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Soft Open Point prototype demonstration in a low voltage network: Control, protection and communication

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Background

A soft-open point (SOP) has been designed, assembled and is planned to be deployed to Romande Energie's Chapelle-sur-Moudon LV network by the end of 2020. The 50 kVA SOP connects both LV networks fed by two distribution transformers. The project has included the design and testing of the SOP hardware, the integration into the existing network (including protection) and the design of suitable control modes.

Control

The control system of the SOP is composed of 3 different algorithms: TRABA, VOLTSAME and VSTB each using P and/or Q as control variable. An example of the TRABA voltage adjustment process can be seen in Fig.1.
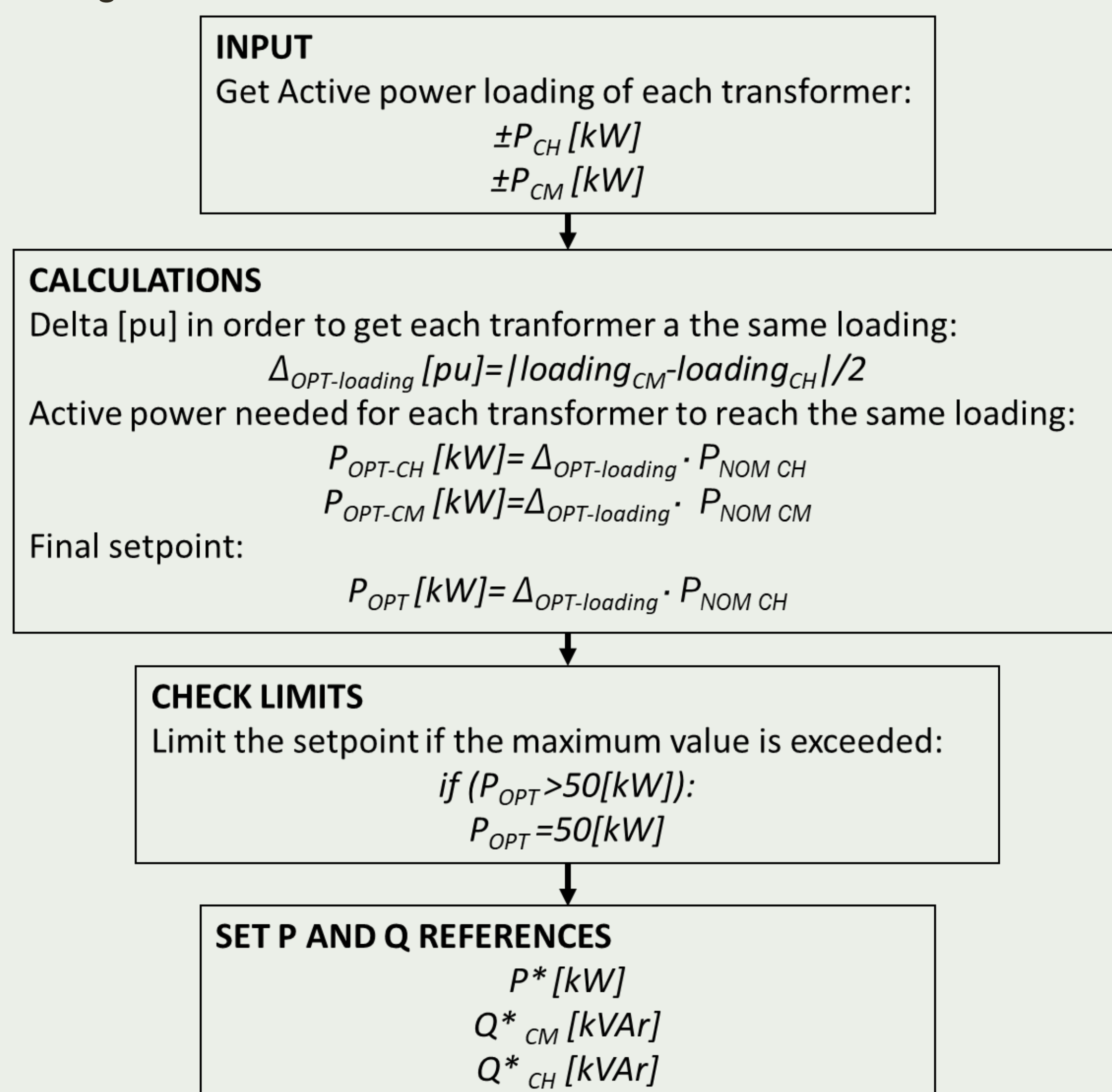
INPUT
Get Active power loading of each transformer:
$\pm P_{CH}$ [kW]
$\pm P_{CM}$ [kW]

