*Building **better energy** together*

WELCOME

Nuclear New Build

Constant Terminal Voltage Workgroup

Workgroup – EDF investigation results

Hervé MELJAC

19-09-2014

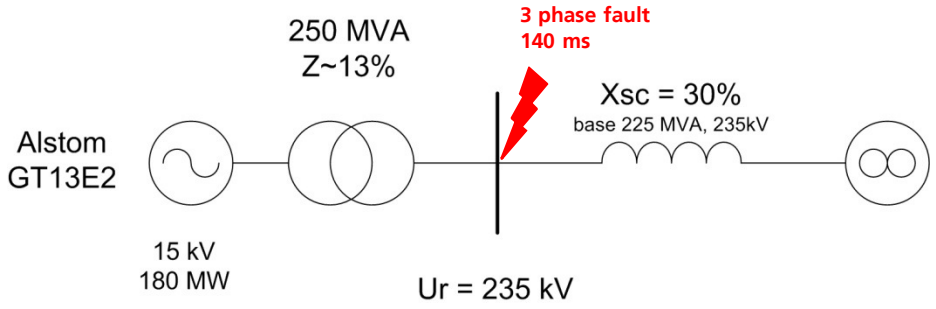
Objective and tools

- Objective:
  - Illustrate the impact on resilience to grid faults of moving in the UQ diagram by changing terminal voltage instead of changing main transformer taps.

- Tools:
  - Eurostag 4.3
  - Single machine study
  - Two different machines considered

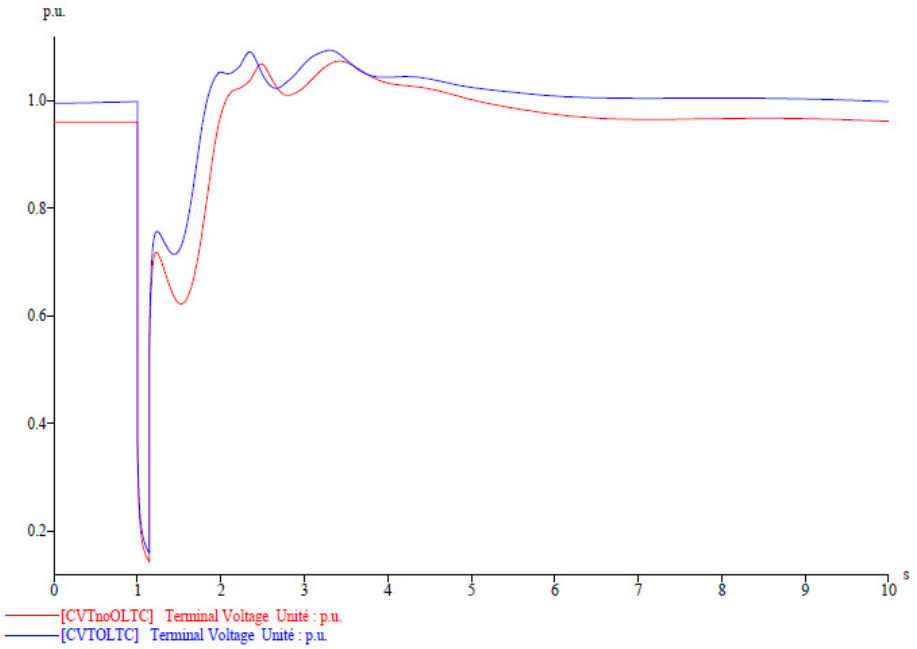
CASE 1: 180MW Open Cycle Gas Turbine

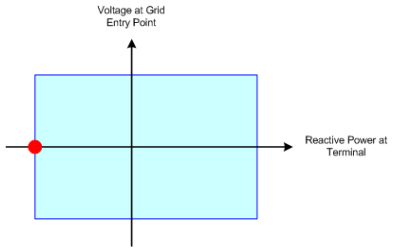
Brief model description

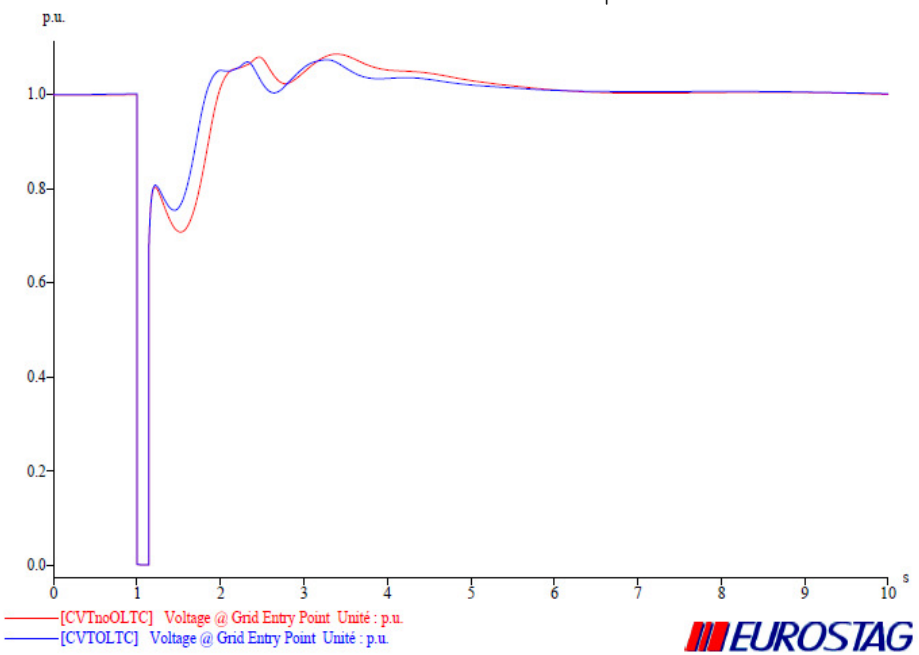


- Equivalent grid model (X_{SC} = 30% base 225MVA, 235kV):
  - S_{SC} = 750 MVA
  - I_{SC} = 1.84 kA
- Alstom GT13E2 open cycle gas turbine with:
  - 225 MVA, pf 0.8, 15kV, 3000rpm generator
  - static excitation – ceiling factor 1.6

Case 1.1: pf 0.95 lead







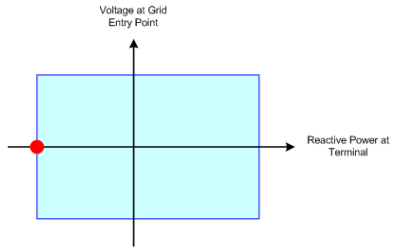
EUROSTAG

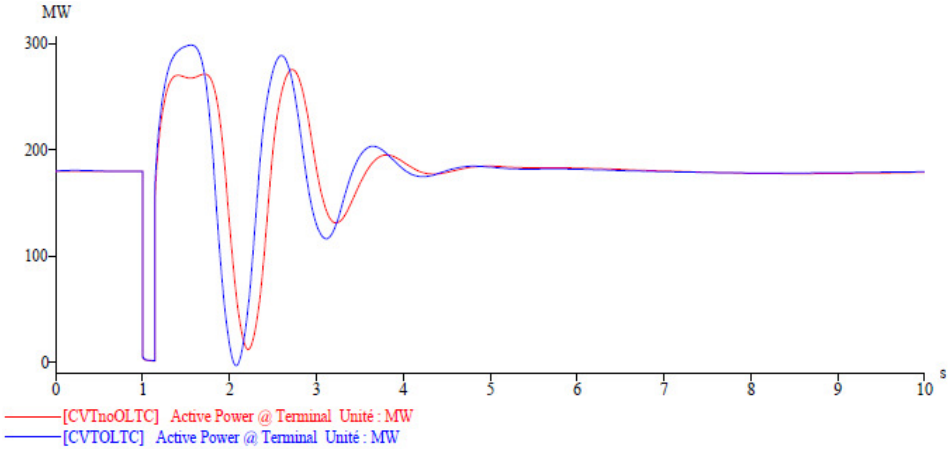
- Critical Fault Clearing Time:
  - With OLTC: 174 ms
  - Without OLTC: 158 ms

