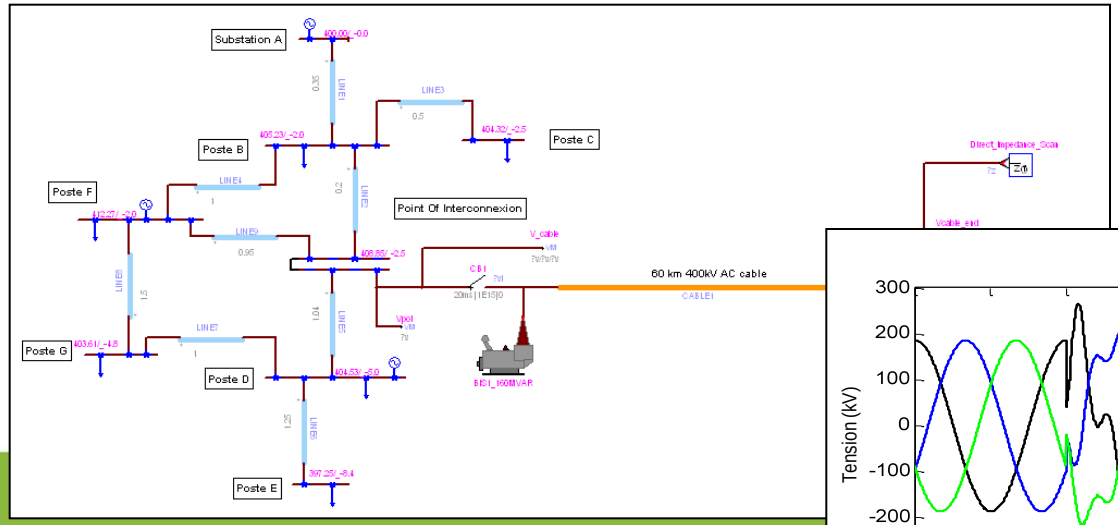
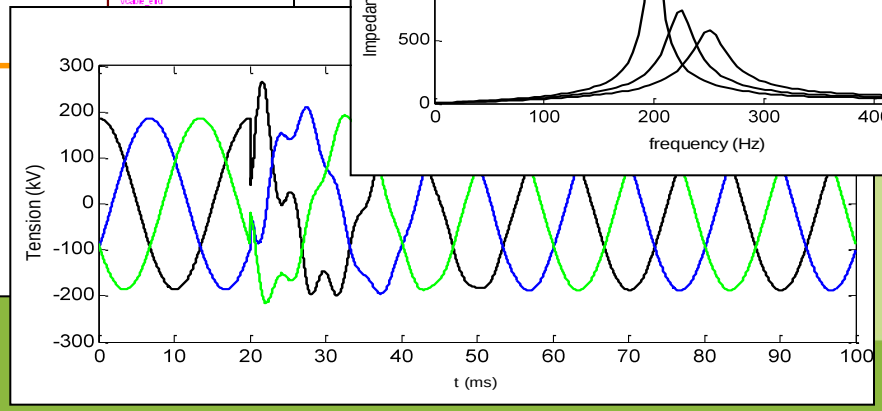
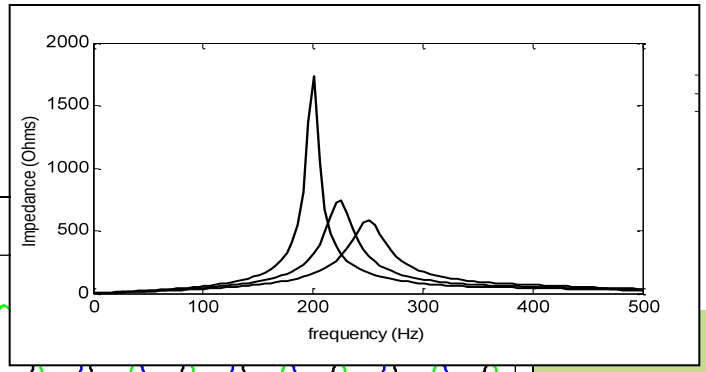
Réseau de transport d'électricité

