Dynamic Equivalancing for RTDS

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Outline

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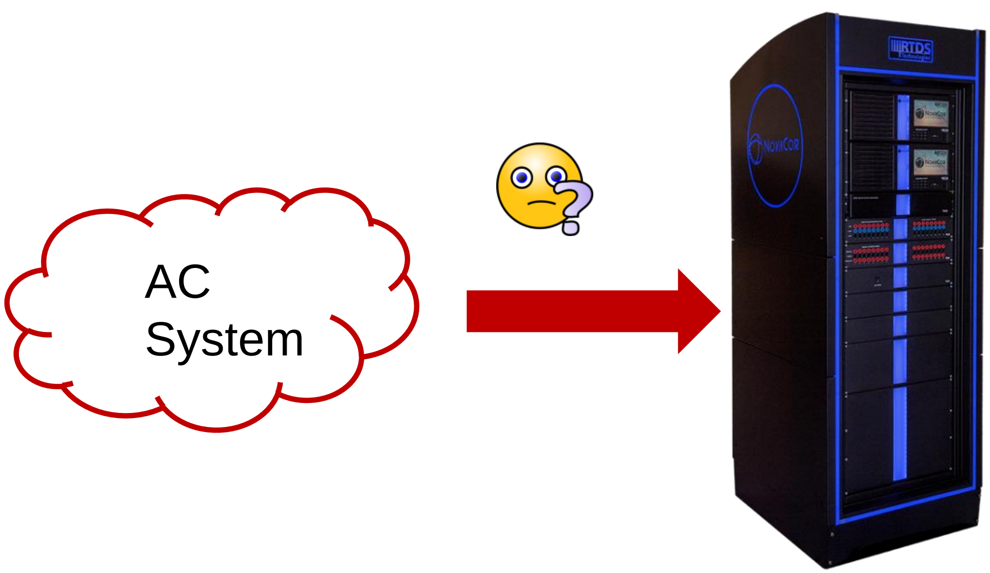
- Network Reduction
- Applications
- Some results
- Summary

Introduction

- With the addition of HVDCs and FACTS devices today's power systems have become complex
- Dynamics of these devices are dominated by the controls
- Interactions between the devices need to be studied
- Need to accurately model the system
  - Control hardware replicas are used

