Knowledge Centre WMC
Wind turbine Materials and Constructions

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Grid connection of large-scale offshore wind power by multi-terminal VSC-HVdc

Examining effects on transient stability

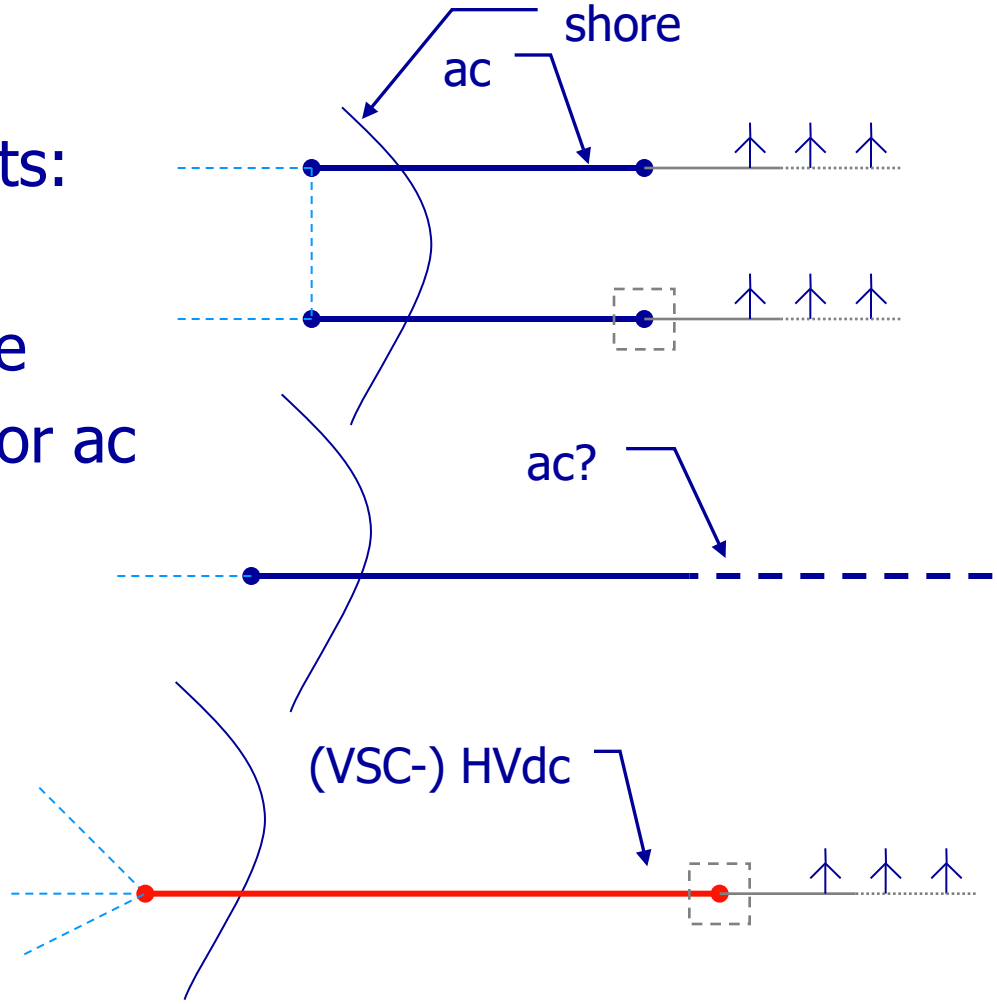
Grid connection of offshore WPPs

Present wind power plants:

Trend: further from shore

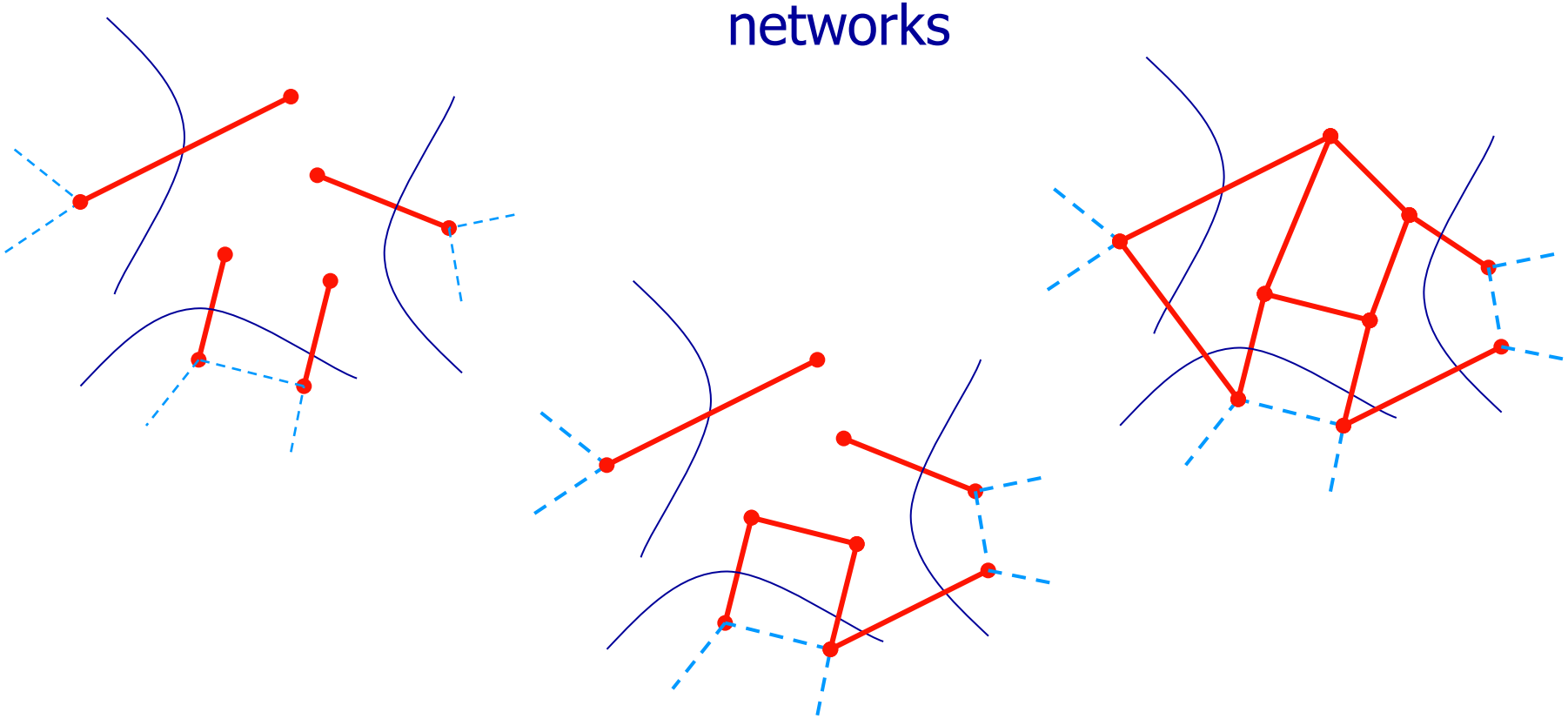
but: complications for ac

Solution: (VSC-) HVdc



Transnational offshore networks

Interconnections may gradually evolve to meshed dc networks

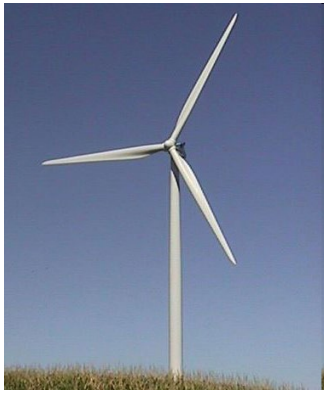


Power system related challenges

2010-2030: substitution of power plants by WPPs

Less rotating inertia

Overall dynamic behaviour will change



Affects transient stability

Operation of multi-terminal VSC-HVdc during disturbances

VSCs have different behaviour

Converters offer excellent controllability

- Voltage support during ac faults
- Frequency response

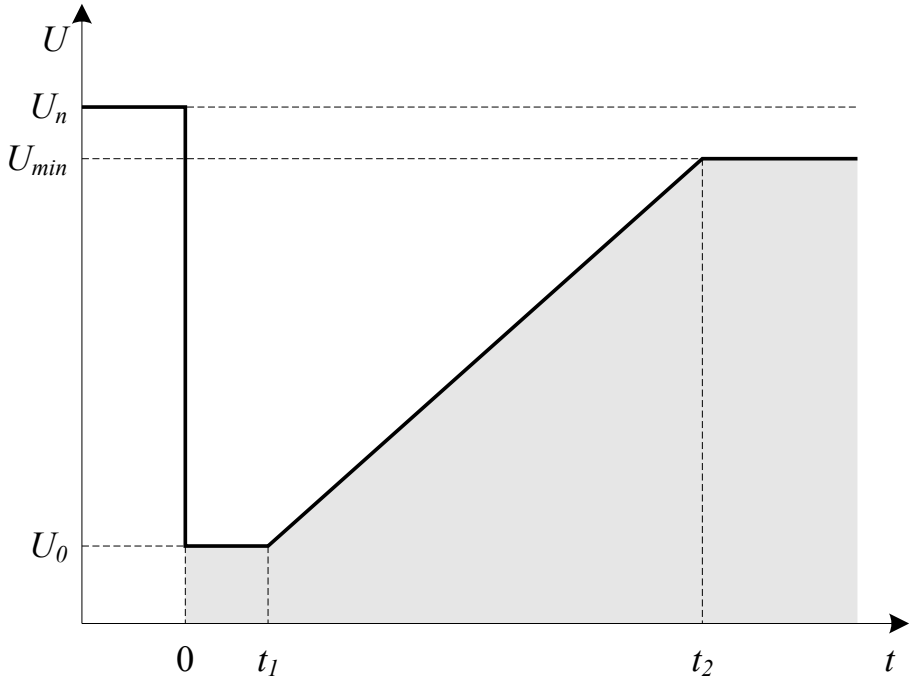
Other aspects that influence power system dynamics:

- Low-voltage ride-through
- VSC protection

Low-voltage ride-through

VSC-HVdc schemes must stay connected during faults