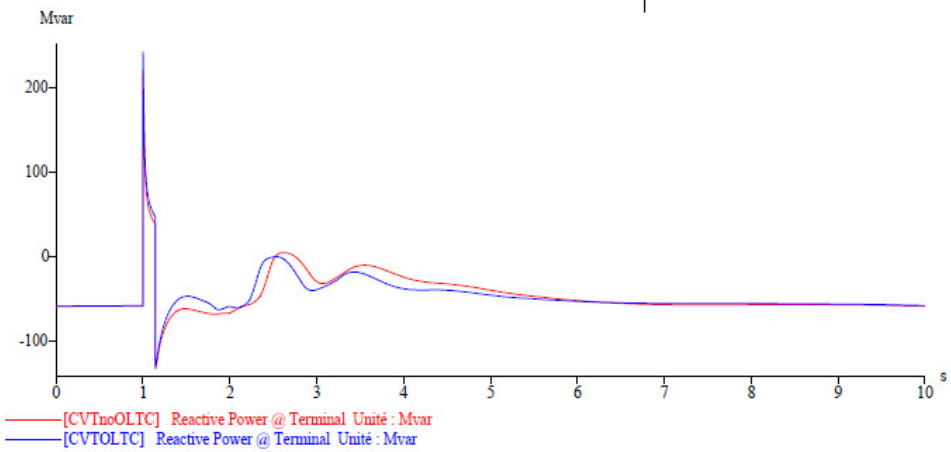
Better stability margin with OLTC

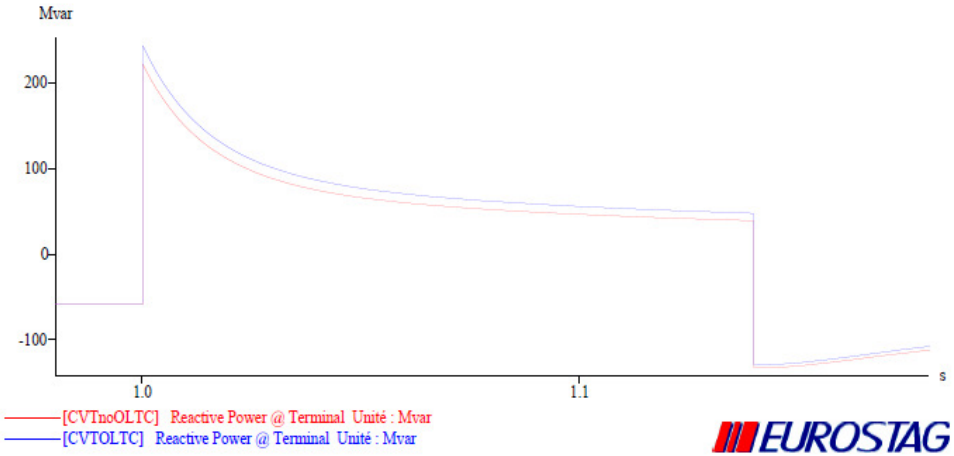
HPC EDF ENERGY

Case 1.1: pf 0.95 lead





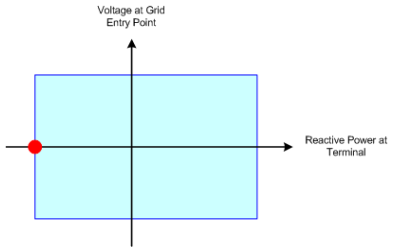


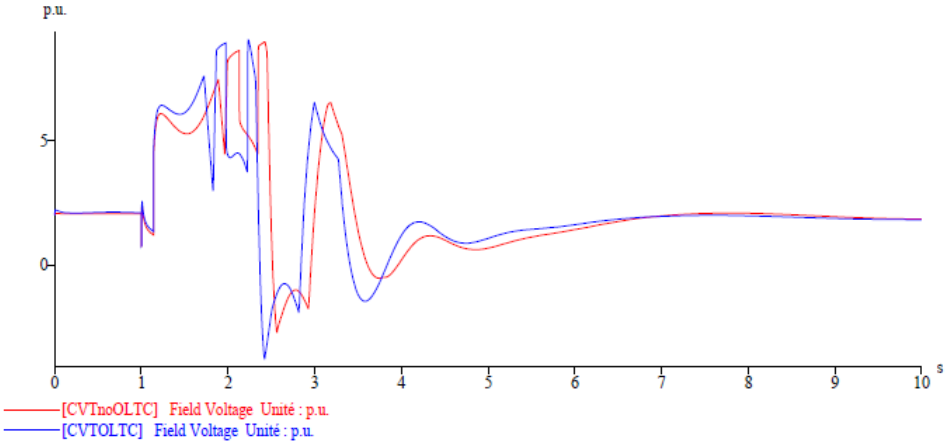


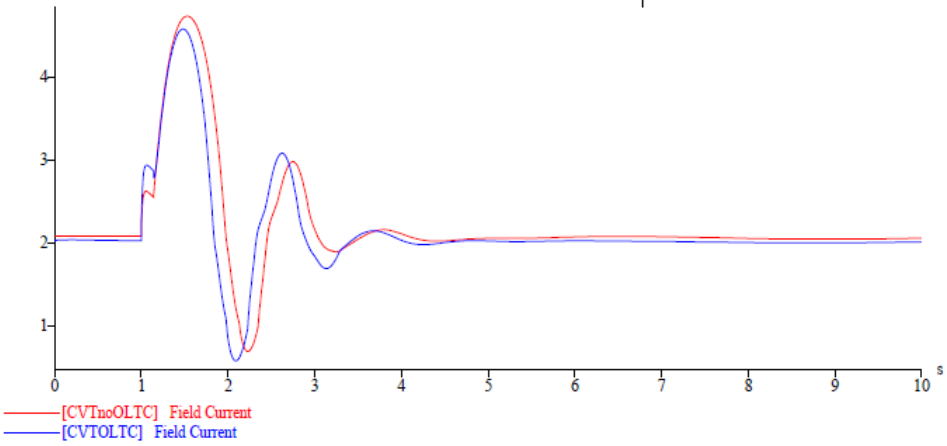
EUROSTAG

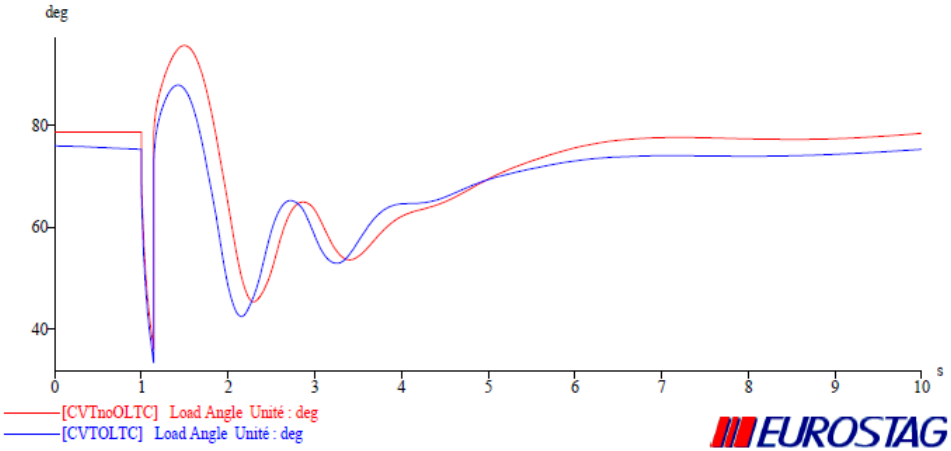
HPC
EDF ENERGY

Case 1.1: pf 0.95 lead





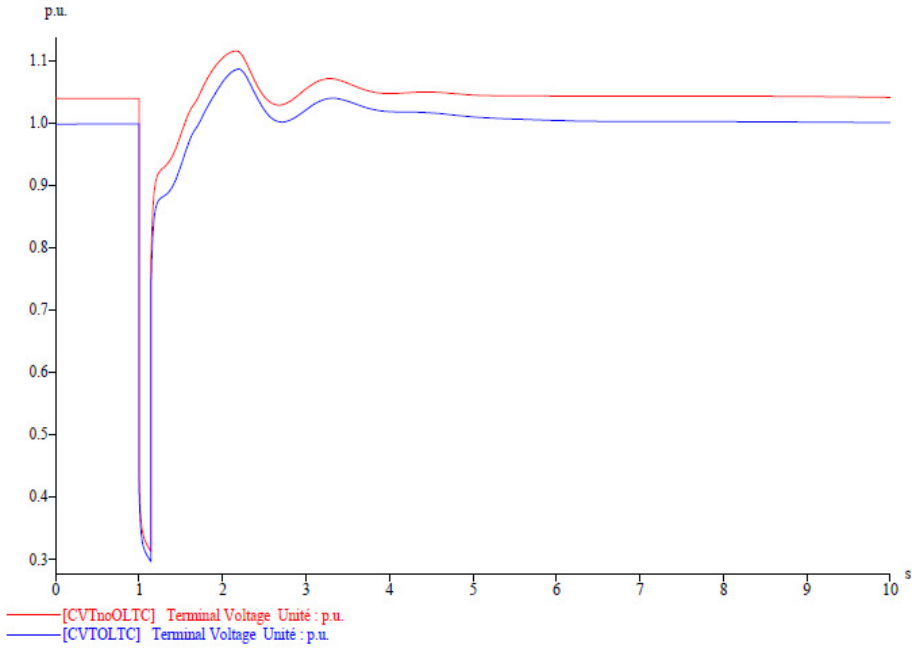


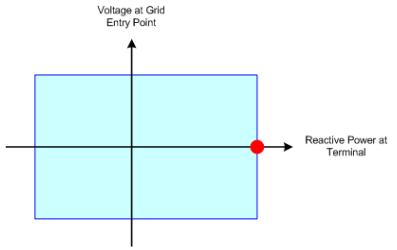


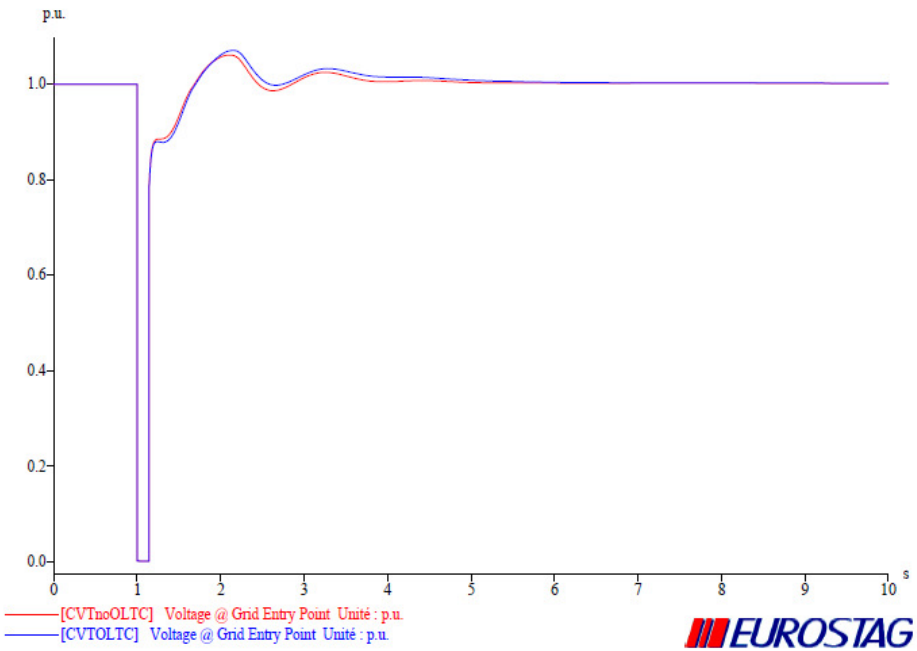
EUROSTAG

HPC EDF ENERGY

Case 1.2: pf 0.85 lag







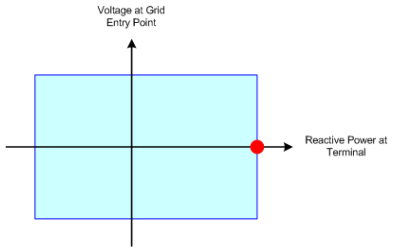
EUROSTAG

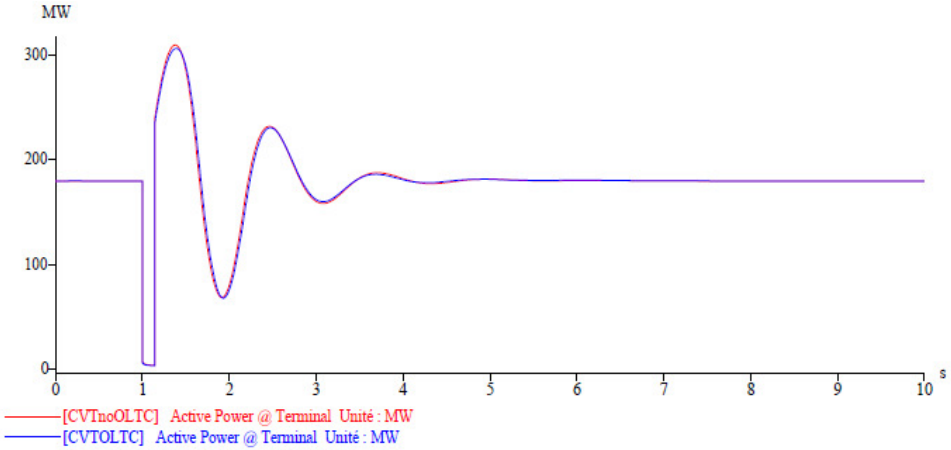
- Critical Fault Clearing Time:
  - With OLTC: 252 ms
  - Without OLTC: 261 ms

