HVDC Control Strategies to Improve Transient Stability in Interconnected Power Systems

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Supélec

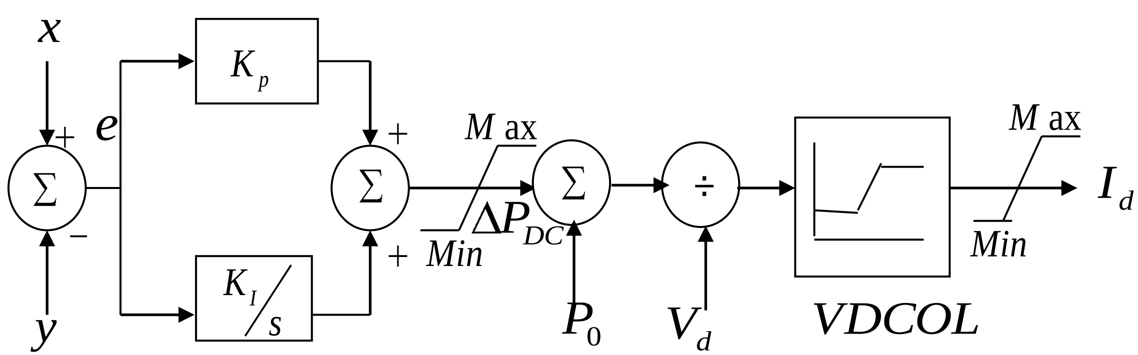
Transient stability control schemes

- Emergency generator/load shedding
- Fast valving and breaking resistors
- Fast excitation control
- Tie-line reactance control
- FACTS controllers
- HVDC controls
  - Power flow control flexibility
  - Fast response to disturbance

HVDC Modulation Scheme

Modulation strategies investigated are based on

- Rotor speed $$e = \frac{d}{dt}(w_{DCr} - w_{DCi})$$
- Phase difference $$e = \frac{d}{dt}(\delta_{DCr} - \delta_{DCi})$$
- Tie line flows $$e = \frac{d}{dt}(P_{IA})$$



Modulation scheme

Power System Model

- *Load representation*

$$P_{di} = P_{doi}(a_i + b_i V_i + c_i V_i^2)$$

$$Q_{di} = Q_{doi}(a_i' + b_i' V_i + c_i' V_i^2)$$

- *Generator model*

Synchronous machines are represented by a constant voltage source behind a transient reactance