CALCULATIONS
Delta [pu] in order to get each tranformer a the same loading:
$\Delta_{OPT-loading}$ [pu]=$|loading_{CM}-loading_{CH}|/2$
Active power needed for each transformer to reach the same loading:
P_{OPT-CH} [kW]= $\Delta_{OPT-loading} \cdot P_{NOM\ CH}$
P_{OPT-CM} [kW]=$\Delta_{OPT-loading} \cdot P_{NOM\ CM}$
Final setpoint:
P_{OPT} [kW]= $\Delta_{OPT-loading} \cdot P_{NOM\ CH}$

CHECK LIMITS
Limit the setpoint if the maximum value is exceeded:
if (P_{OPT}>50[kW]):
P_{OPT} =50[kW]

SET P AND Q REFERENCES
P^* [kW]
Q^*_{CM} [kVAr]
Q^*_{CH} [kVAr]

Fig.1 TRABA algorithm process

Fig.2 shows the result of the simulation, for the TRABA mode: The power of the 2 transformers is brought to equal power over the whole day.
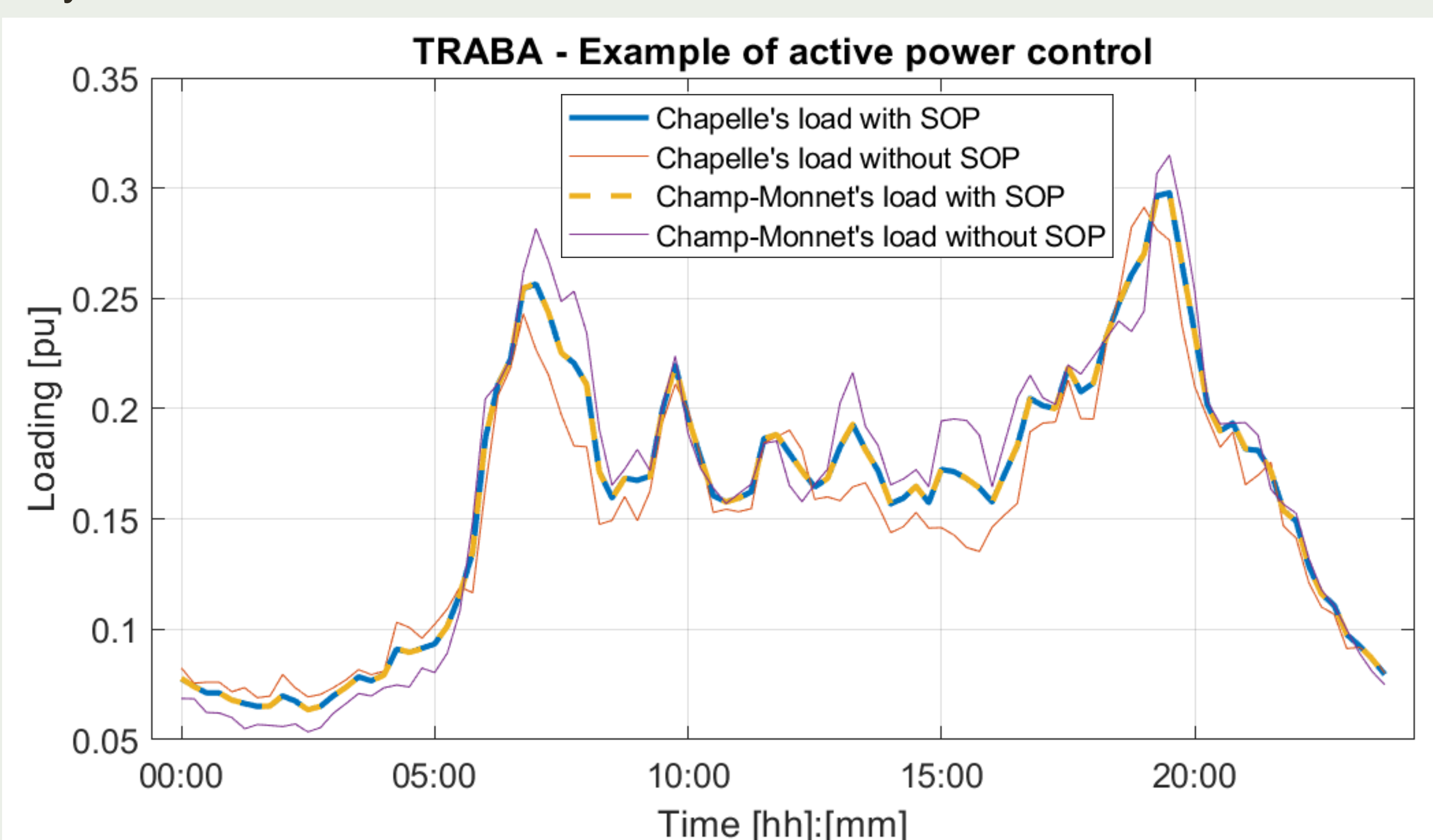
Protection