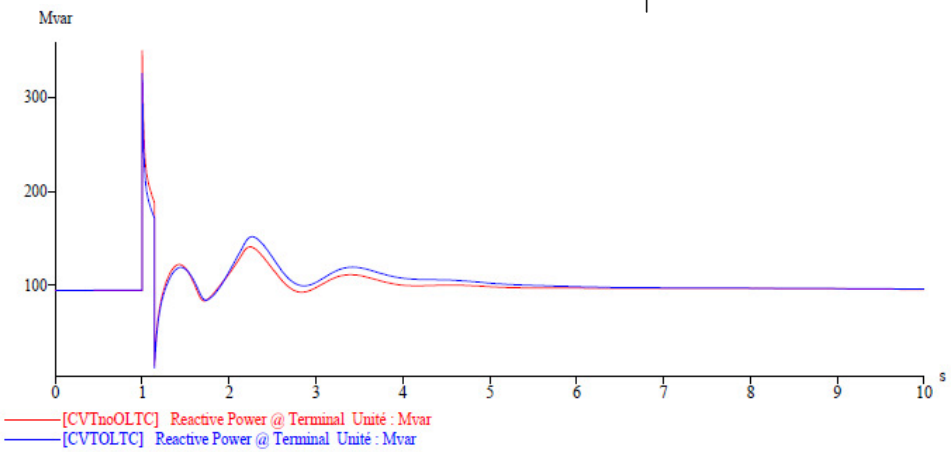
Better stability margin without OLTC

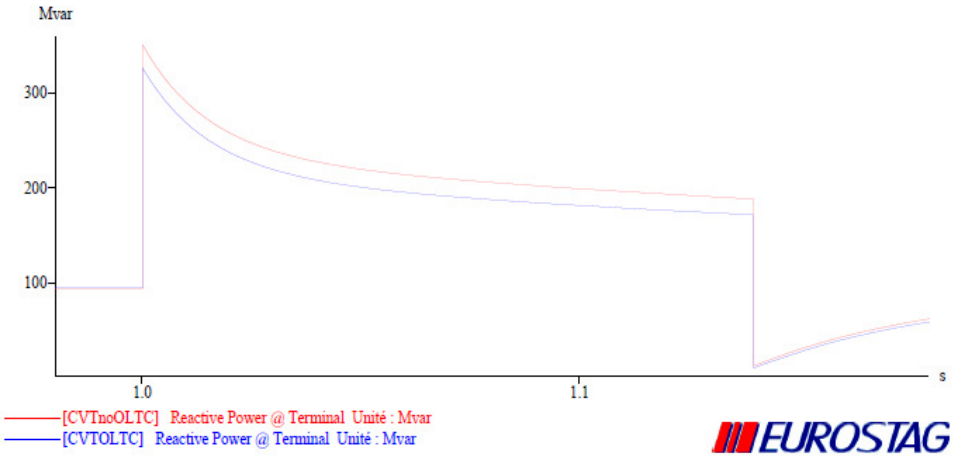
HPC EDF ENERGY

Case 1.2: pf 0.85 lag





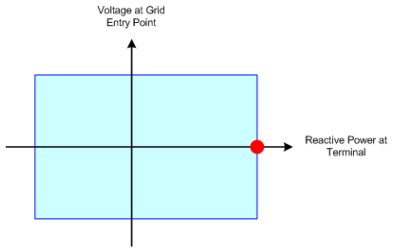


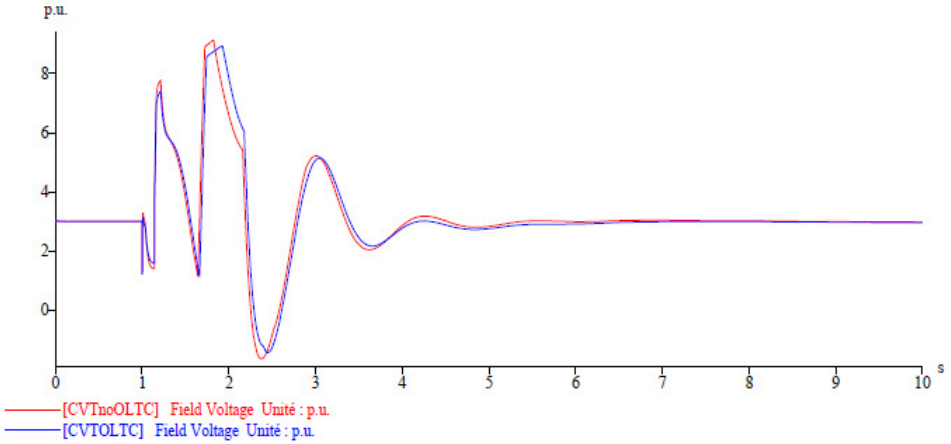


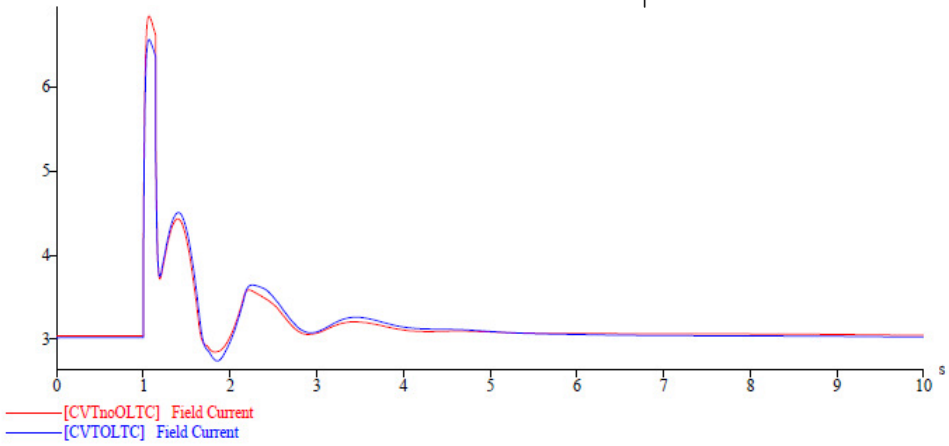
EUROSTAG

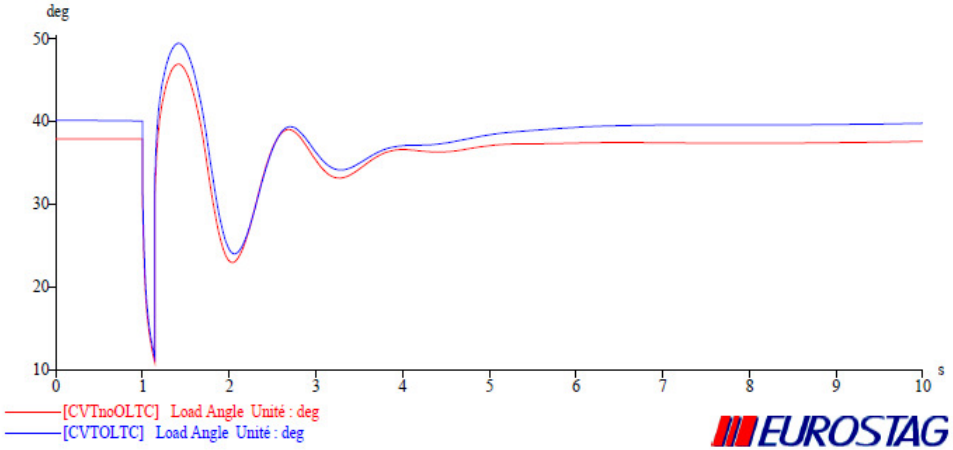
HPC
EDF ENERGY

Case 1.2: pf 0.85 lag









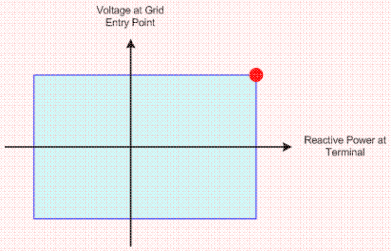
EUROSTAG

HPC EDF ENERGY

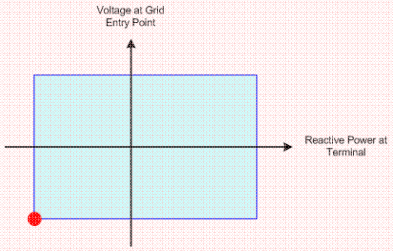
Case 1: other points investigated

Critical Fault Clearing Times

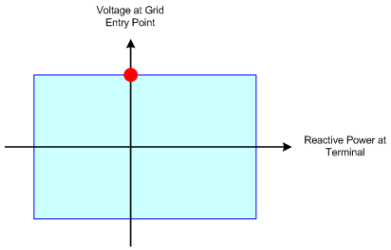
These points cannot be reached with nominal tap



