

GRID EMT

SIMULATION INITIATIVE

Overcoming EMT Study Challenges for HVDC

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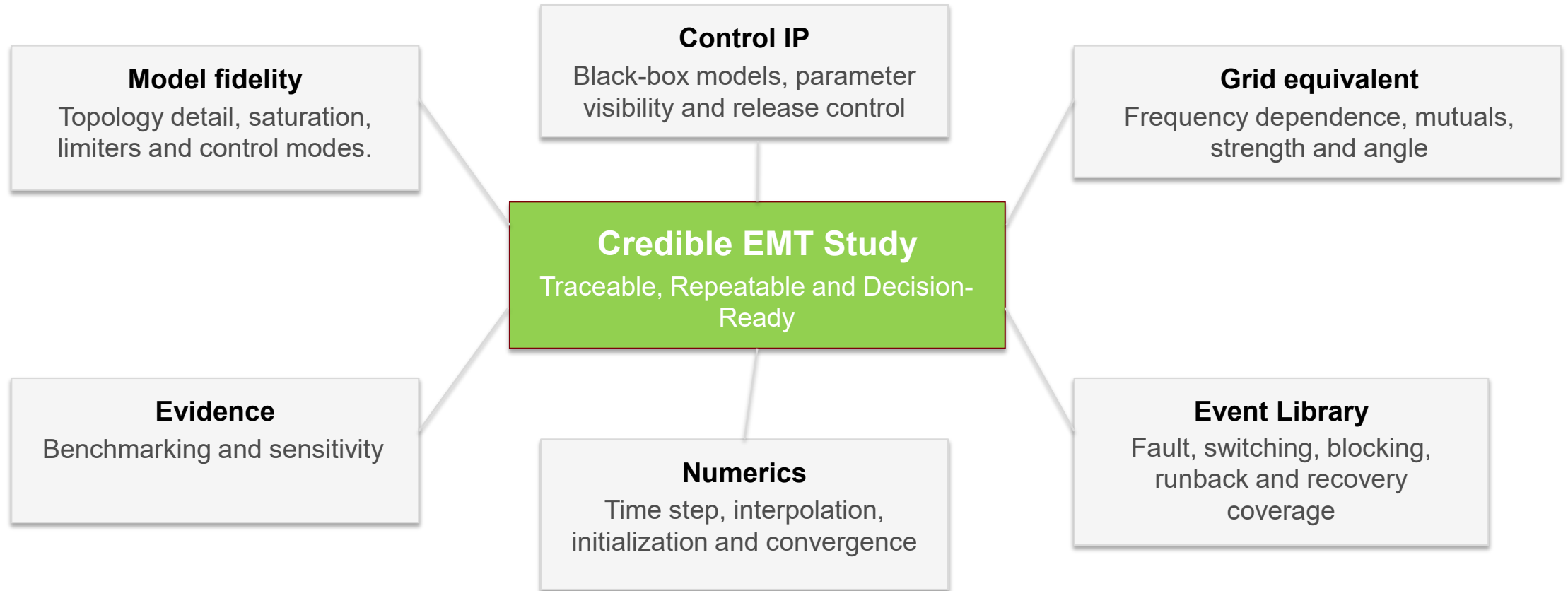
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Motivation

- High Voltage Direct Current (HVDC) projects concentrate fast controls and power electronics into a small electrical footprint.
- RMS tools remain essential for grid studies, but EMT analysis is where many equipment-specific risks become observable.
- A credible EMT model is a documented chain from data quality and model assumptions to repeatable simulations and defensible engineering decisions.

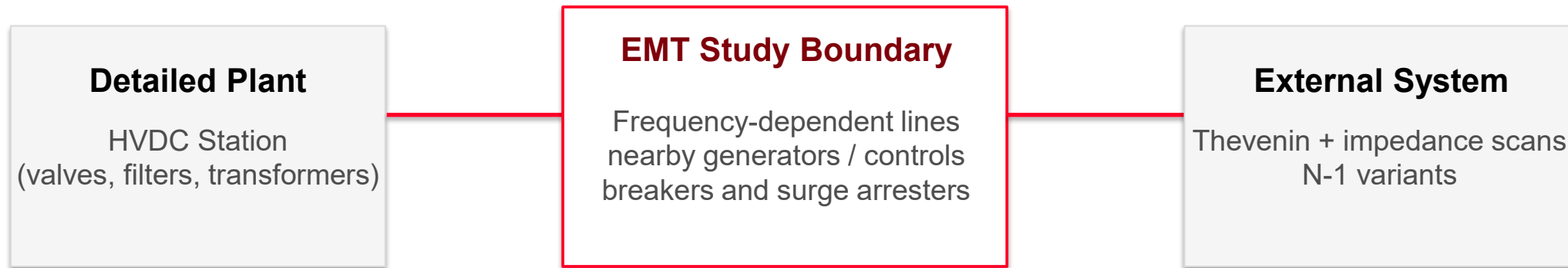


Challenges



Grid Equivalents

- A compact EMT network model is practical, but the boundary matters. Frequency-dependent behavior, mutual coupling and system strength shape control interactions and overvoltage results.
- Power Electronics Based Systems (FACTS , Inverter-based generation plants, data centers...) located close to an HVDC station should be modelled in detail to check for overvoltages, evaluate controller interactions.
- Generator Models are essential for Sub-Synchronous Oscillation Studies.