Challenge due to decoupling onshore – offshore



Protection of VSCs

VSC should be protected against over-voltages and excessive currents

- di/dt high → fast protection reaction required
- Internal limiting
- Direct-voltage balancing / resynchronisation required

Protection influences power output considerably

VSC-HVdc influences dynamics

Protection and control mechanisms have a large geographic impact

Direct-voltage and power oscillations

This induces effects on a much longer time interval:

- Frequency swings
- Voltage fluctuations

These phenomena become more important for high capacities

HVdc must be accurately included in grid integration studies

Grid integration studies need speed

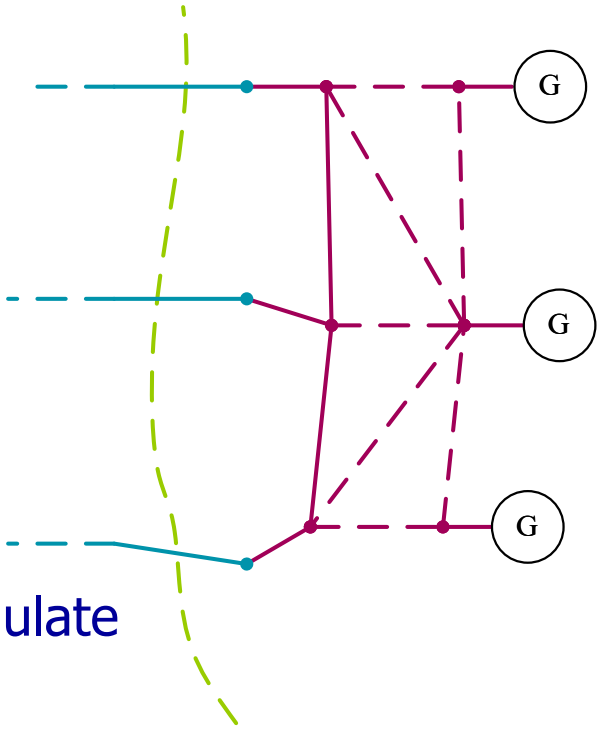
Usually, stability simulation (PSS/e or Digsilent)

