Using the RTDS to Test Integrated Systems

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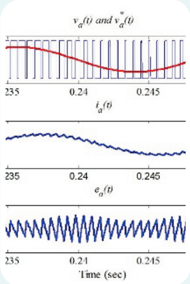

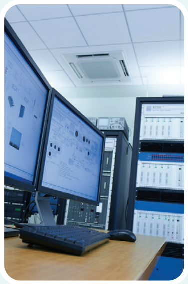

Pre-feasibility Studies	Spec studies	Design Studies	Dynamic Studies	Factory System Test	Factory Acceptance Tests / Dynamic Performance Tests

Utility/Developer → Vendor →

Review → Review →

Using the RTDS to Test Integrated Systems

- FST is typically internal to the Vendor
  - Chance to “kick the tires” before showing the customer
  - For the most part uses static equivalents. Vendor has to deliver required performance (more on this later!)
- FPT/DPS is the chance for the customer to witness the testing
  - Again, typically done with static equivalents
  - While we need to ensure the performance is met as outlined in the spec, we also need to ensure dynamic stability!
    - More important in weak systems

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How do we prove

Original stability studies that lead to requirement

Static Equivalent that proves response rates are met – simulation (even controls)

Static equivalents with actual controls (RTDS)

Equivalent ac system models with actual controls

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- Dynamic Performance Tests are performed to test the performance of the hardware and software of the control system
- EMT programs such as PSCAD and RTDS are used for DPT
- Not practical to implement large AC networks in these simulators
- AC network is reduced

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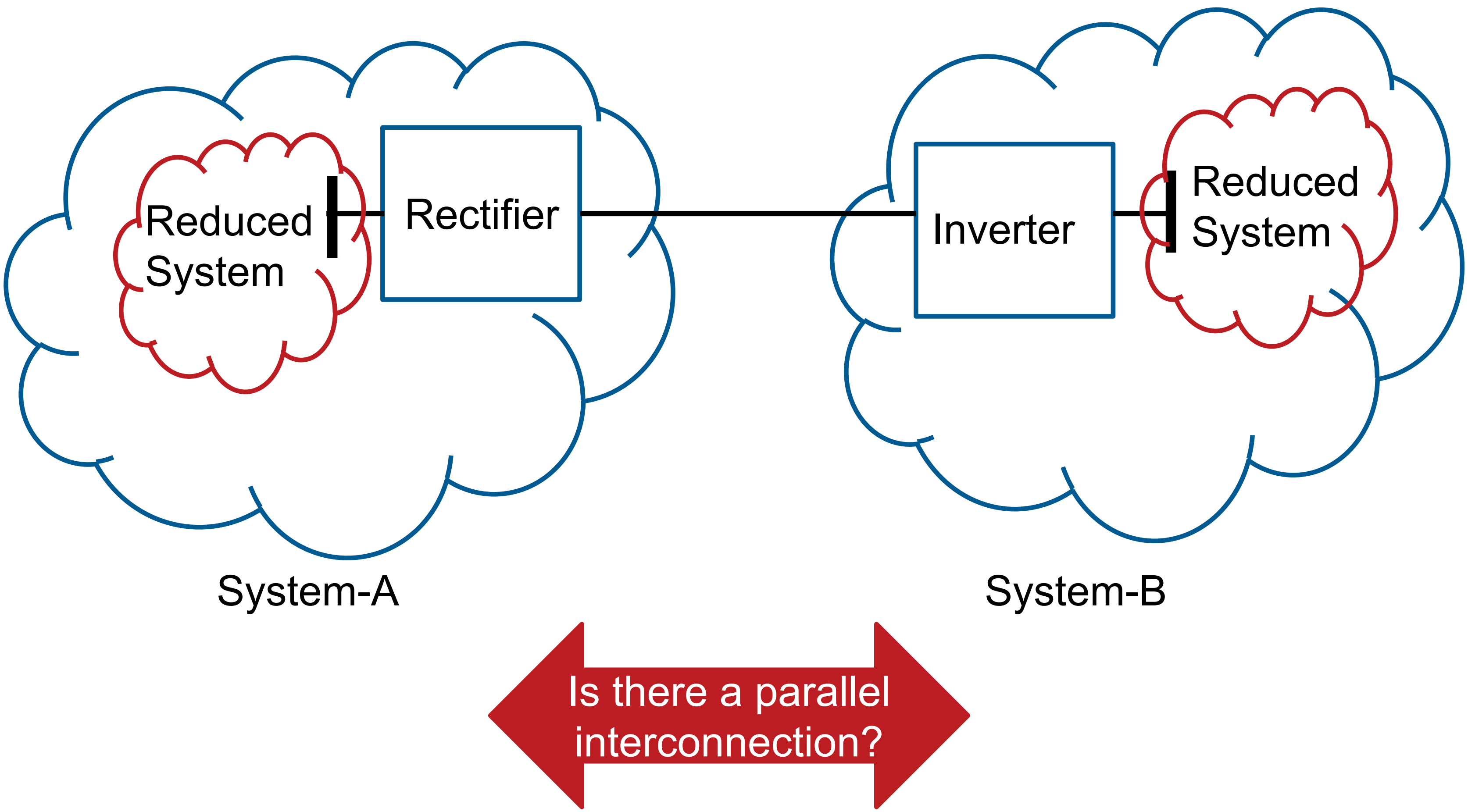
- When reducing the AC system, the following needs to be satisfied:
  - AC network should be able to fit in to the RTDS system available
  - The steady-state and dynamic performance of the reduced network should match the full system
    - SCL
    - Bus voltages and angle
    - Active and reactive power flows
    - Dynamic response at the terminal of the test equipment
      - Voltage and frequency response for a three-phase to ground fault