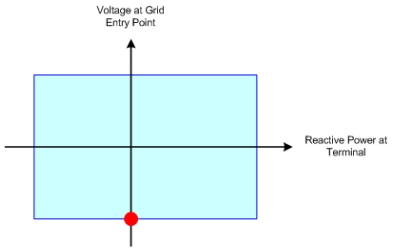
With OLTC: 260 ms
W/out OLTC: 273 ms



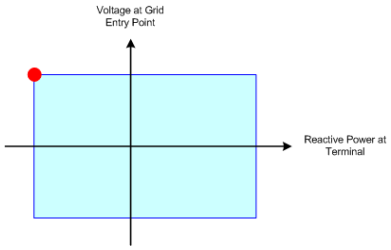
With OLTC: 165 ms
W/out OLTC: 142 ms



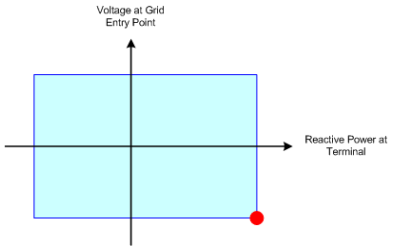
With OLTC: 227ms
W/out OLTC: 244 ms



With OLTC: 210 ms
W/out OLTC: 192 ms

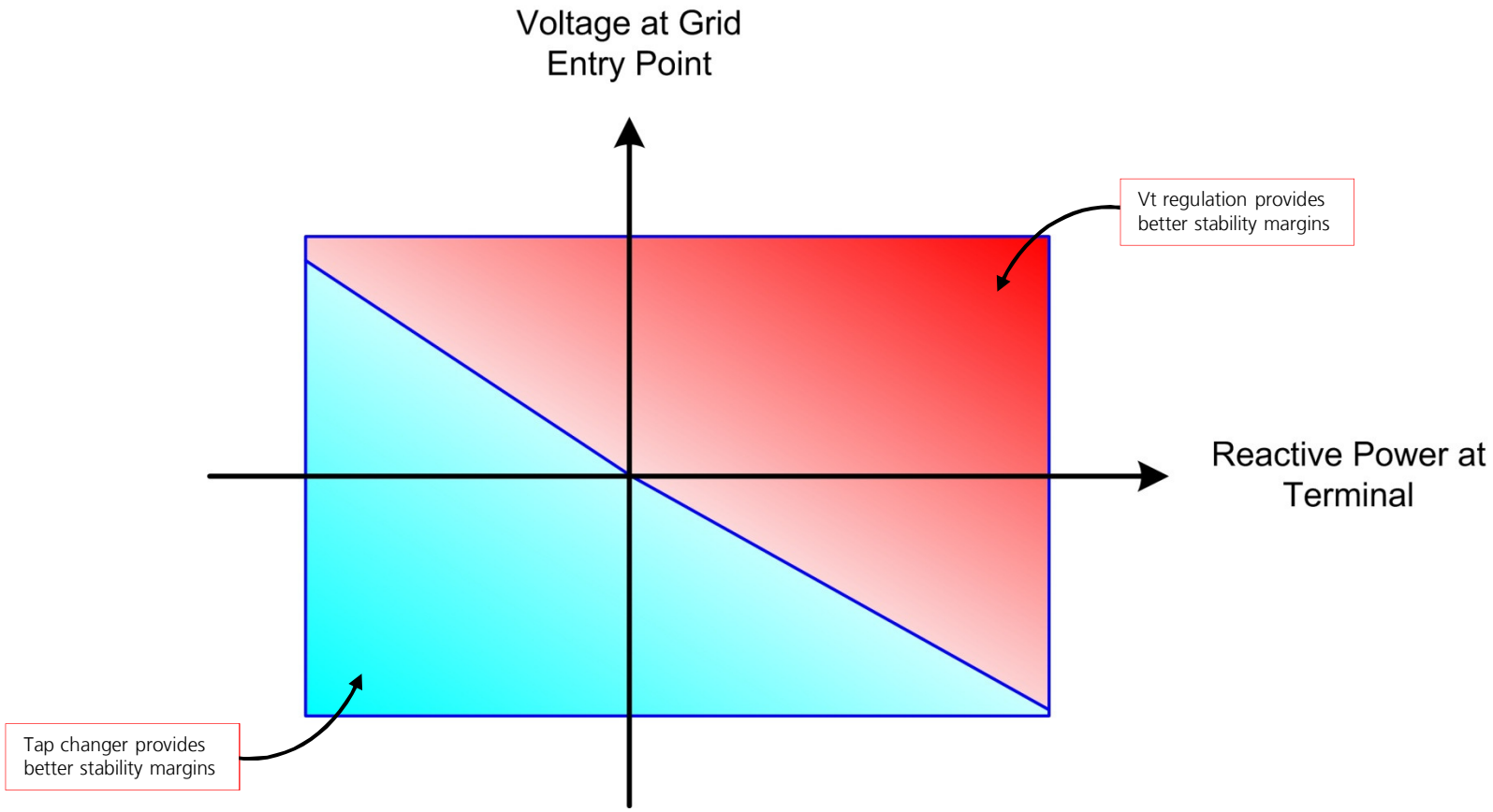


With OLTC: 180 ms
W/out OLTC: 186 ms



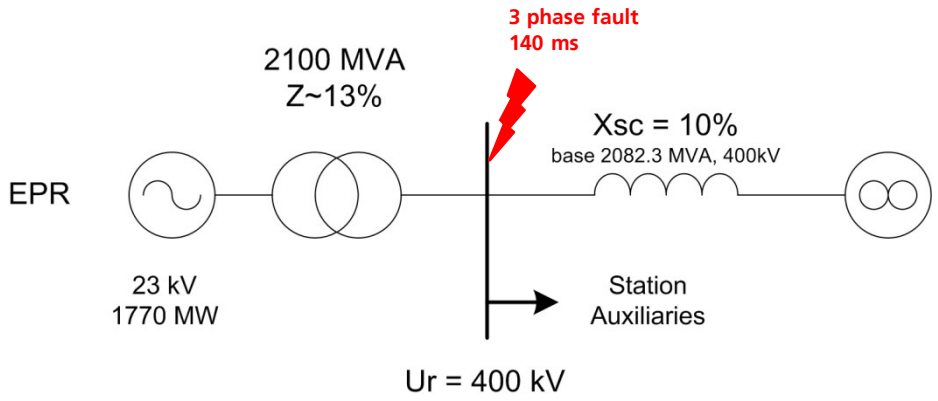
With OLTC: 240 ms
W/out OLTC: 239 ms

Case 1: Tap changer vs. Vt regulation



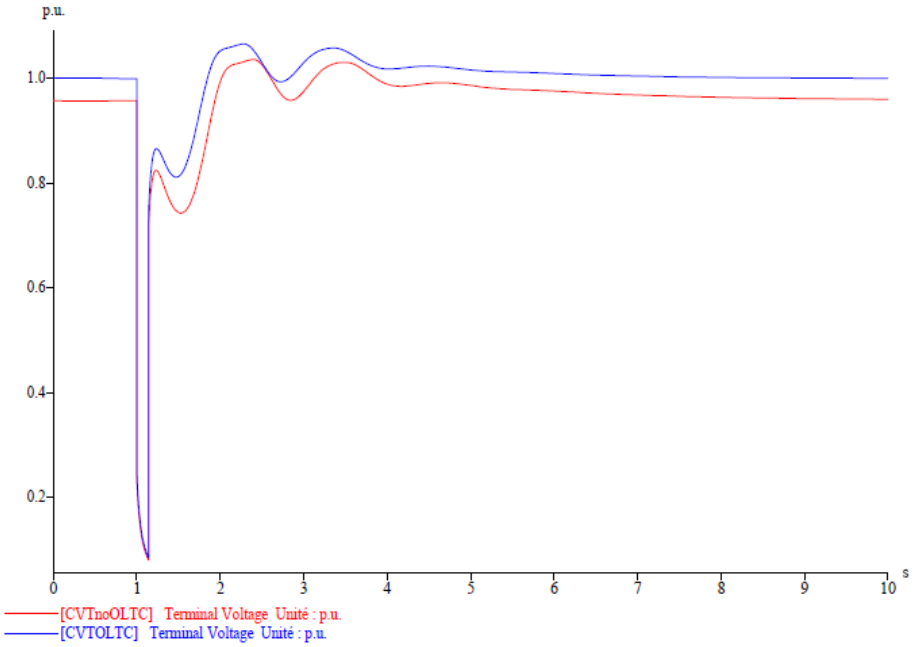
CASE 2: 1770MW Nuclear Power Plant

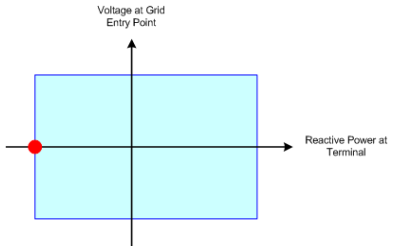
Brief model description

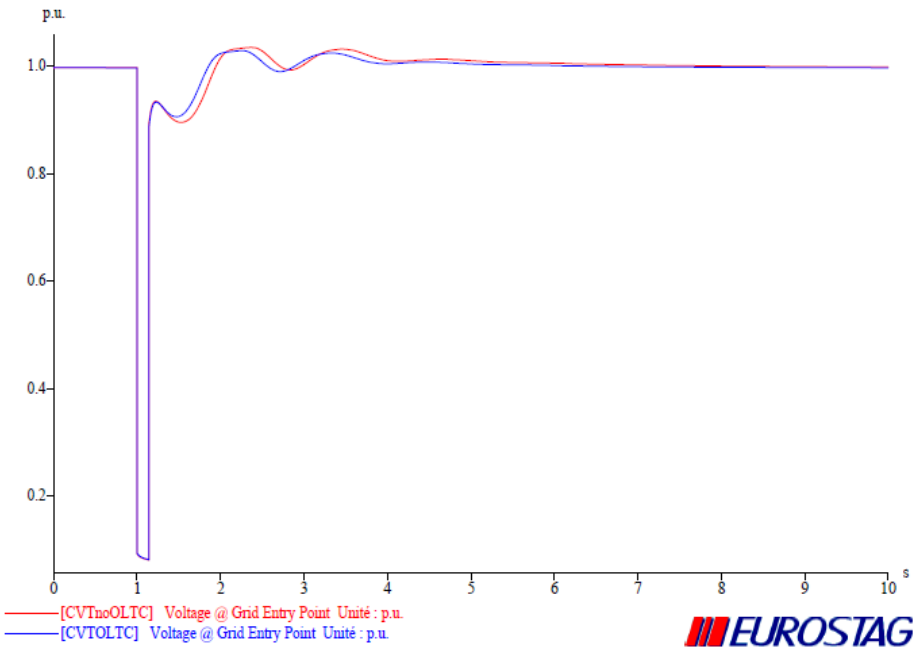


- Equivalent grid model (X_{SC} = 10% base 2082.3MVA, 400kV):
  - S_{SC} = 17.7 GVA
  - I_{SC} = 25.55 kA
- EPR with:
  - 2082.3 MVA, pf 0.85, 23kV, 1500rpm generator
  - brushless exciter – ceiling factor 2

Case 2.1: pf 0.95 lead







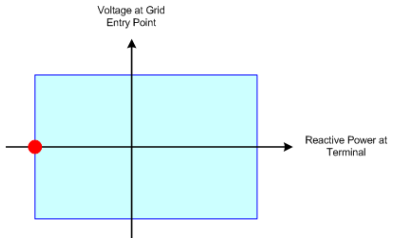
EUROSTAG

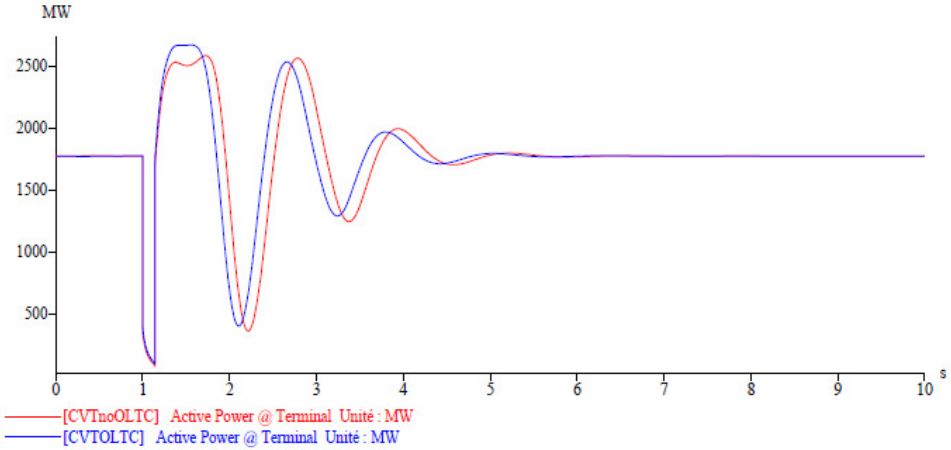
- Critical Fault Clearing Time:
  - With OLTC: 181 ms
  - Without OLTC: 165 ms