Only slower behaviour is of interest

VSCs and WPPs: variable power sources

Fast, but:

- Power flows in dc networks are difficult to simulate
- Direct voltage fluctuations are neglected



Simulation of multi-terminal VSC-HVdc needs speed and accuracy

Dynamics in dc circuit are fast

Usually electro-magnetic transients (EMT) simulation

VSCs and WPPs: more detailed models

Accurate, but:

- The ac system must be simulated accurately as well (slow)
- Detailed specifications of equipment are not easily available

How to achieve both speed and accuracy?

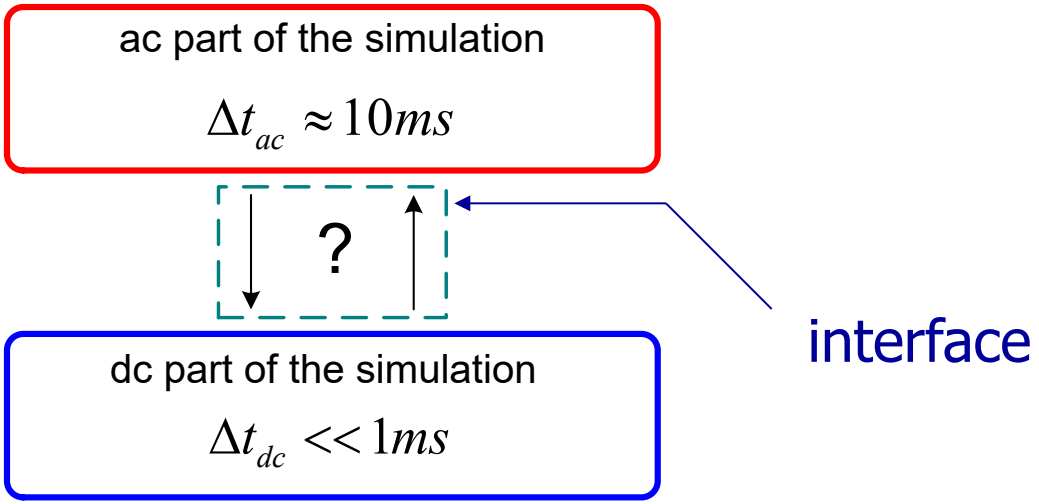
a solution: multi-rate simulations

Represent ac system by phasors (so stability type simulations):

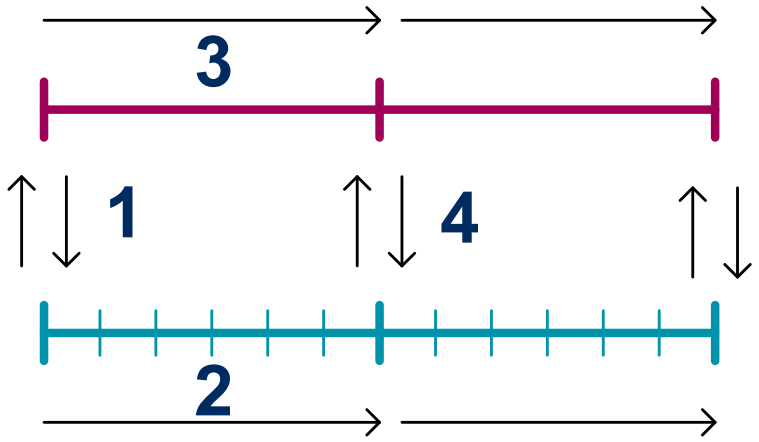
- Large time-step size

Simulate HVdc system by EMT:

- Small time-step size



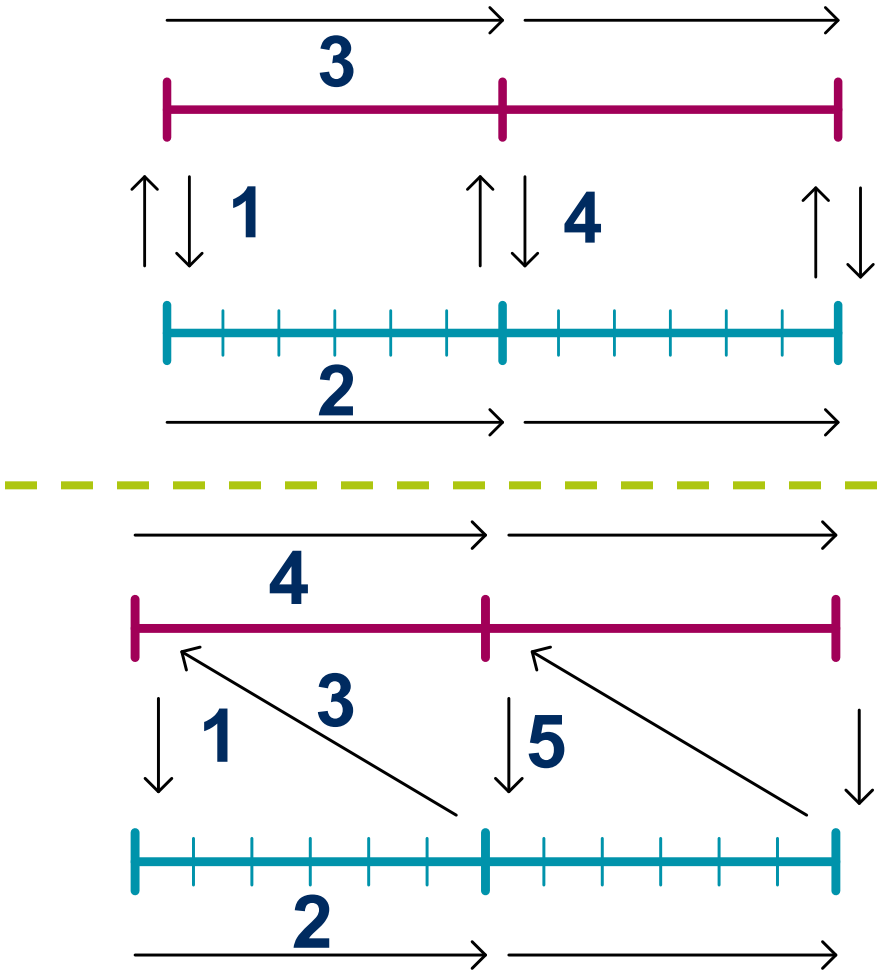
Interface



Important aspects:

- Order of interfacing
- Interface location(s)
- Transformation of variables

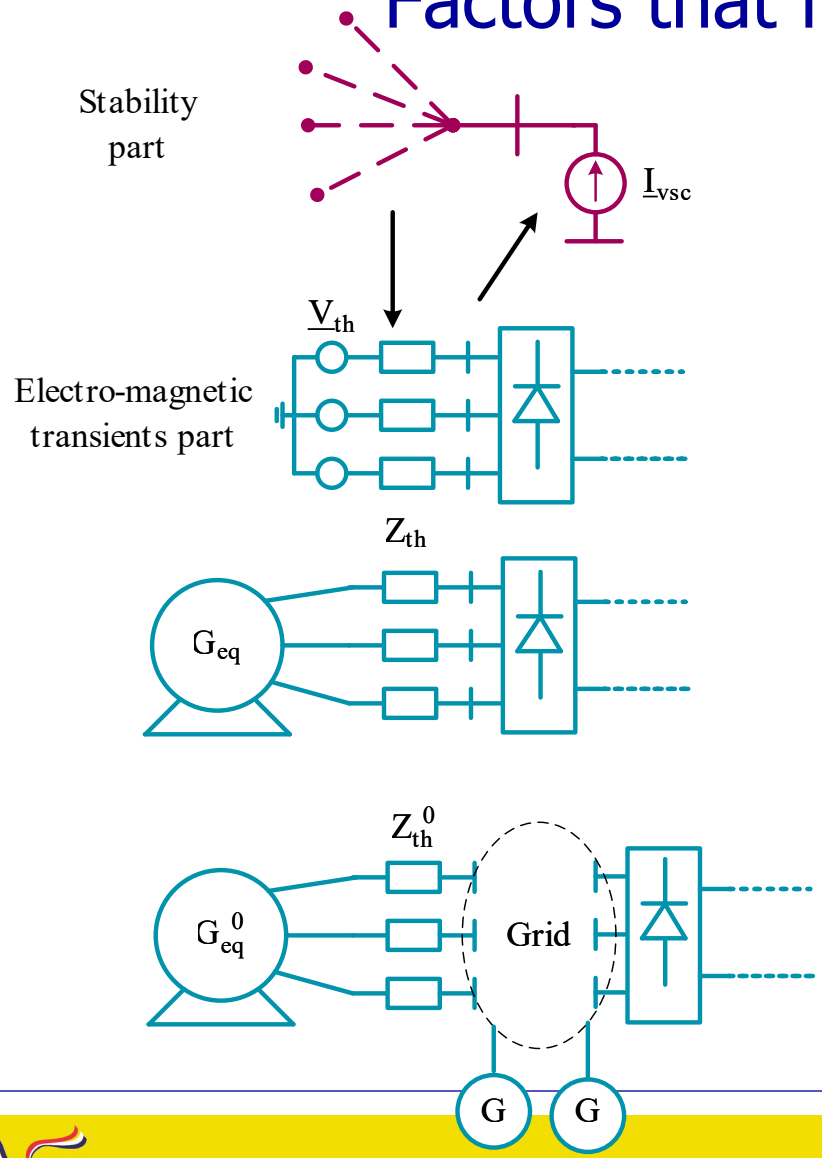
Factors that influence performance



Order

- Which part first
- Inclusion into numerical solution scheme
- Series or parallel computation