EMTP RV
ElectroMagnetic Transients Program

EMTP STUDIES PERFORMED TO INSERT LONG AC CABLES IN THE FRENCH GRID







Simon DESCHANVRES
Yannick VERNAY
RTE, CNER, Substations Department

EMTP-RV Users Group
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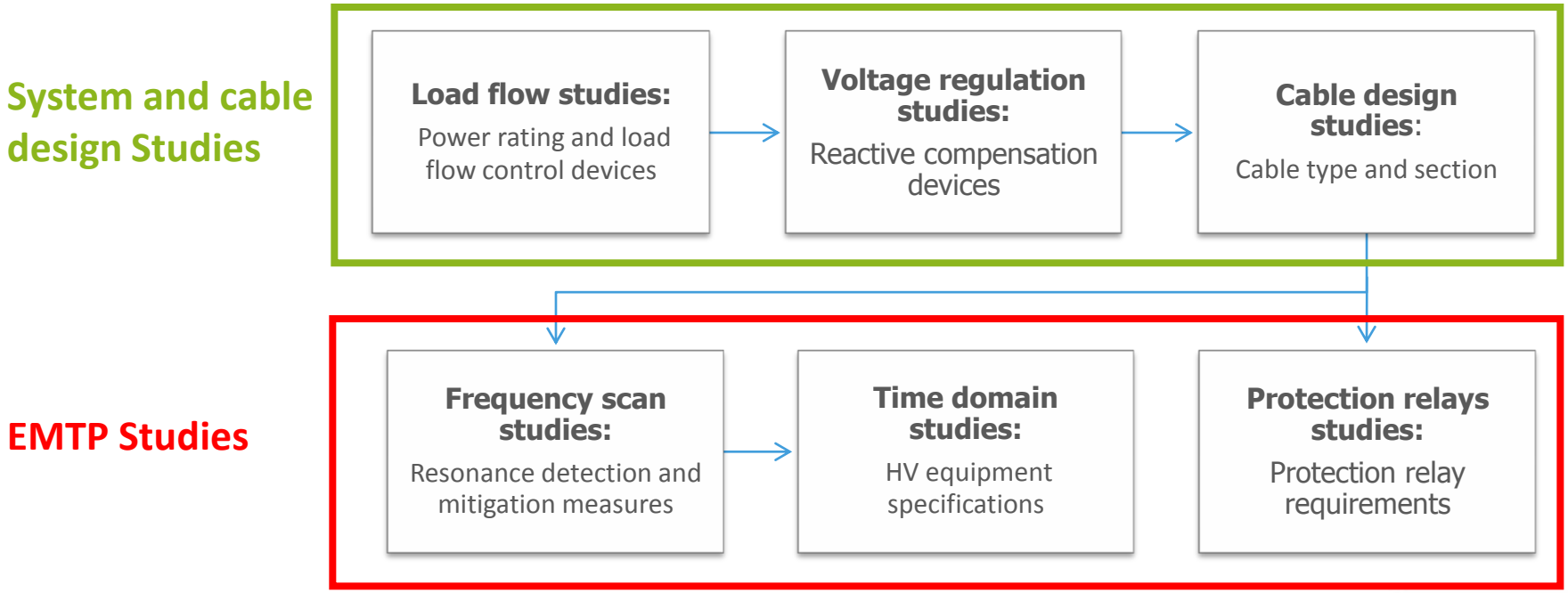
Long HVAC Cable : New solutions of transmission on the French grid

Insertion of long HVAC cable in the grid became an attractive solution... and leads to several questions :