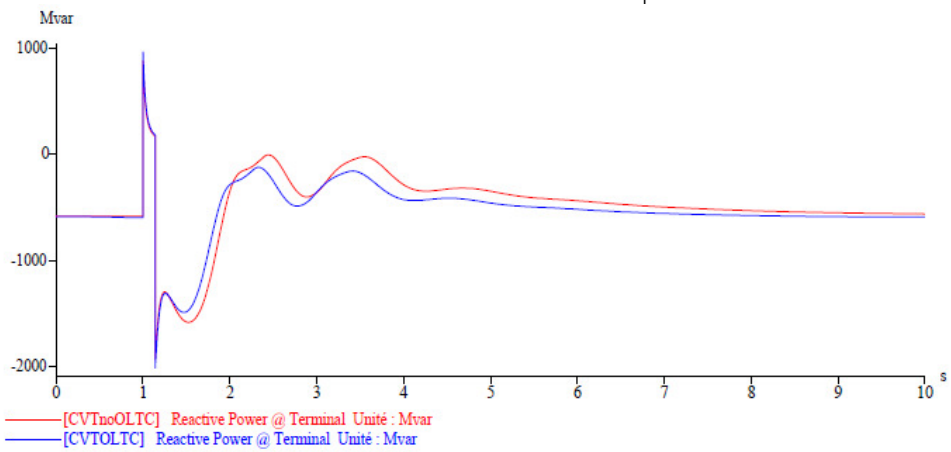
Better stability margin with OLTC

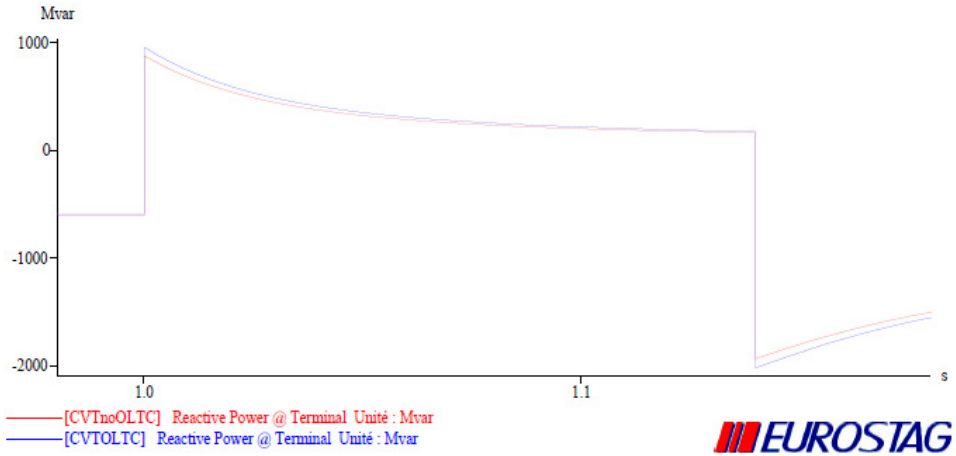
HPC EDF ENERGY

Case 2.1: pf 0.95 lead





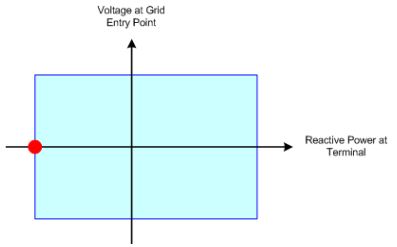


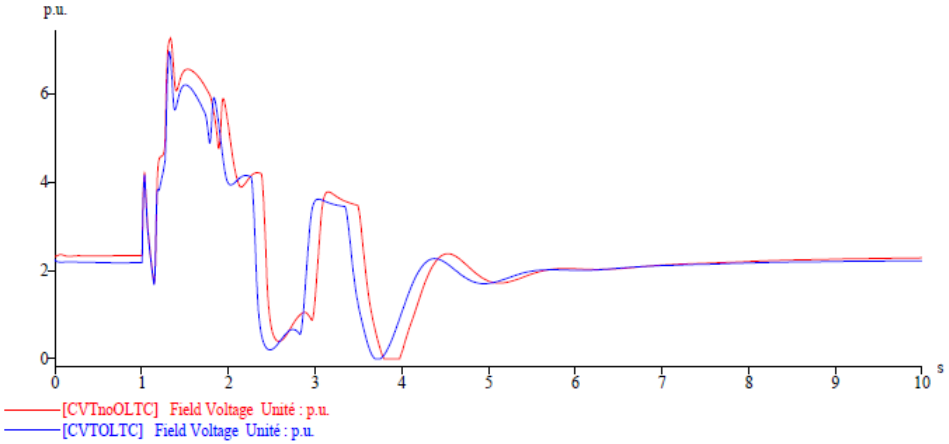


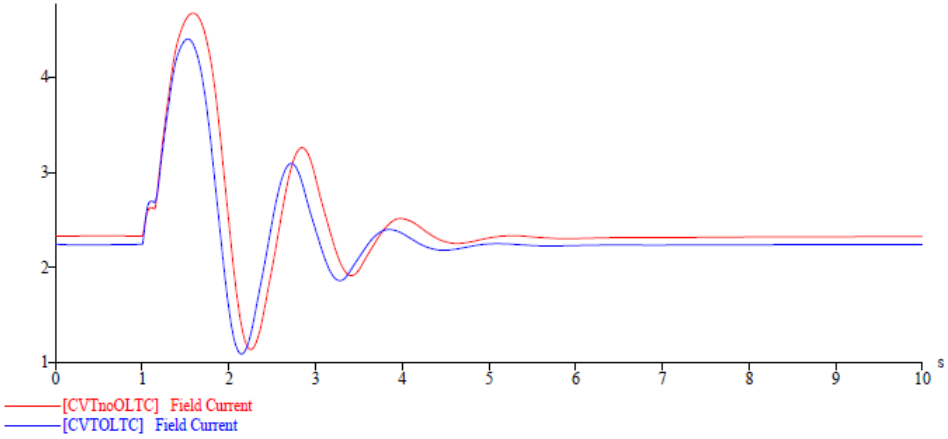
EUROSTAG

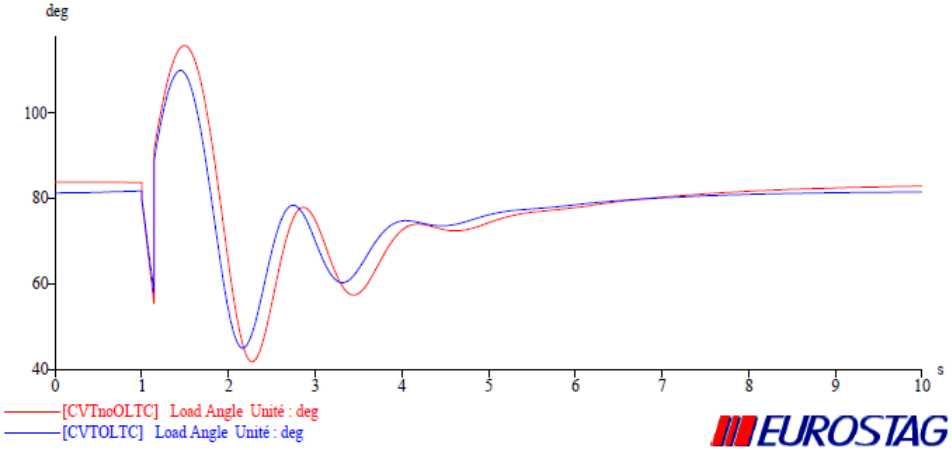
HPC
EDF ENERGY