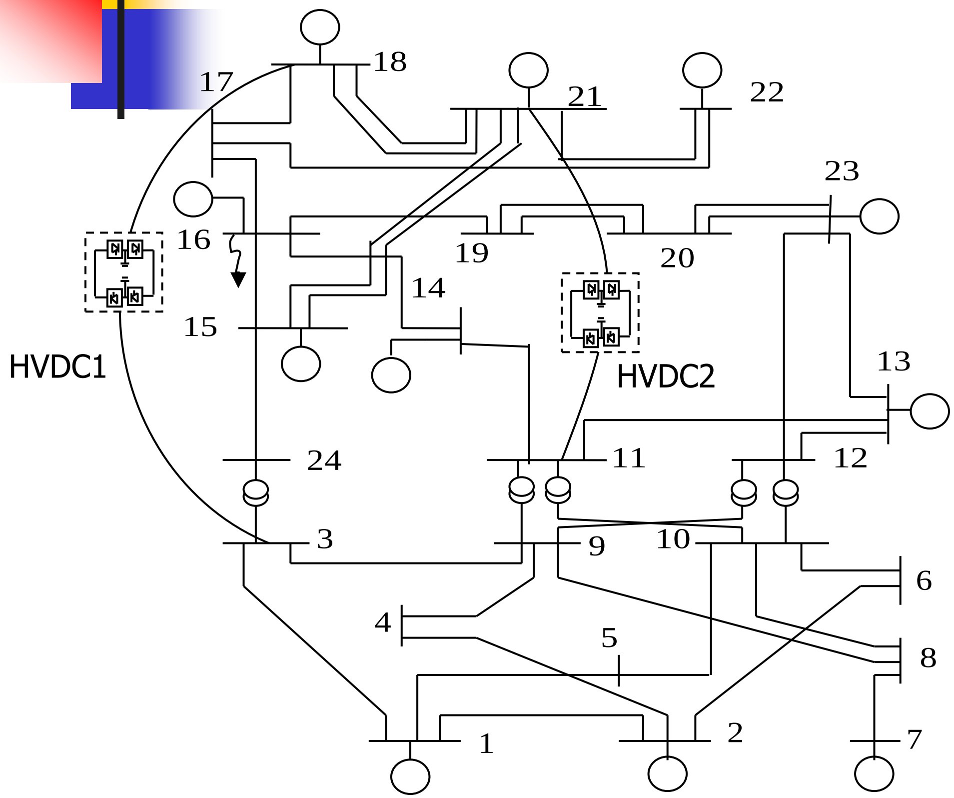
- *Network representation*

The system branches are represented by constant admittances

- *HVDC representation*

The power flow through the HVDC-link is represented as a positive load at the rectifier bus, and negative load at the inverter bus.

Case study



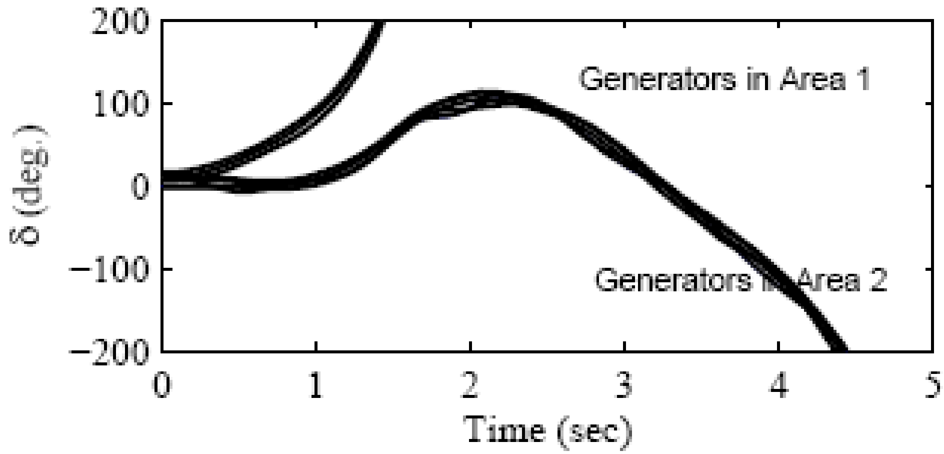
IEEE 24 bus RTS-96 system with two HVDC-links

Fault

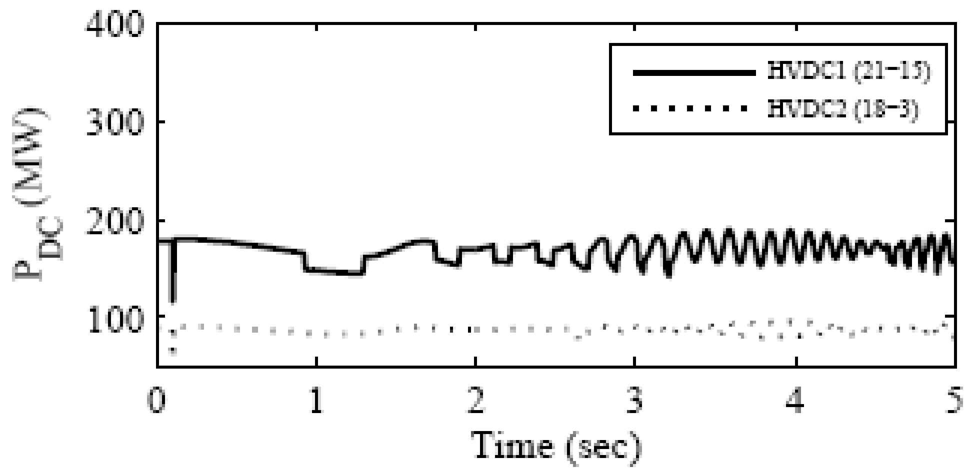
3 ph to ground fault at bus 16 initiated at t=0.1 sec