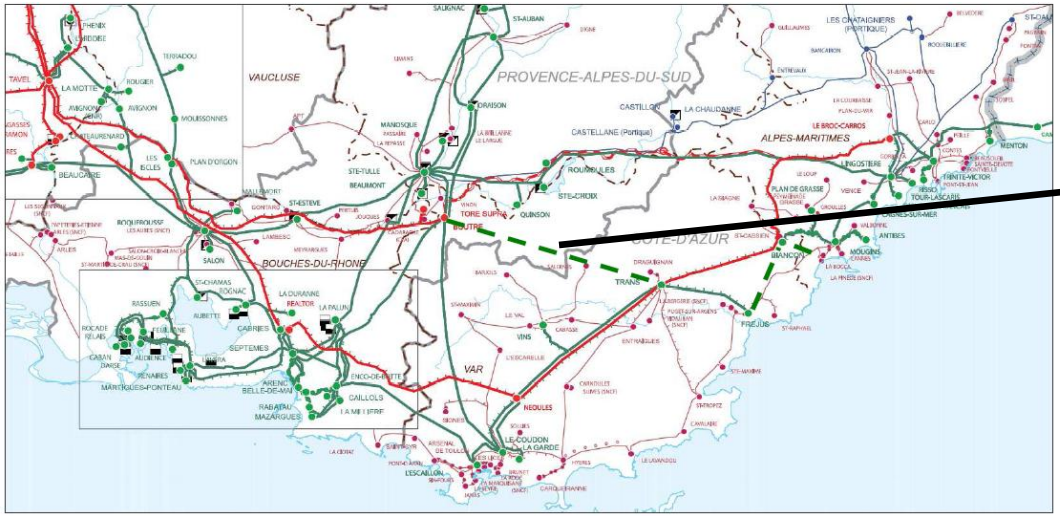
- Series compensation ?
- Shunt compensation ?
- Substation equipment specifications ?
- Protection relay requirements ?

Electrical studies have to be conduced

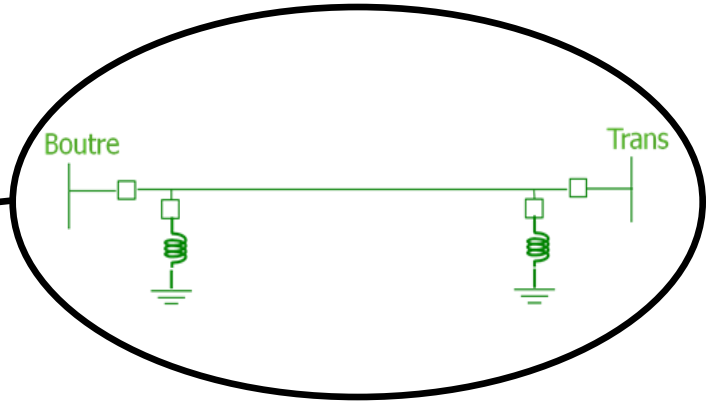


Project example : The Boutre Trans cable project

Study case: Insertion of a 225kV cable in the South East of France



Insertion of the Boutre Trans cable in the grid of the South East of France



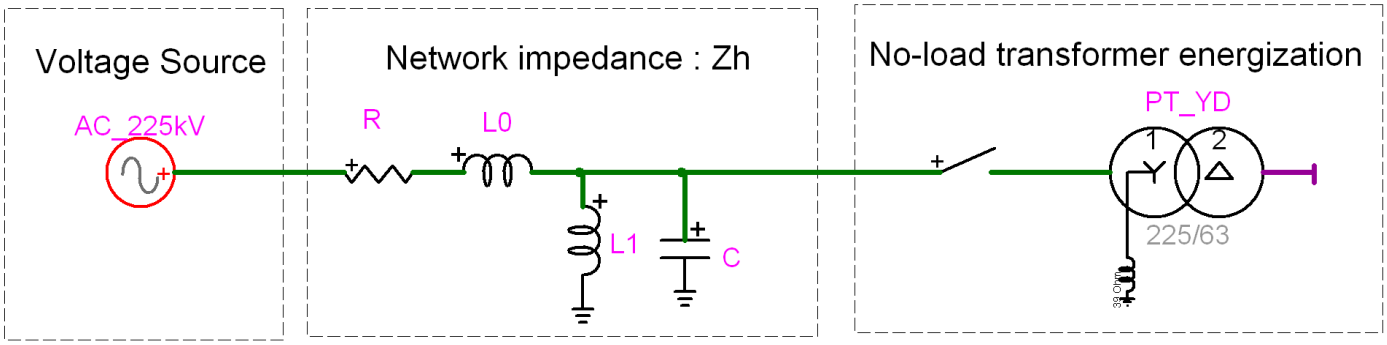
- **Long cable** : 66 km
- **Shunt compensation** : 2 shunt reactors of 80 MVAR at cable ends to reduce the capacitive effect

Insertion of a long HVAC cable in a meshed network based mainly on overhead lines → A new study case for RTE

Frequency Scan Studies – Why?