Case 2.1: pf 0.95 lead





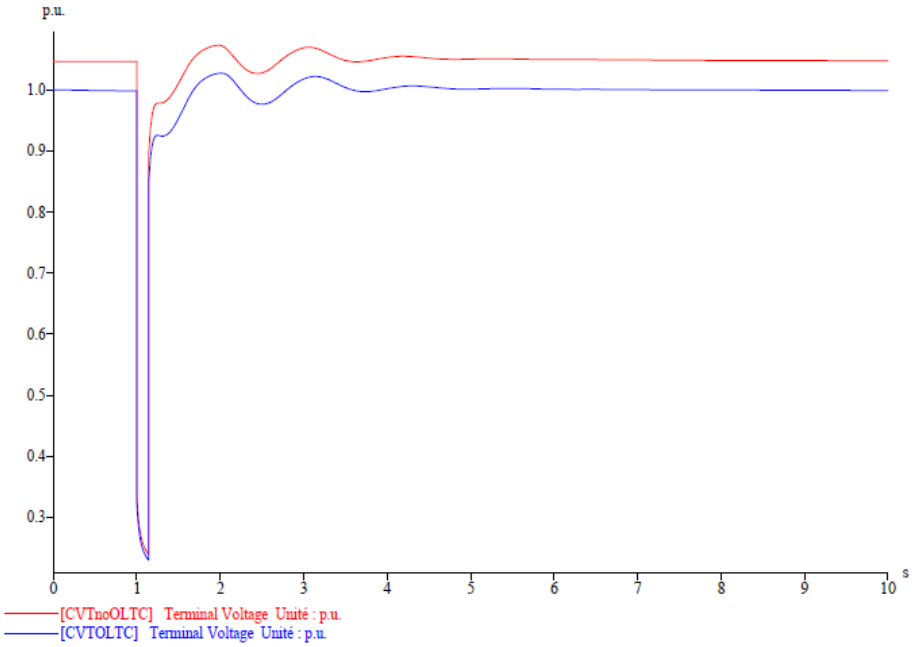


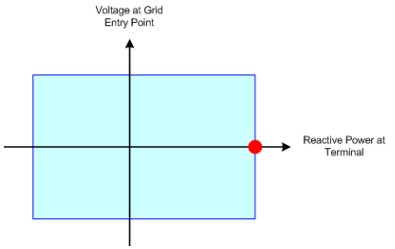


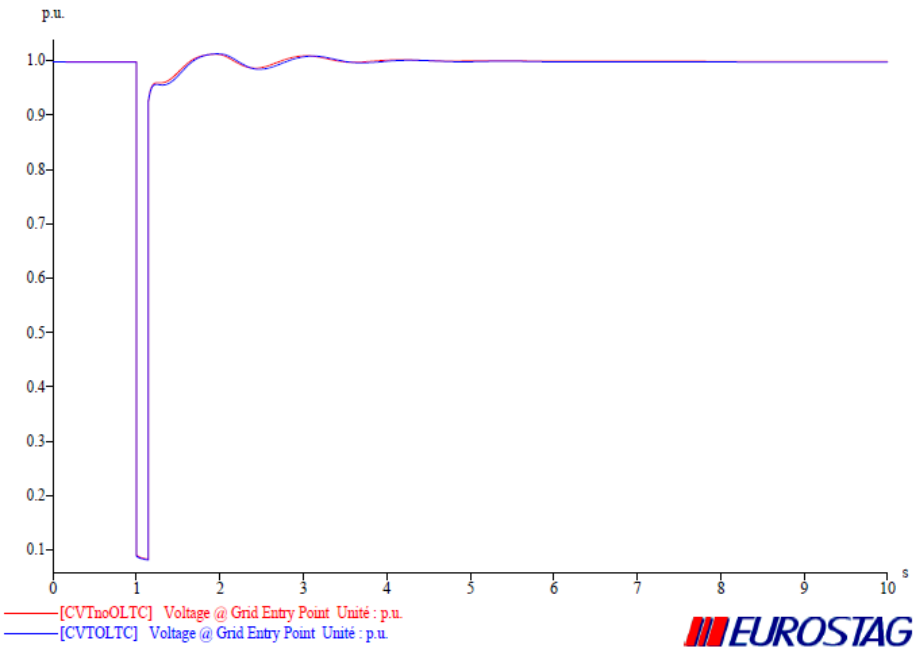
EUROSTAG

HPC EDF ENERGY

Case 2.2: pf 0.85 lag







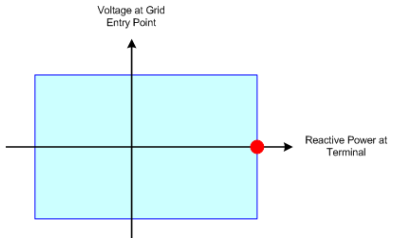
EUROSTAG

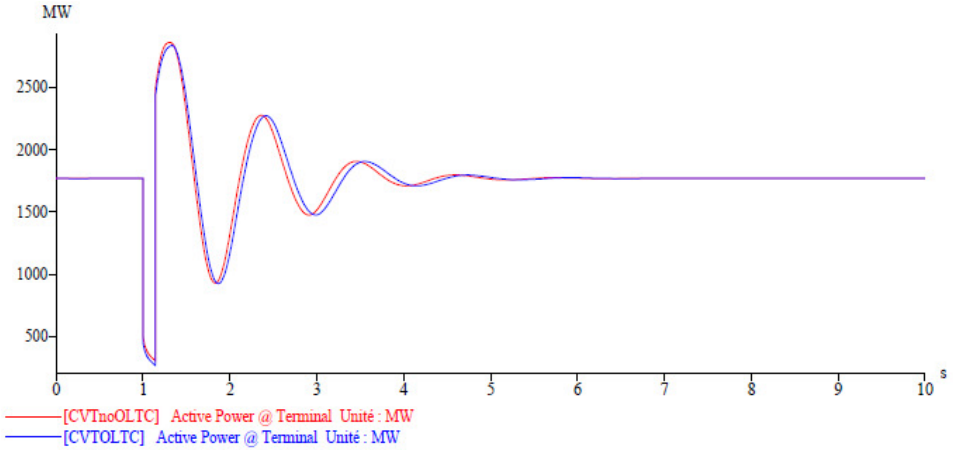
- Critical Fault Clearing Time:
  - With OLTC: 315 ms
  - Without OLTC: 332 ms

