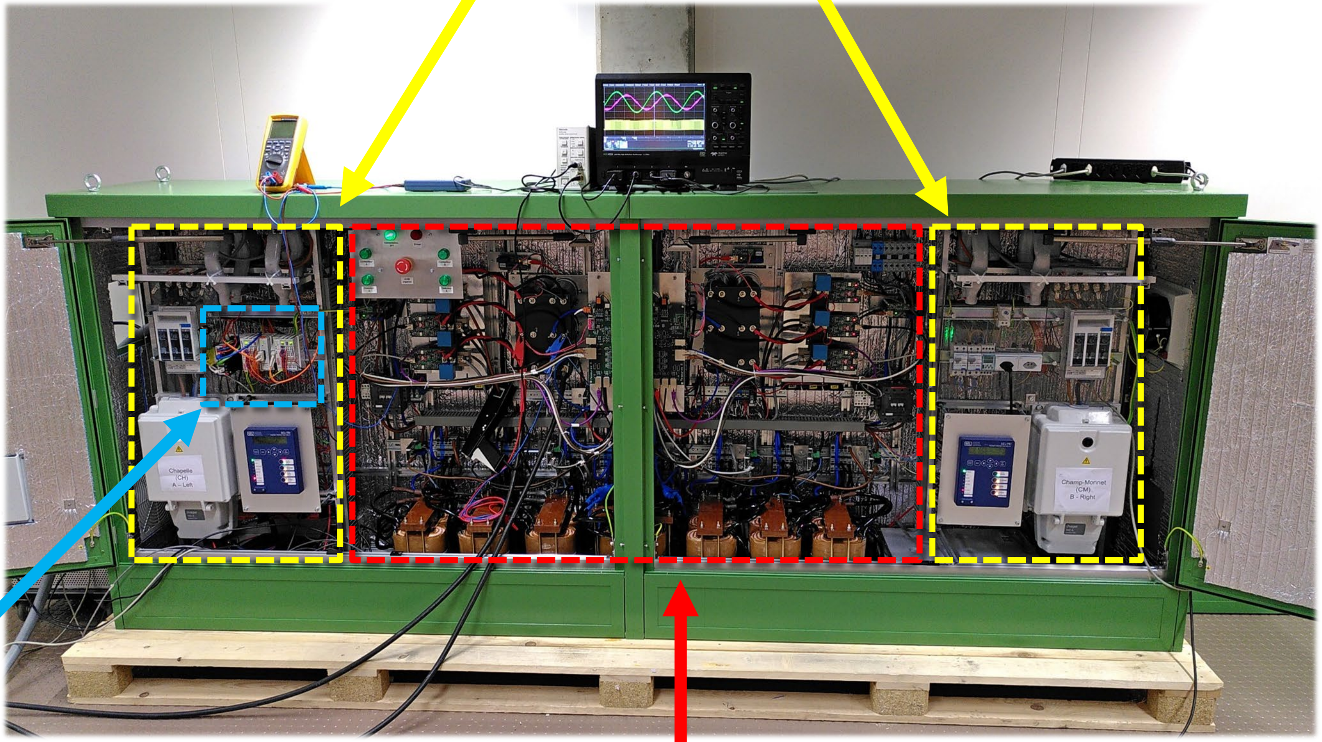
Voltage/current measurement card



IGBT driver card

The 50 kVA prototype for Chapelle-sur-Moudon: Cupboard layout

SOP power section and protections



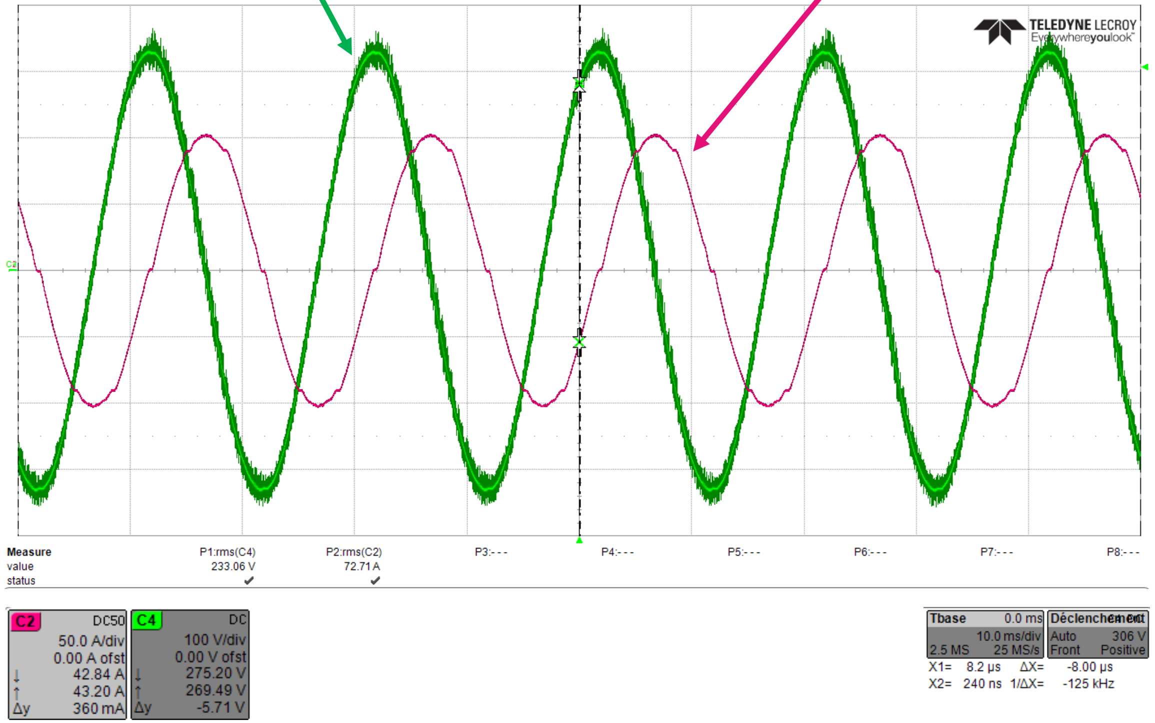
The 50 kVA prototype for Chapelle-sur-Moudon: Laboratory preliminary tests (state at 26.10.2020)

- One inverter was tested alone on a grid emulator in ReIne laboratory.
  (Emulator: Regatron TC.ACS.50.528.4WR.S.L.C)

- Prototype on site installation : end of 2020

Grid phase voltage
230 V_{rms}

Grid phase current
72,7 A_{rms}



Inverter phase voltage and current.
49 kVar capacitive reactive power

Conclusions

- The design and the realisation phase of a 50 kVA SOP prototype are finishing by the end of 2020.
- The on site tests will start at the beginning of 2021.
- The 50 kVA prototype benefits from the system studies performed at HEIA-FR, the detailed simulation activities performed at HEIG-VD and the experience made with the first 15 kVA laboratory prototype developed by HEIG-VD in 2018 in the frame of SCCER-Furies.
- Aim of the on site tests is to validate the usefulness of the SOP at system level.

Thank you for your attention

This research is part of the activities of the Swiss Competence Centre for Energy Research on the Future Swiss Electrical Infrastructure (SCCER-FURIES), which is financially supported by the Swiss Innovation Agency (Innosuisse - SCCER program).