Problem : Insertion of a capacitive element (long HVAC cable) in a network mainly inductive

Need to detect possible adverse resonances of the network with a low harmonic current source



Time domain studies for transformer energization → Great time consuming:

- Long time phenomena (~ 5s)
- Variation of time closing of the transformer circuit breaker
- Variation of the residual fluxes of transformer.
- EMTP model of the transformer studied (air core inductance)

Need to detect the dangerous topologies in a time constrained project with:

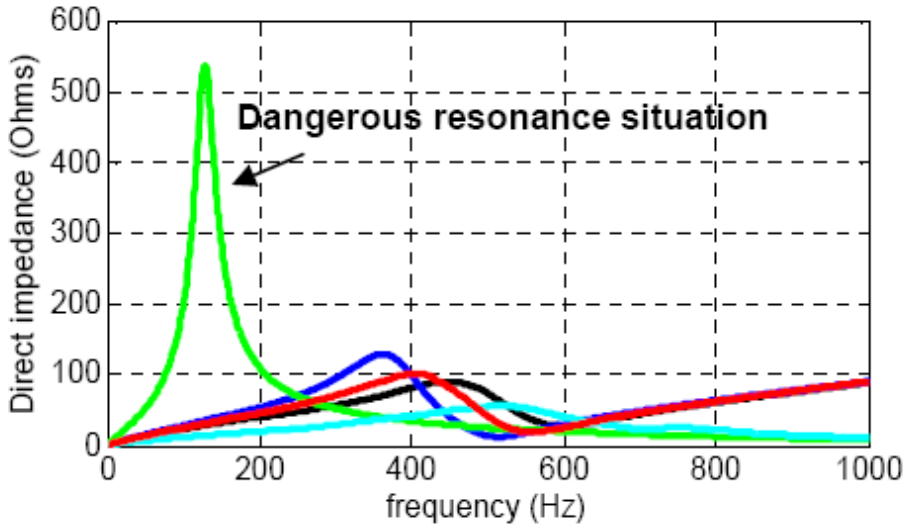
→Frequency Scan Studies

→Harmonic criterion

Frequency Scan Studies – Network model

Observation of low frequency phenomena (from 50 to 2kHz) → Need to model a great part of the network

Various network topologies are analyzed : bus bar connection, transformer out of service, line out of service (≈ 200 networks topologies studied for an insertion cable project)



Harmonic impedance at connection point depending of the network connections

Large network model and various network topologies → Opportunity to import data from system tools

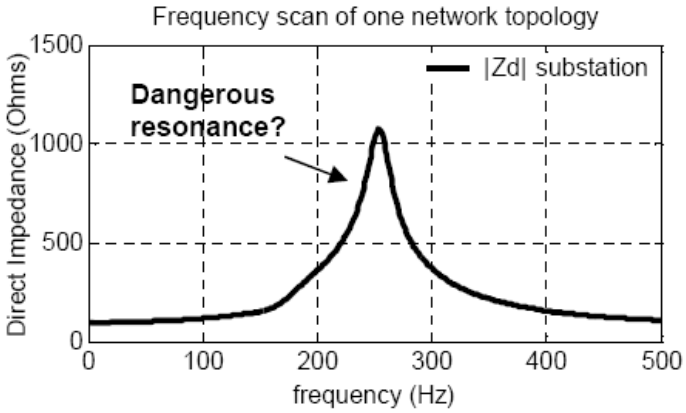
Frequency Scan Studies – Result analysis

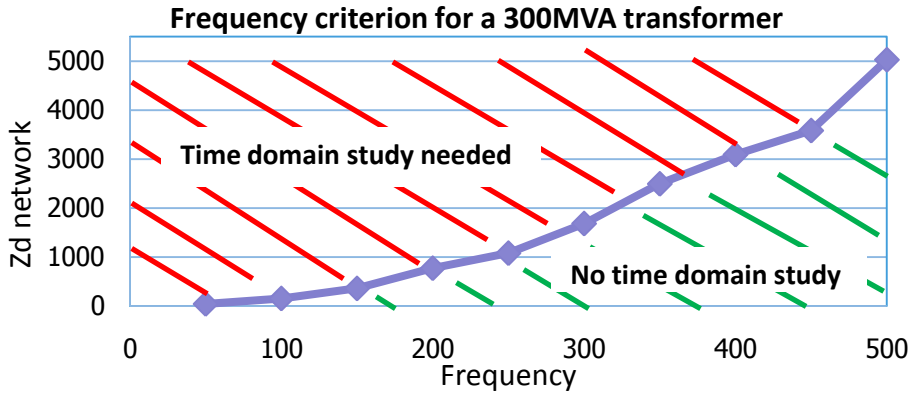
Need of an harmonic frequency criterion to limit the number of time domain studies in meshed and loaded network