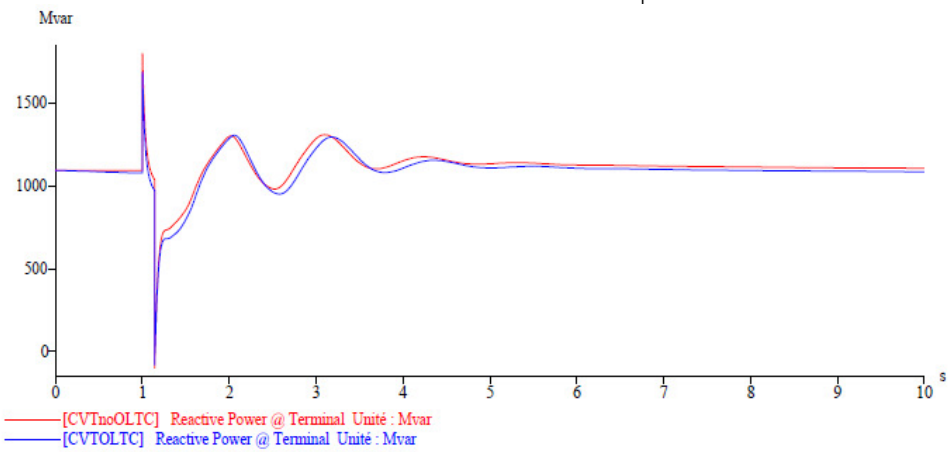
Better stability margin without OLTC

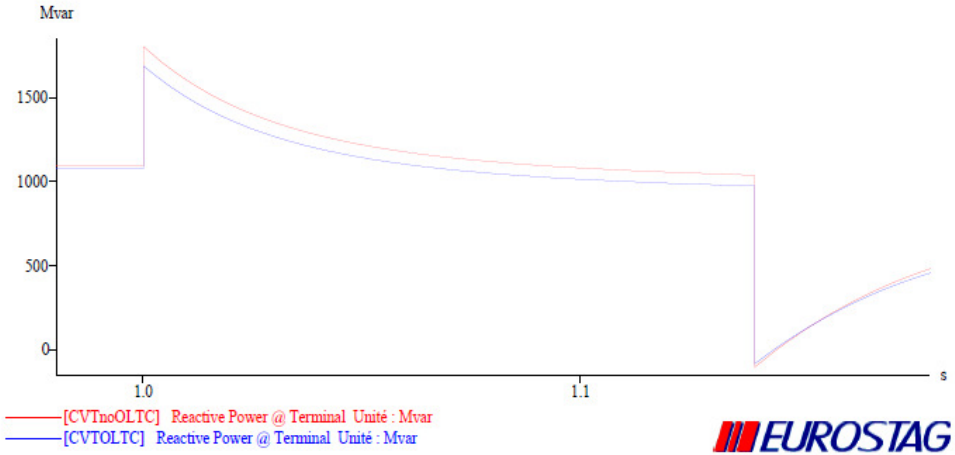
HPC EDF ENERGY

Case 2.2: pf 0.85 lag





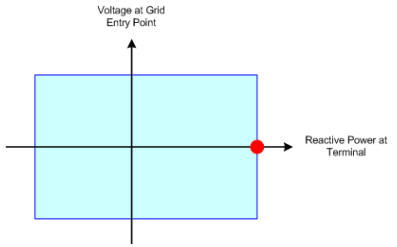


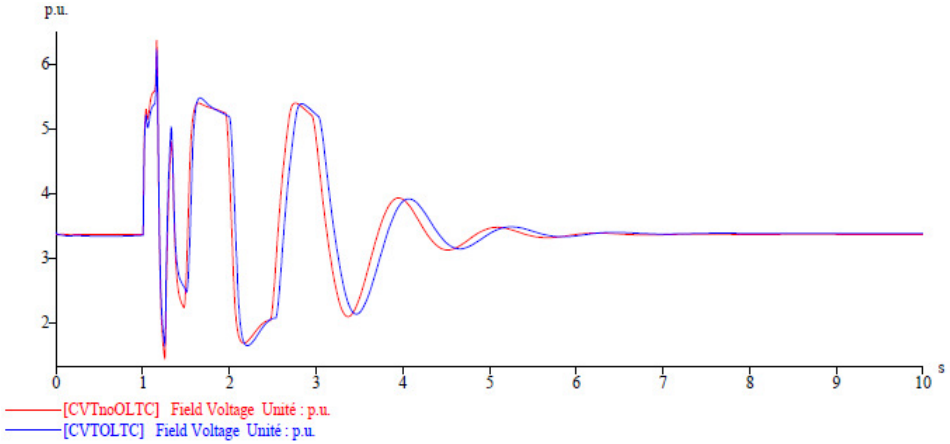


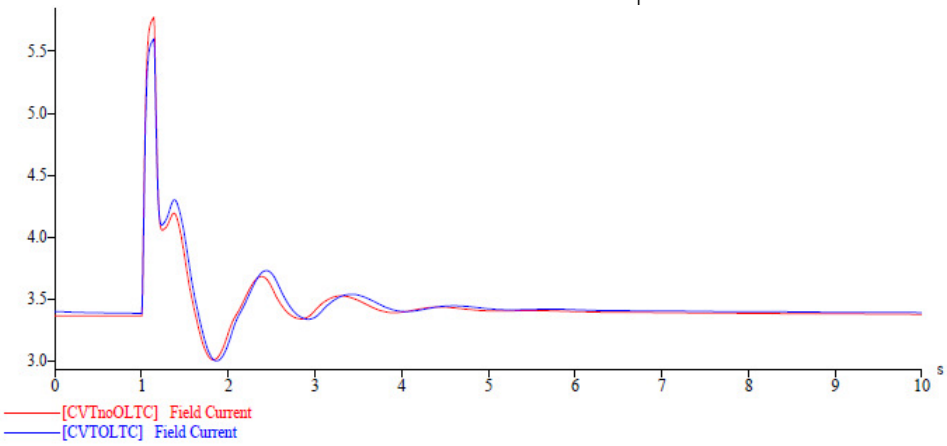
EUROSTAG

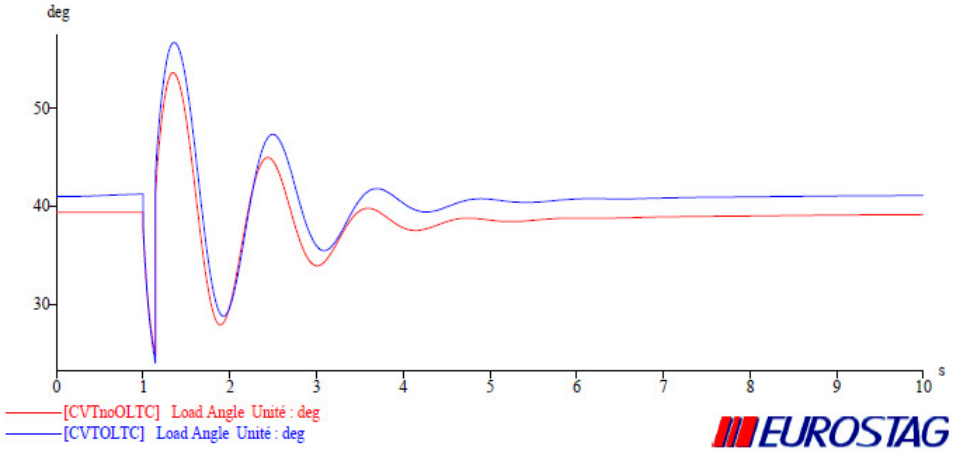
HPC

Case 2.2: pf 0.85 lag









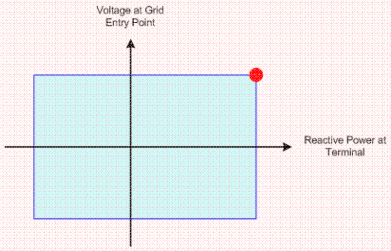
EUROSTAG

HPC EDF ENERGY

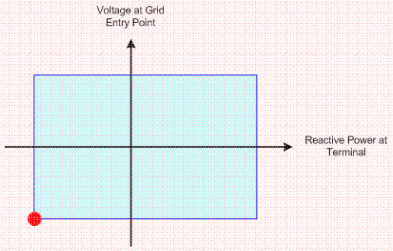
Case 2: other points investigated

Critical Fault Clearing Times

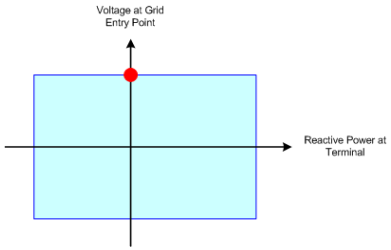
These points cannot be reached with nominal tap



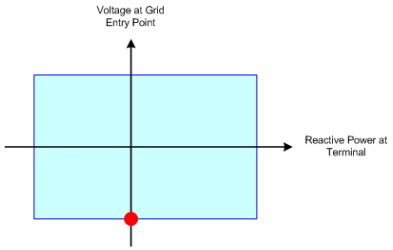
With OLTC: 317 ms