SOP protection is achieved using multiple devices (IED's). Two IED's for the feeder station, and two for the SOP. Fig.3 shows the schematic of the protection devices with the configured protection logics.
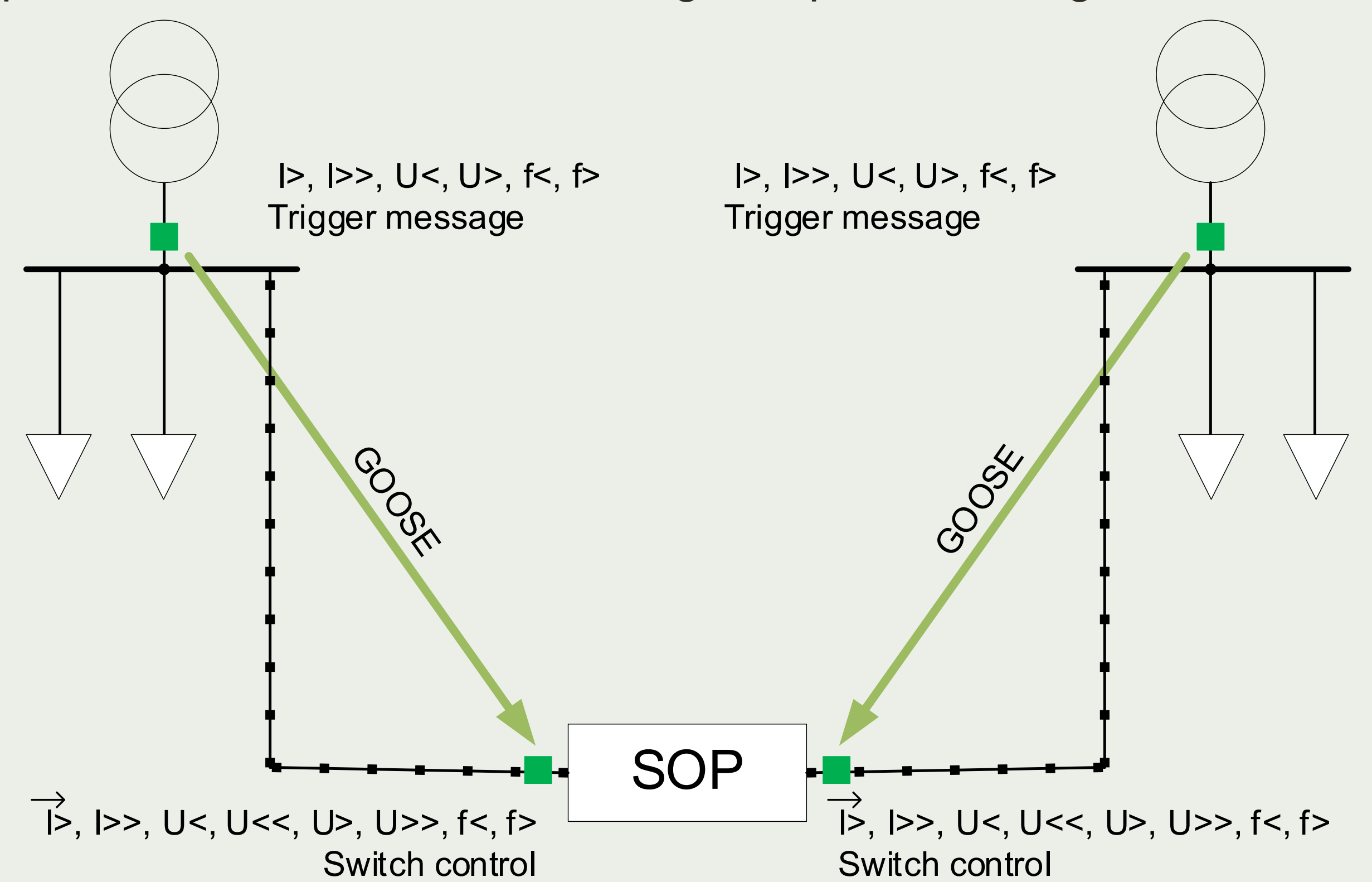