Definition of a criterion based on the harmonic current generated by the transformer during his energisation:

$$\Delta V \simeq \max \left| z_h . i_h \right|$$

h : harmonic range



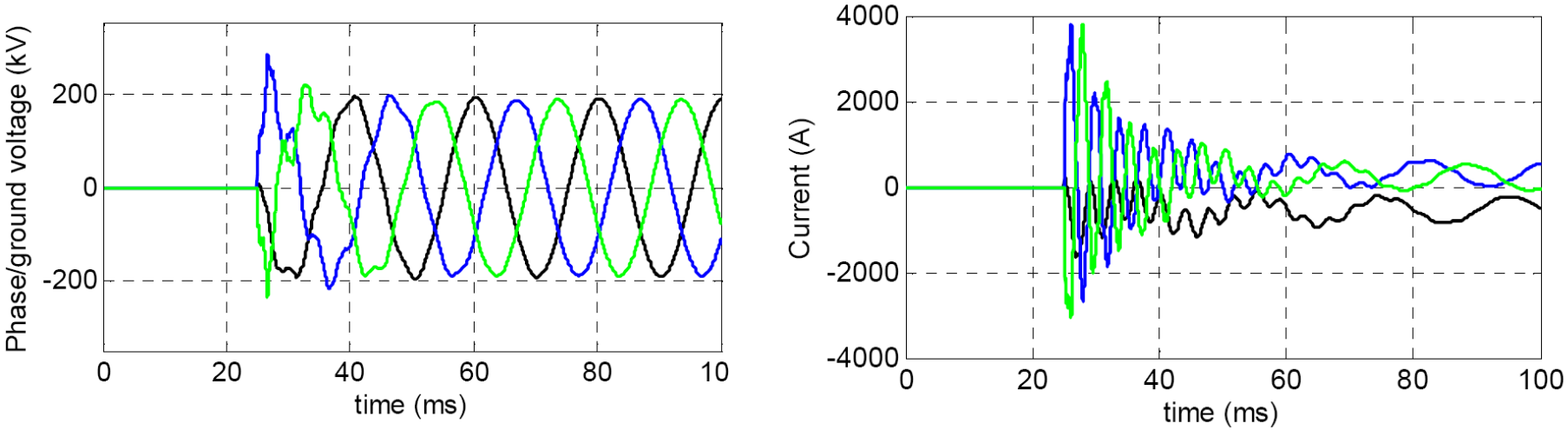


Comparison of a Frequency Scan with the criterion

Time saving to detect a potential dangerous resonance situation for transformer energization.

Time domain Studies – Unload cable energization

Energization of the cable can lead to **slow front overvoltages** and **high inrush currents.**



Voltage and current in the cable during energization

A statistical approach is used to find the most severe situation:

→Variation of CB time closing on 1 period (400 simulations on 1 period)

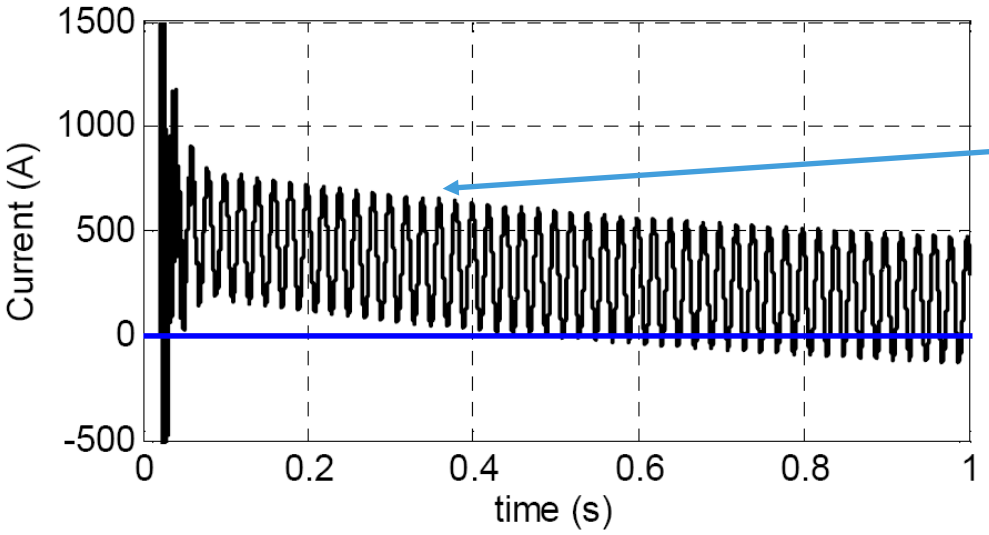
→ Variation of time disparities between CB poles (~ 5 ms)