AC Network Reduction: For a HVDC transmission System



Network Reduction in PSS/E

- The Full network model is given in PSS/E
- Step 1
  - HVDC under study is modelled as a PQ load in the load flow (Positive P value for rectifier and negative Q value for Inverter)
    - 0MW transfer cases are created to validate the Inverter AC network
  - Aggregate multiple generators on the same plant to a single generator
  - Aggregate the coherent generators together
- Step 2:
  - Create a short-circuit equivalent of the area out side the area to be kept
  - Verify the power flow
- Step 3:
  - Dynamic response of the voltage and the frequency at the device connection point is matched with the full network
    - The parameters for the equivalent generators at the boundary busses will be tuned

Example #1: An HVDC Interconnection Project

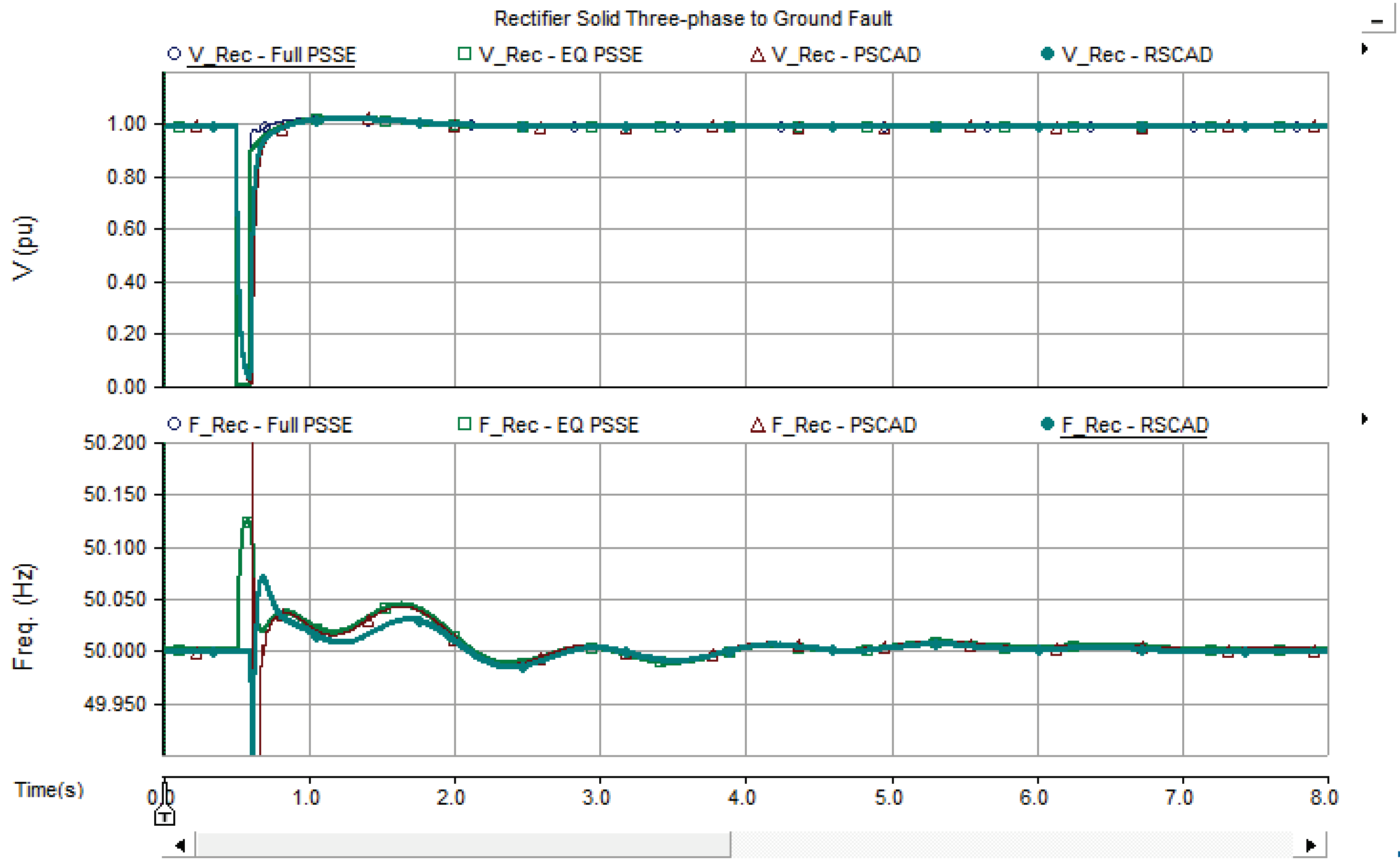
- Two isolated AC systems are connected via a HVDC transmission System
- AC network at the two terminals were needed to be reduced to fit in to the RTDS resources available:
- Challenges:
  - Large number of generators connected very close to both the terminals
  - Only a three rack RTDS (using GPC card) was available (2 racks for the HVDC stations and 1 rack for the AC system)
  - Space available to model only 9 generators, and maximum 24 buses