Scenarios

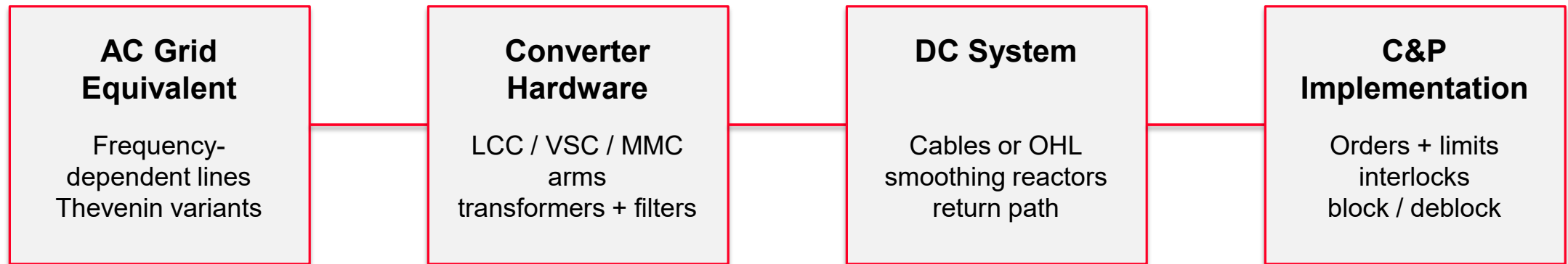
- Define a compact set of credible interactions, i.e., avoid hundreds of scenarios that won't affect the final conclusions.
- Typical scenarios are seen below.

Event Family	Normal Grid	Weak Grid	Outage / N-1	Recovery State
Faults	3 ϕ , 1 ϕ	low SCR, high X/R	remote clearing	post-fault ramp
Switching	line / cable energization	filter switching	transformer inrush	reclose / deblock
Converter events	blocking, bypass	runback limits	pole outage	restart sequence
Control changes	mode change	PLL stress	AC voltage control loss	order restoration



Detailed HVDC EMT Model

- A credible HVDC case is a coordinated package: electrical plant, control logic, protection behavior, measurement channels and documented limits.



Measurements & Sampling

PLL, firing signals, filters and sample times

Observability Hooks

State variables, limiter flags and event markers

Release envelope

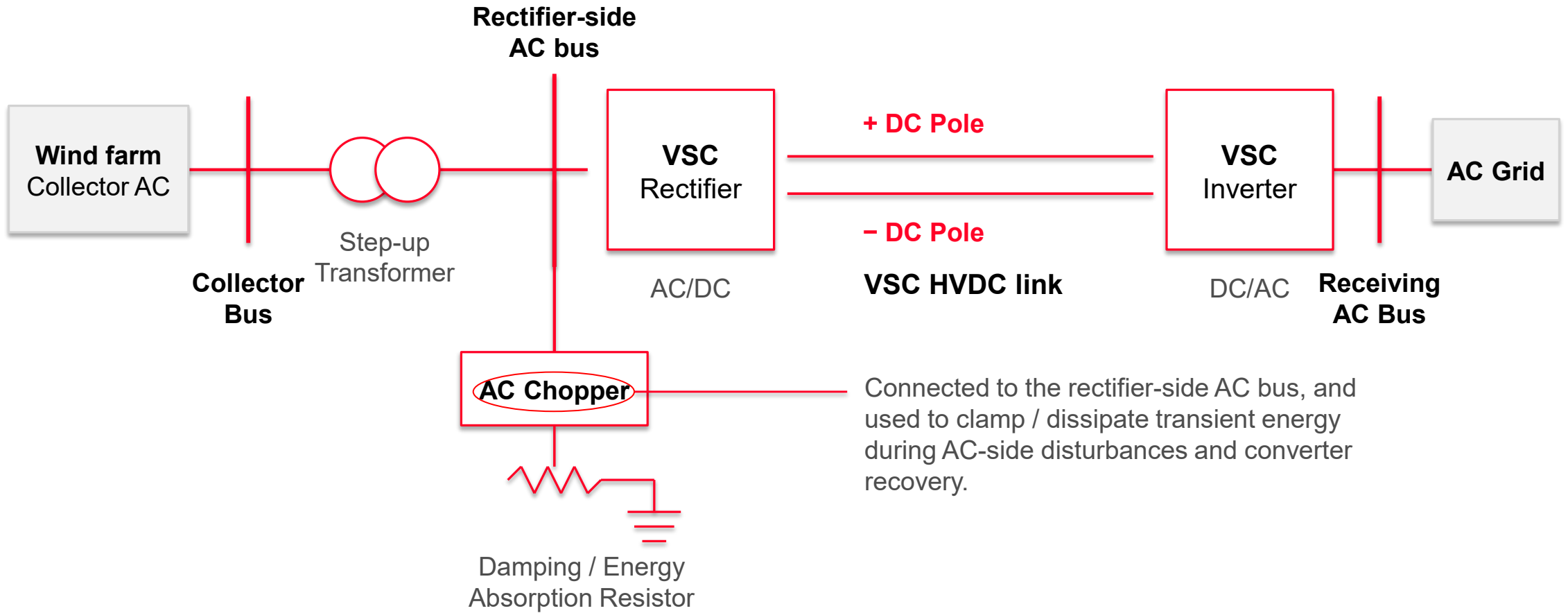
Valid modes, unsupported events and initialization limits