Fault is cleared by tripping 3 ckts 16-14, 16-17 and 16-19 at t=0.2 sec

Simulation results without HVDC control

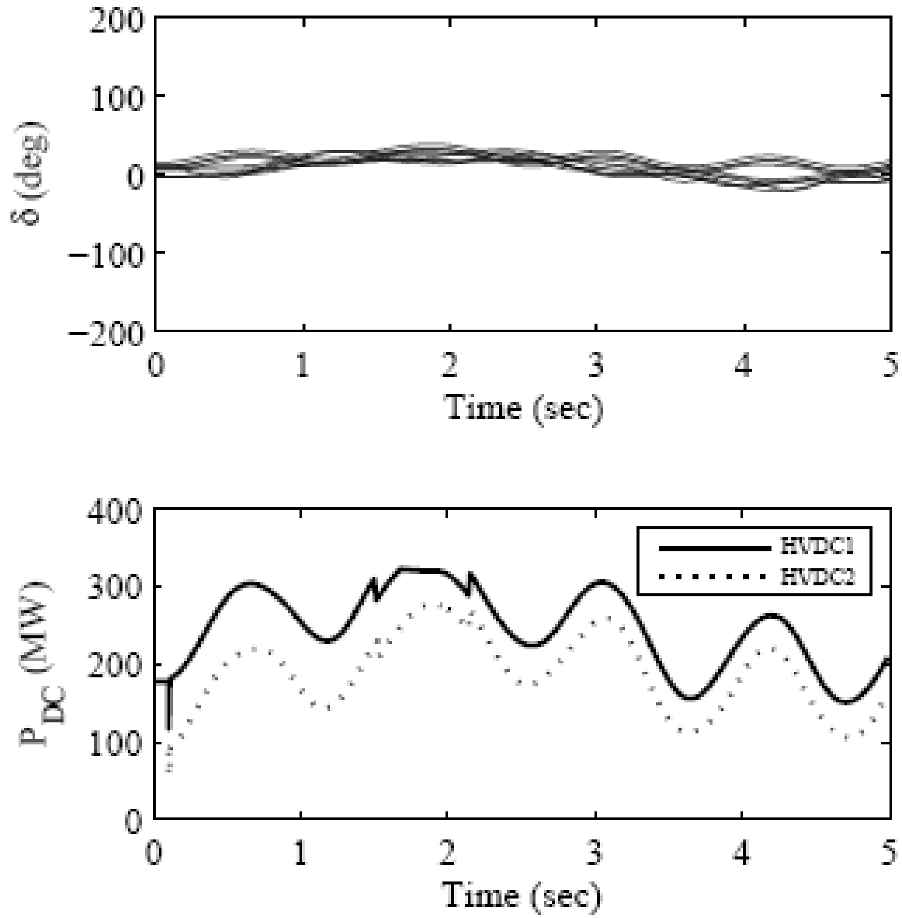


Power swing plot



Power flow through HVDC-links

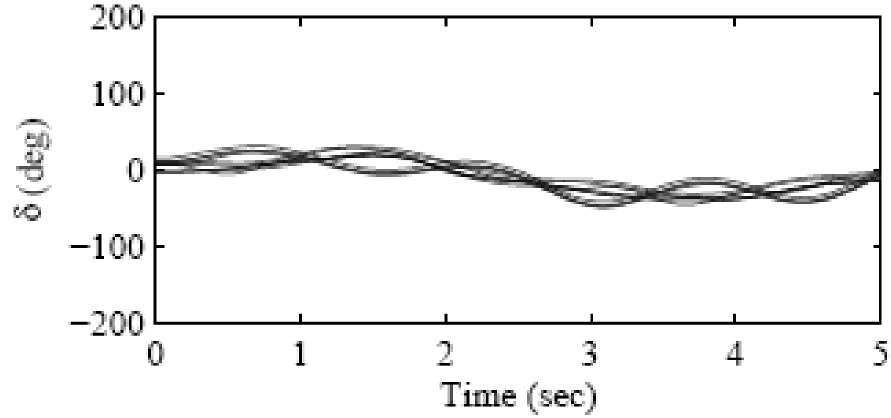
HVDC modulation based on rotor speed



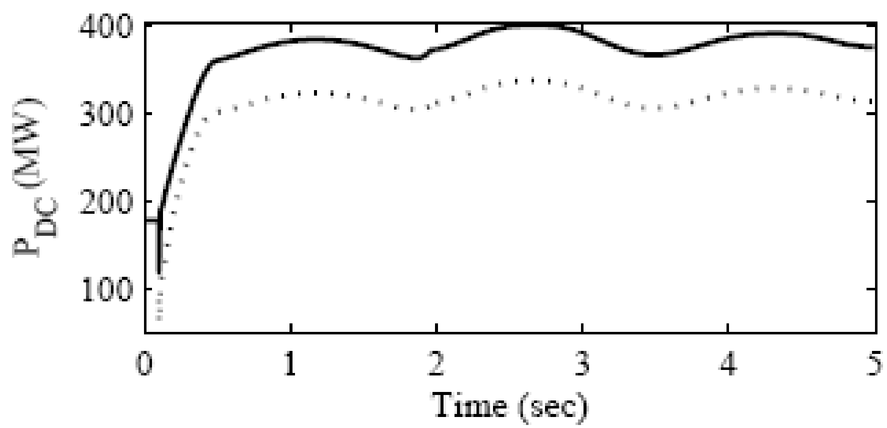
Power swing plot

Power flow through HVDC-links

HVDC modulation based on phase angle

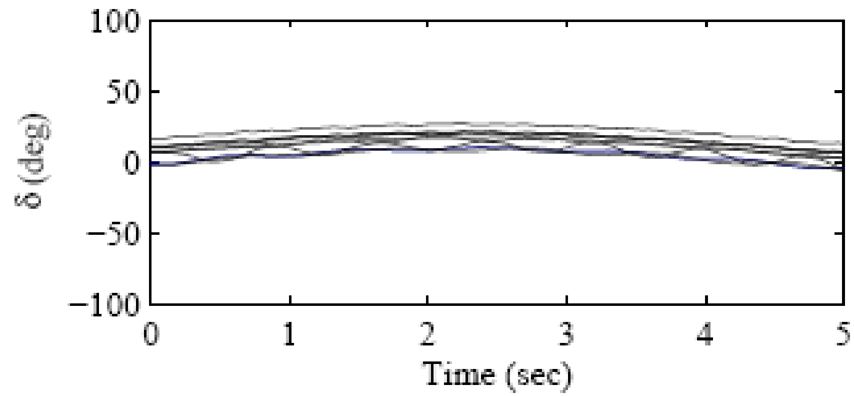


Power swing plot

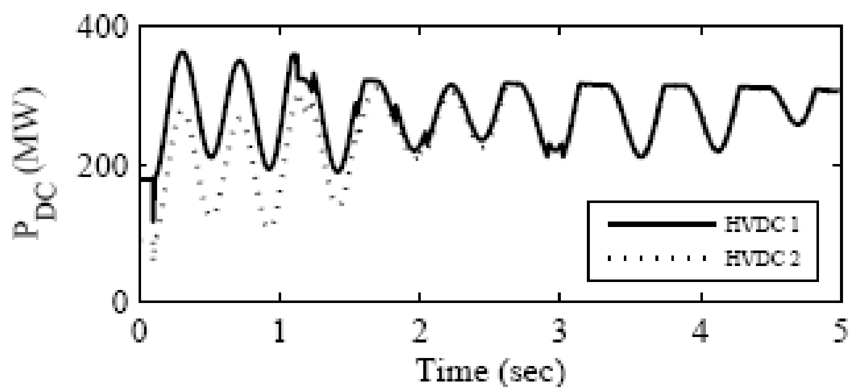


Power flow through HVDC-links

HVDC modulation based on tie line flow



Power swing plot



Power flow through HVDC-links

Comparison of modulation schemes in terms of CCT

Contingency	Strategy 1 (ms)	Strategy 2 (ms)	Strategy 3 (ms)	Strategy 4 (ms)
Bus 16, Line 16-14	183	288	307	321
Bus 18, Line 18-21	195	325	336	365
Bus 15, Line 15-21	280	291	305	316
Bus 6, Line 6-2	453	469	462	526

Conclusions

HVDC modulation is an effective alternative for improving transient stability in Power System

HVDC modulation based on AC system quantities are effective in damping the electro-mechanical oscillations

All the input signals are not equally effective for various faults

Performance of the control schemes is highly dependent on controller parameters