Fig.3 Protection scheme

The coordination among IED's is achieved using GOOSE messages over a radio link. The relays are also capable to provide measurements for the control system via Modbus, using the same communication link.
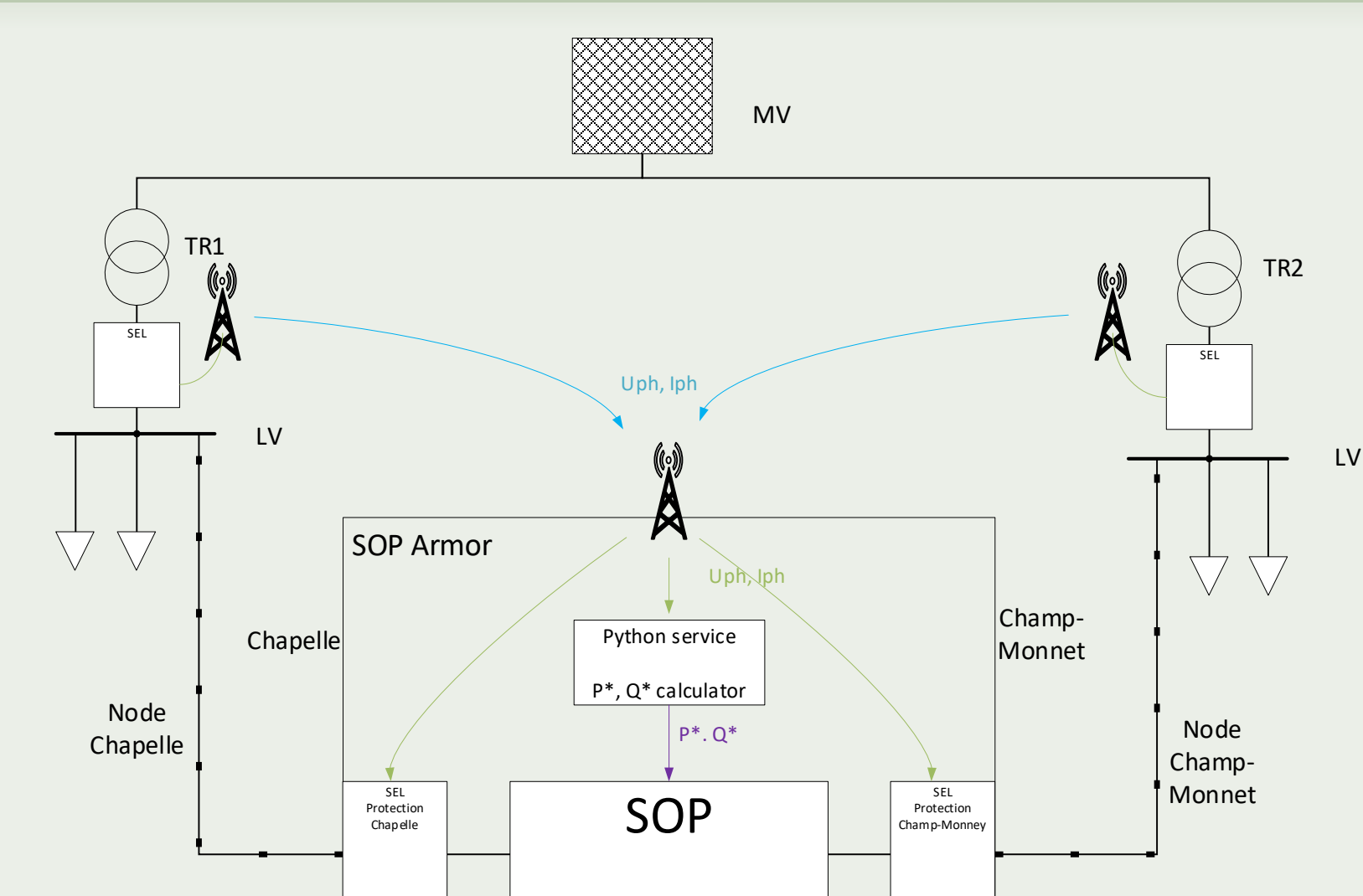
Communication

Fig.4 System communication

One of the requirements for the SOP protection and control system is to have a fail-safe way to detect a fault condition. No communication (wired internet) is pre-existing at either the SOP location or the transformer stations. Cellular networks cannot reach the guaranteed transmission times required and it is impossible to send UDP traffic to fixed IP Addresses in the public 4G network available at the site. Therefore, a system using a radio link for the transmission of IEC 61850 traffic between the measurement points at the transformer stations and the SOP was selected. The trip signals of the protection relays are operating the breakers located at the SOP terminals as illustrated in Figure 6. The SOP protection does not interfere with the LV system protection in place, which is relying on fuses. These fuses still interrupt faults on the LV feeders in the same way as before the addition of the SOP.

Upcoming activities

• Deployment of SOP in the Chapelle-sur-Moudon network
• Validation of the SOP's prototype functionalities – Short term
• Analysis of SOP's long term impact on network quality