Procedure and Results

- A Reduced network was created in PSS/E
  - The largest error in fault level at the HVDC terminals was 0.14% and X/R was 0.5%
  - The largest error in the voltage magnitude and angles of the reduced network buses was 0.73% and 0.98%, respectively
- After validating the dynamic performance, RSCAD PSS/E conversion tool was used to create the RTDS network.

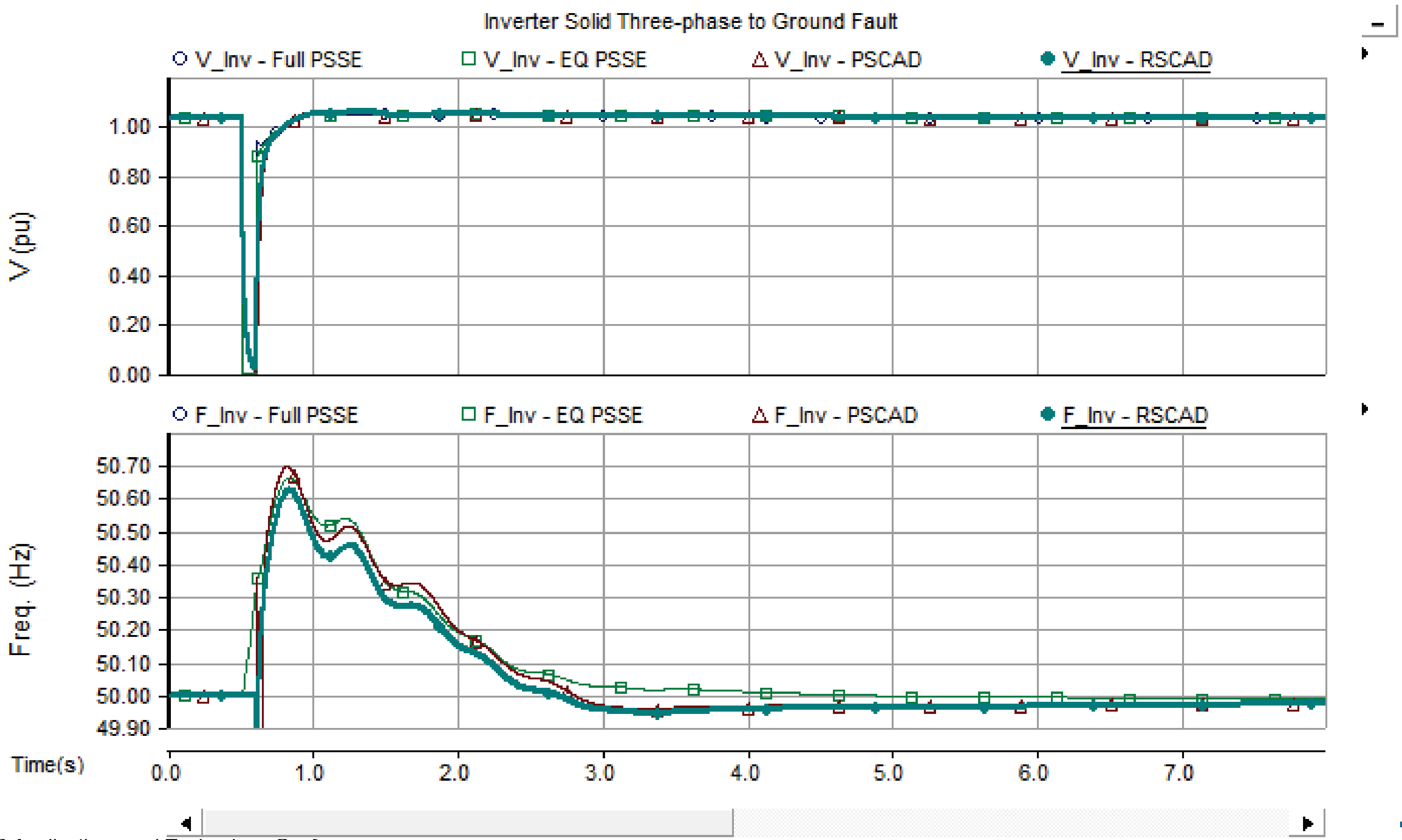
Response for Three-phase to Ground Fault at System-A (Rectifier)

- Case1: Power Transfer System-A -> System-B



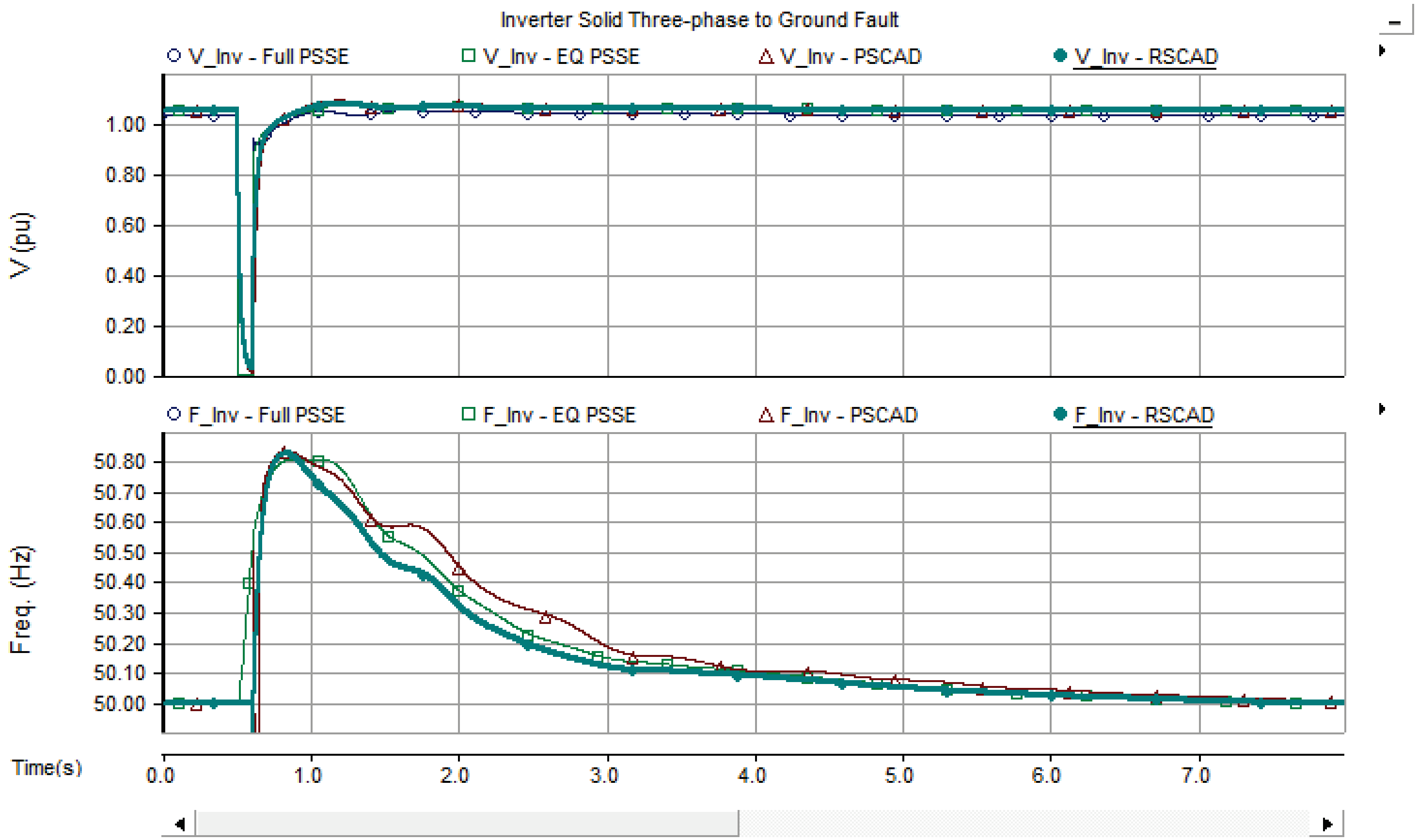
Response for Three-phase to Ground Fault at System-B (Rectifier)