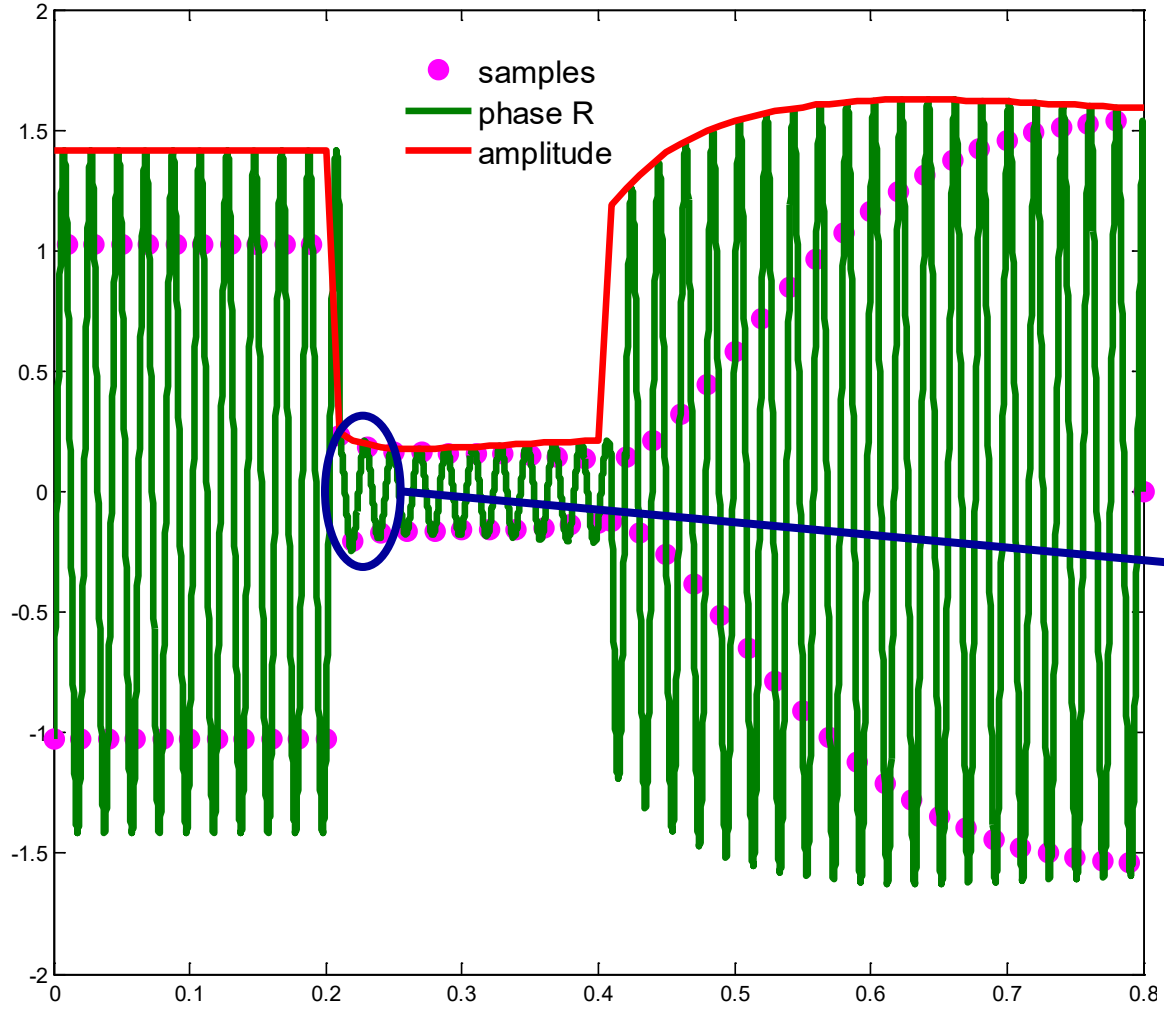
Factors that influence performance



Equivalent representation

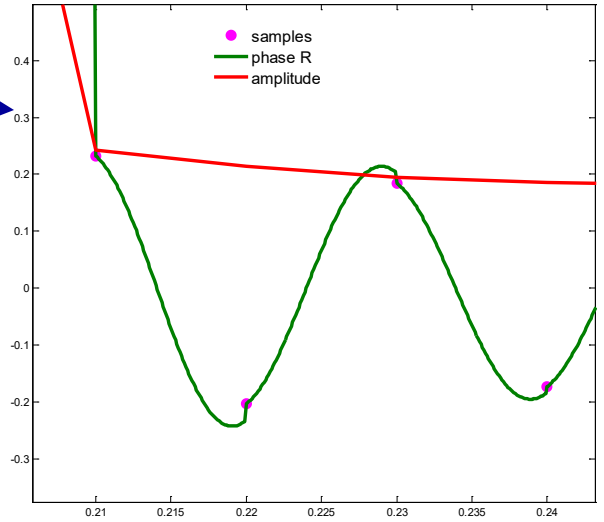
- interfacing at one node or by a network?
- generators: source or dynamic equivalent?