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EMT Simulation

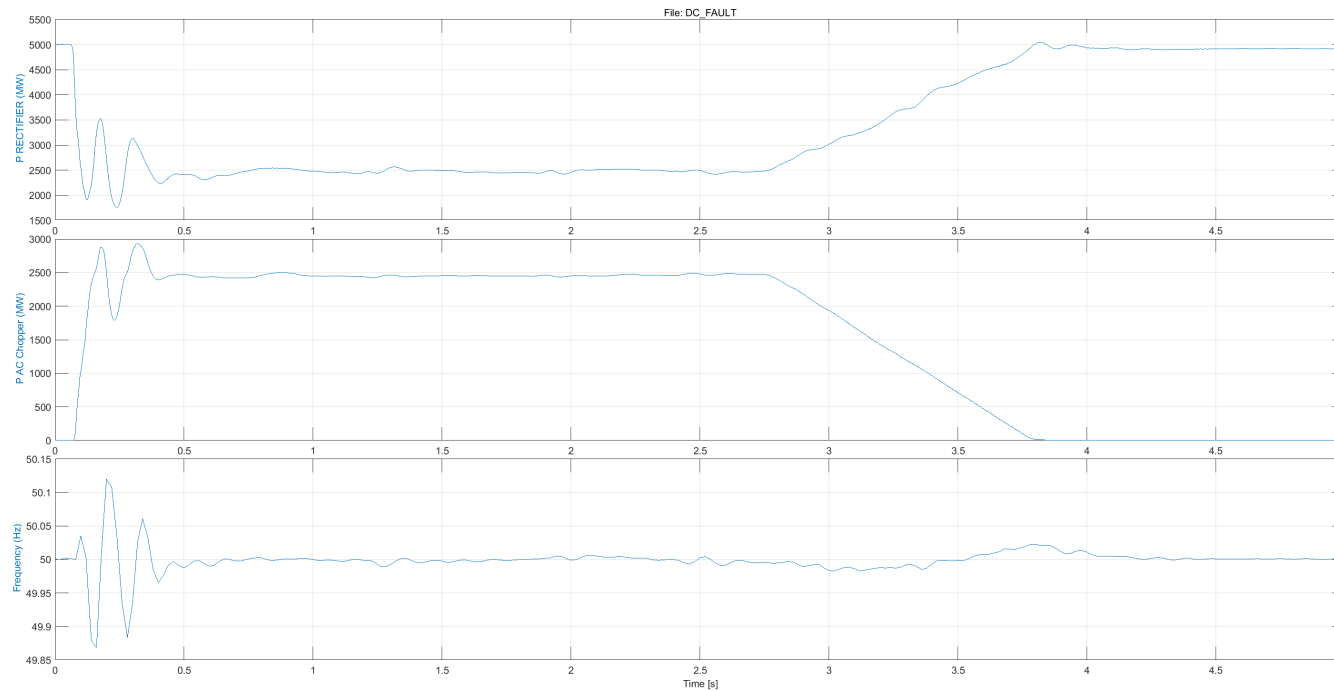


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DC Fault Simulation – Bipole with AC Chopper Action

- One Pole is shut down and restarted a few seconds later.
- The healthy pole keeps transmitting power. The AC chopper takes care of the power unbalance.



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Conclusions

- Credible EMT decisions require traceable, repeatable models.
- Study boundaries must capture grid strength, frequency dependence, mutual coupling, and nearby converter and generator dynamics.
- Models must align plant, controls, protection, measurements, limits, and initialization.
- Use a compact, risk-based event library focused on faults, switching, converter events, weak-grid, and N-1 states.





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