- Case 2: Power Transfer System-B -> System-A



Response for Three-phase to Ground Fault at System-B (Inverter)

- 0 MW Power Transfer with Case 1 network configuration



Example #2: An HVDC Interconnection Project

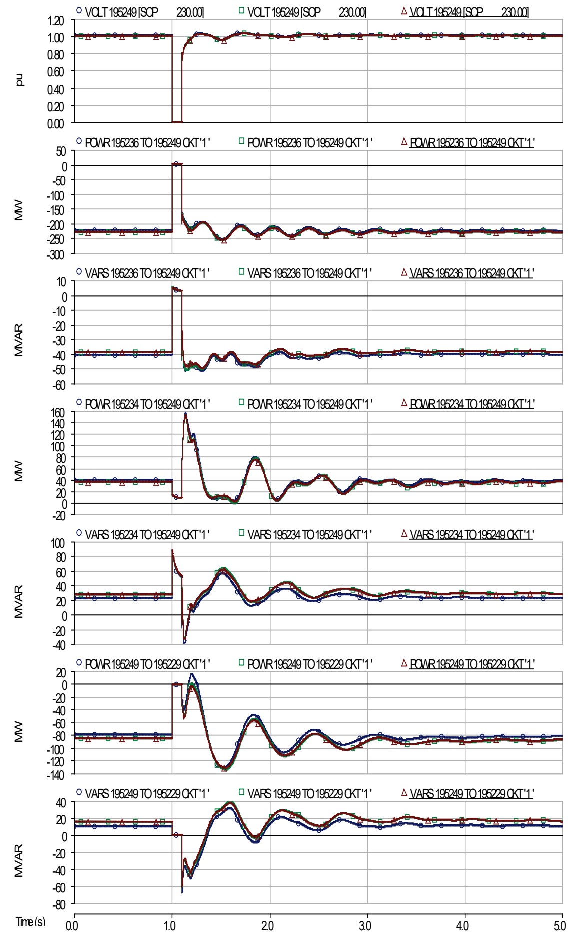
- Two isolated AC systems are connected via a HVDC transmission System
- AC network at the two terminals were needed to be reduced to fit in to the RTDS resources available:
- Challenges:
  - Larger system to be tested
    - 373 buses
  - Maintain frequency response of system
  - Limited number of racks

Example #2: An HVDC Interconnection Project

Blue – Full PSSE case (373 buses)

Green – Reduced case for PSCAD conversion (234 buses)

Red – Reduced case for RTDS (90 PSSE buses, 51 RTDS buses)



Thank you!

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