Boutre Trans project : No excessive transient overvoltages or inrush currents compared to the insulation specification of the cable and substation equipments

Time domain Studies – Zero miss effect, Phenomenon

When one cable is energized with its compensation, the CB see the DC transient current component of the reactor inrush current

Compensation rate > 50% ⇨ The current is not crossing zero during several cycles : **Zero Miss Effect**



Current in the CB after cable energization

The damping of the DC component will depend of the losses of the system (shunt reactor, cable, network)

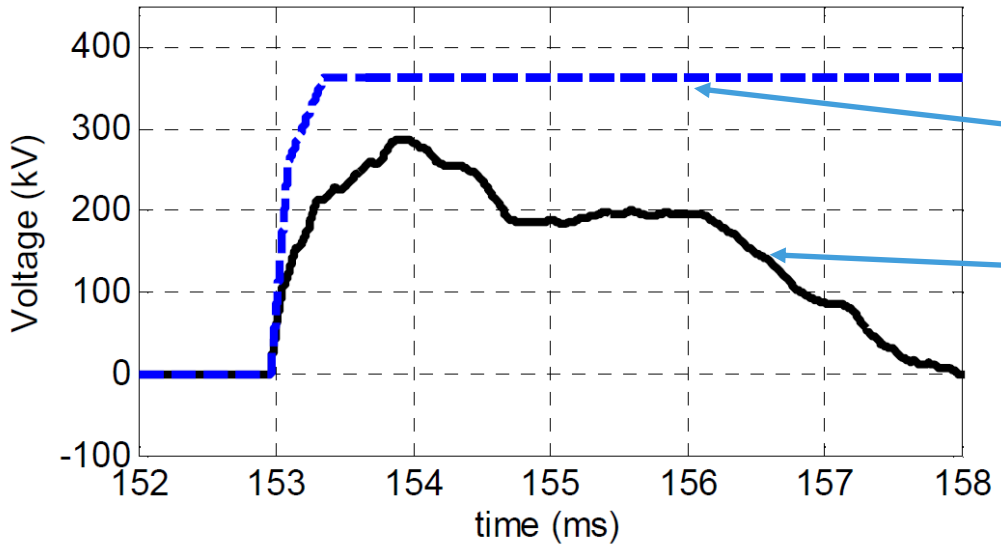
Risk : Failure of the CB in case open/close/open operation (protection relay error, one-phase ground fault, human error..)

In Boutre Trans project the compensation rate is about 60%. Mitigation techniques have to be investigated

Time domain Studies – Ground fault clearing

When clearing a fault, **TRV (=Transient Recovery Voltage)** appears between the terminals of CB.

Cable ground faults (3-phase and 1-phase) have been simulated at each 25% of the cable to check the duty of the CB.



IEC Standard for 225kV CB

TRV waveform for a 3-phase to ground fault

Slow front, high amplitude TRV waveform.
In Boutre Trans project, TRV keeps under the IEC standards

Conclusions

HVAC cables have different characteristics from overhead lines:

- Strong capacitive effect
- Interaction with additional devices (Shunt reactor, Series reactor, Phase shifting transformer..)
- High voltage and current transients

Electrical studies have to be conduced deeper than for HVAC overhead lines

Electromagnetic transients generated by the cable raises a lot of new technical questions for RTE that have to be answered with EMTP Studies

Interaction of those different studies show the need to have a study methodology dedicated to the cable insertion study (actual work of the CIGRE WG C4.502) and to develop tool for network data exchange.