Factors that influence performance

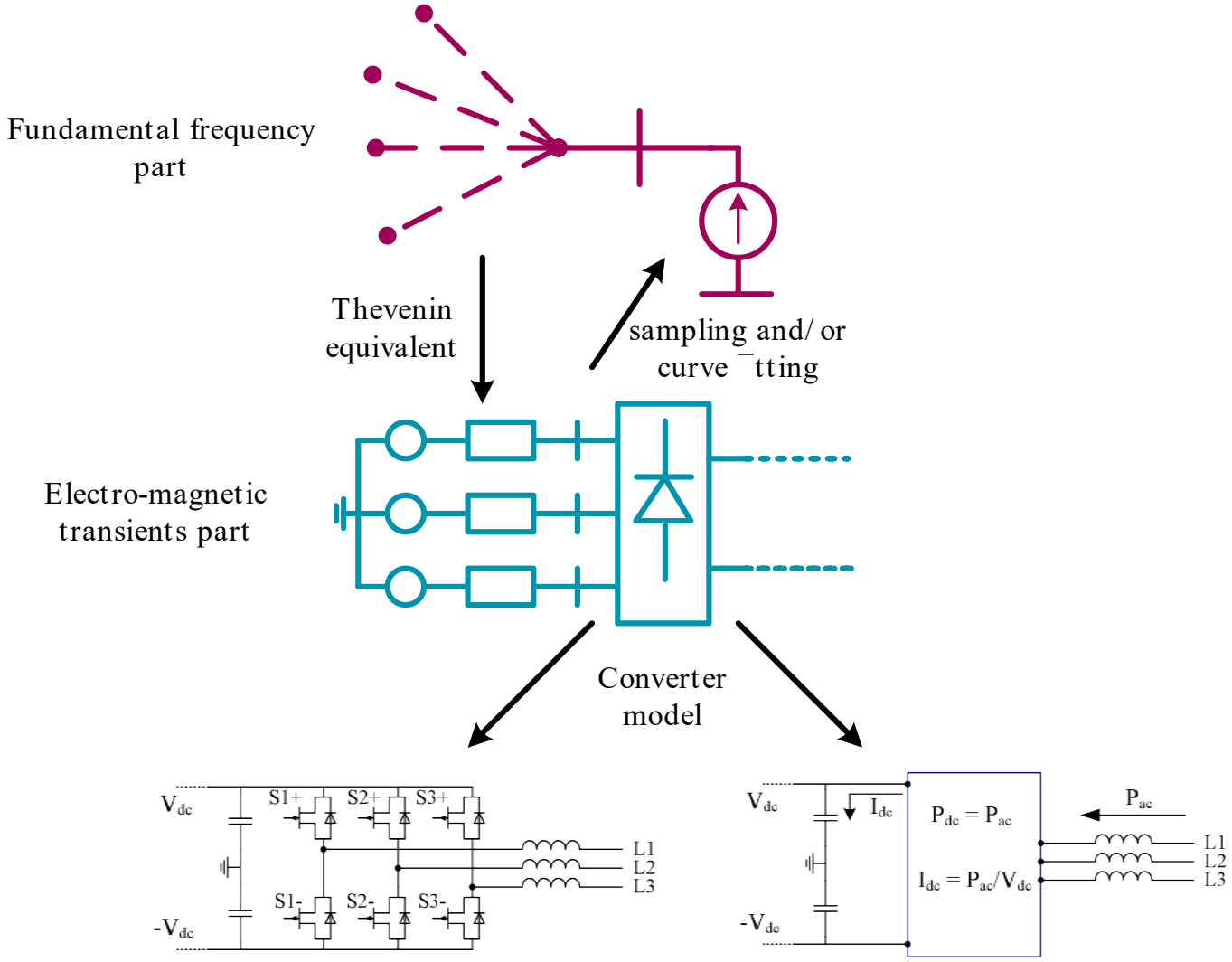


Transformations

- Phasor to waveform
- Waveform to phasor



General VSC interface



Summary

- Future wind power plants will be connected through VSC-HVdc
- Operation of VSC-HVdc is different compared to ac
- Influence on transient stability must be examined

The inclusion of multi-terminal VSC-HVdc into stability simulations requires special treatment

Thank you

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