W/out OLTC: 340 ms



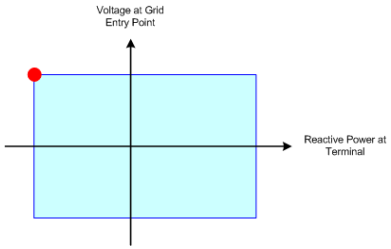
With OLTC: 172 ms
W/out OLTC: 157 ms



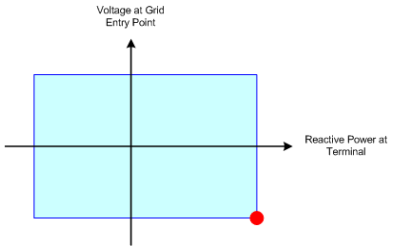
With OLTC: 249 ms
W/out OLTC: 265 ms



With OLTC: 239 ms
W/out OLTC: 214 ms

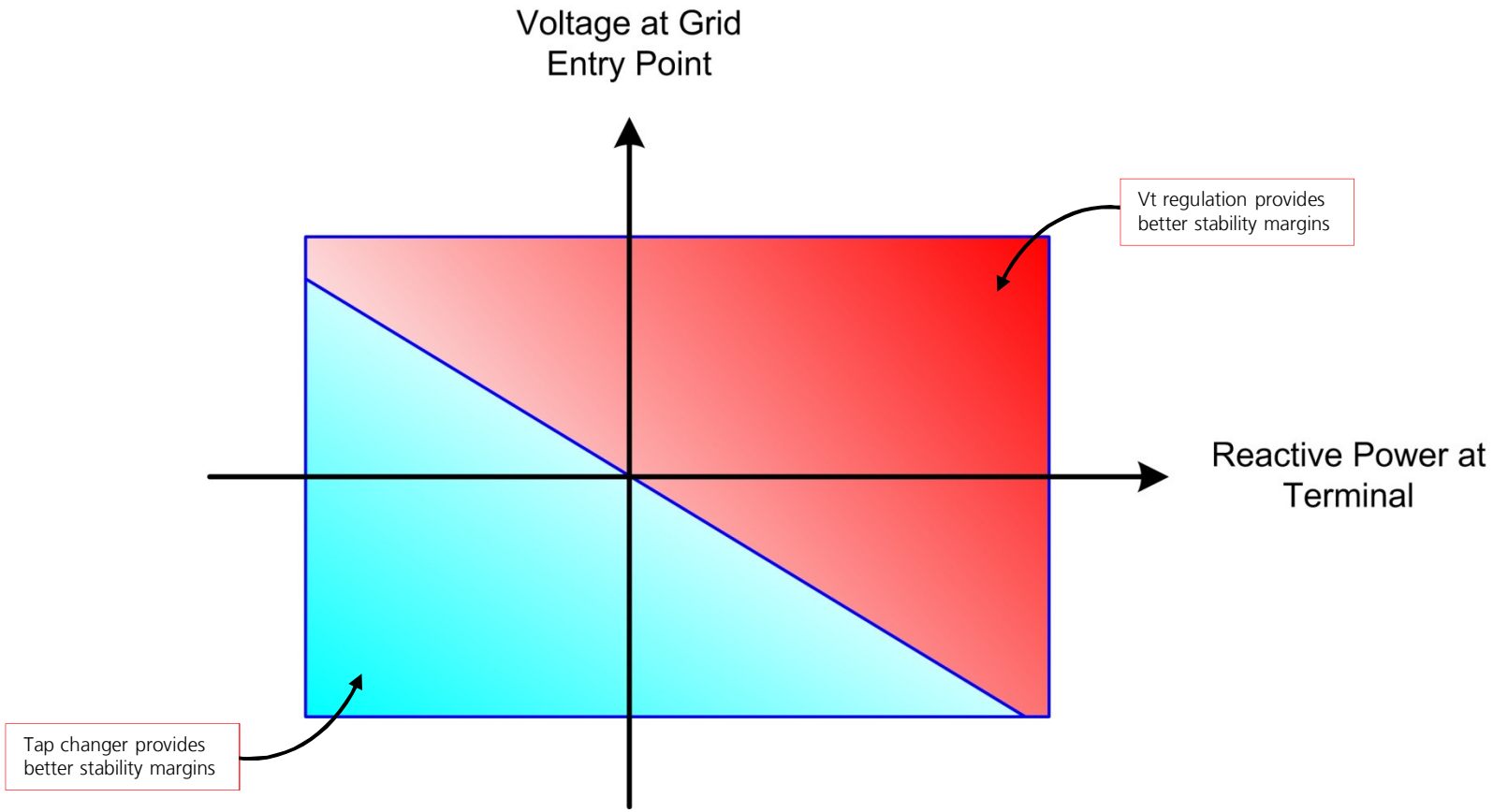


With OLTC: 188 ms
W/out OLTC: 190 ms



With OLTC: 311 ms
W/out OLTC: 317 ms

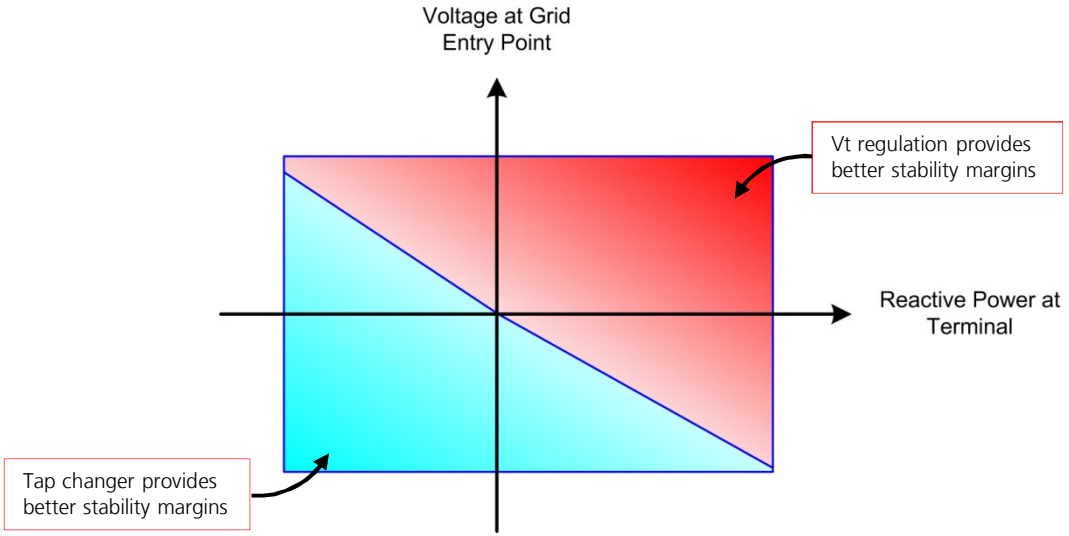
Case 2: Tap changer vs. Vt regulation



CONCLUSION

Conclusion

- Consistent results for both case studied. Basically:



- For any operating point on the UQ diagram, stability margin is, a higher initial terminal voltage provides better stability margin.

- Both methods of controlling reactive power give comparable results.

THANK YOU