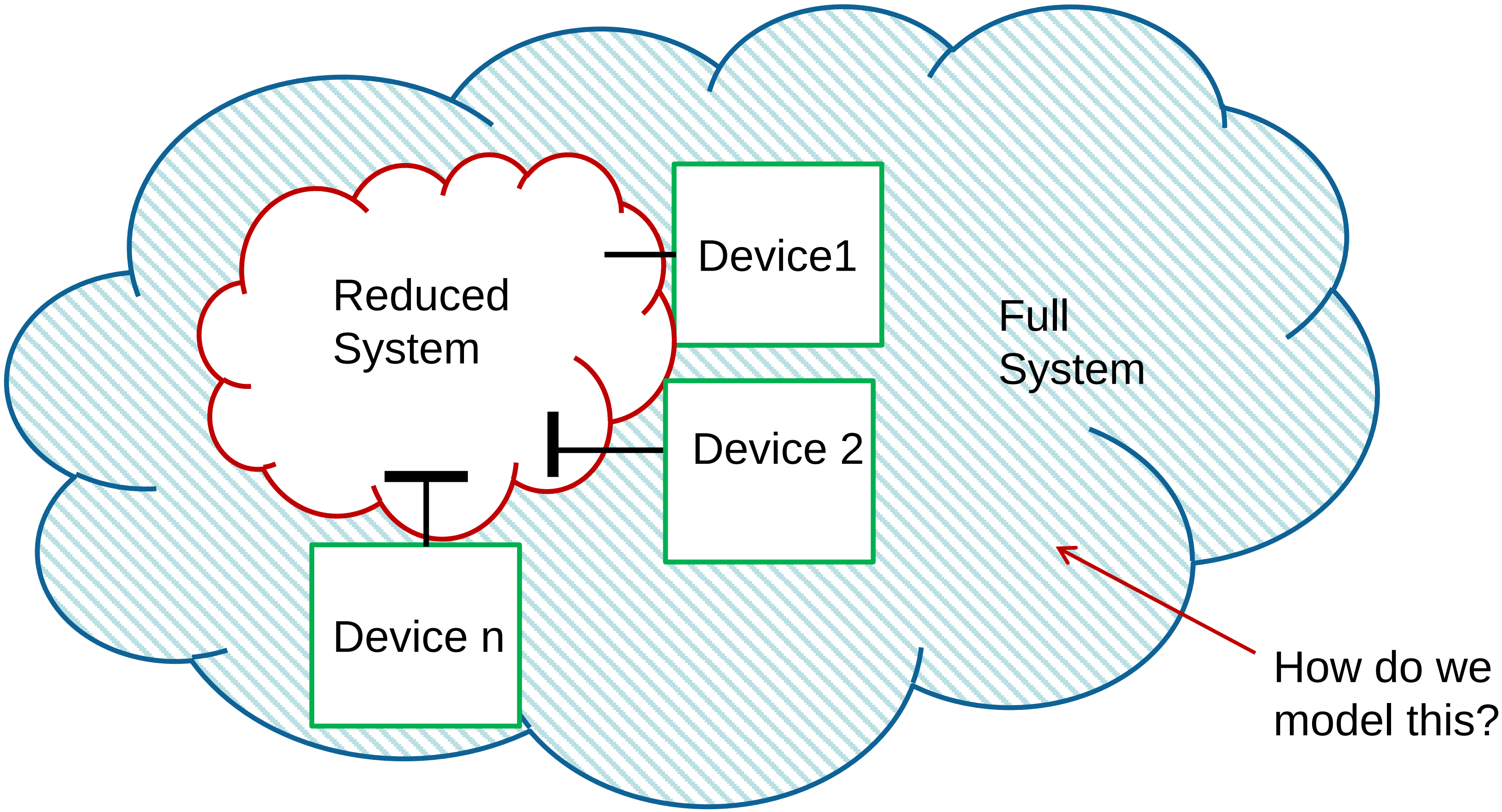
Introduction

- Only a limited number of RTDS racks are available



- Able to fit
- Accuracy
- As detailed as possible

AC Network Reduction



AC Network Model

- Static equivalents
  - Good steady state performance
- Co-simulation
- Dynamic equivalents
  - Good steady state performance
  - Good dynamic performance at selected buses

Network Reduction in PSS/E

- The Full network model is given in PSS/E
- Step 1
  - Identify the area to be retained in detail
  - 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

Applications

- Dynamic Performance Testing (DPT)
- Integrated AC System Models
  - One or multiple control replicas may be used
  - AC system studies
  - Interaction studies
  - Operator training

Example1: An HVDC Interconnection Project

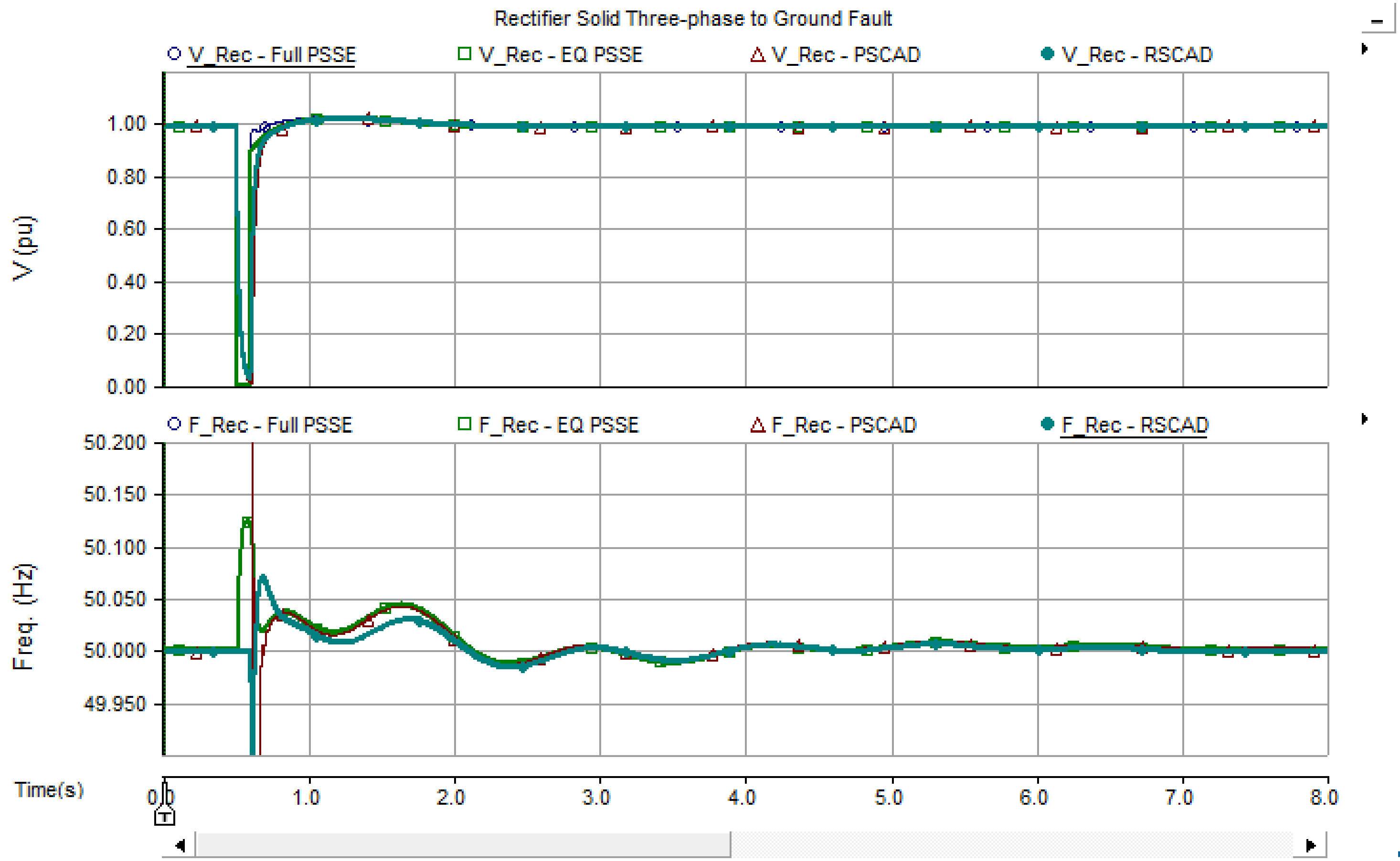
- Two isolated AC systems are connected via a HVDC transmission System
- AC network at the two terminals were needed to be reduced to fit in to the RTDS resources available:
- Challenges:
  - Large number of generators connected very close to both the terminals
  - Only three racks (using GPC) cards 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.

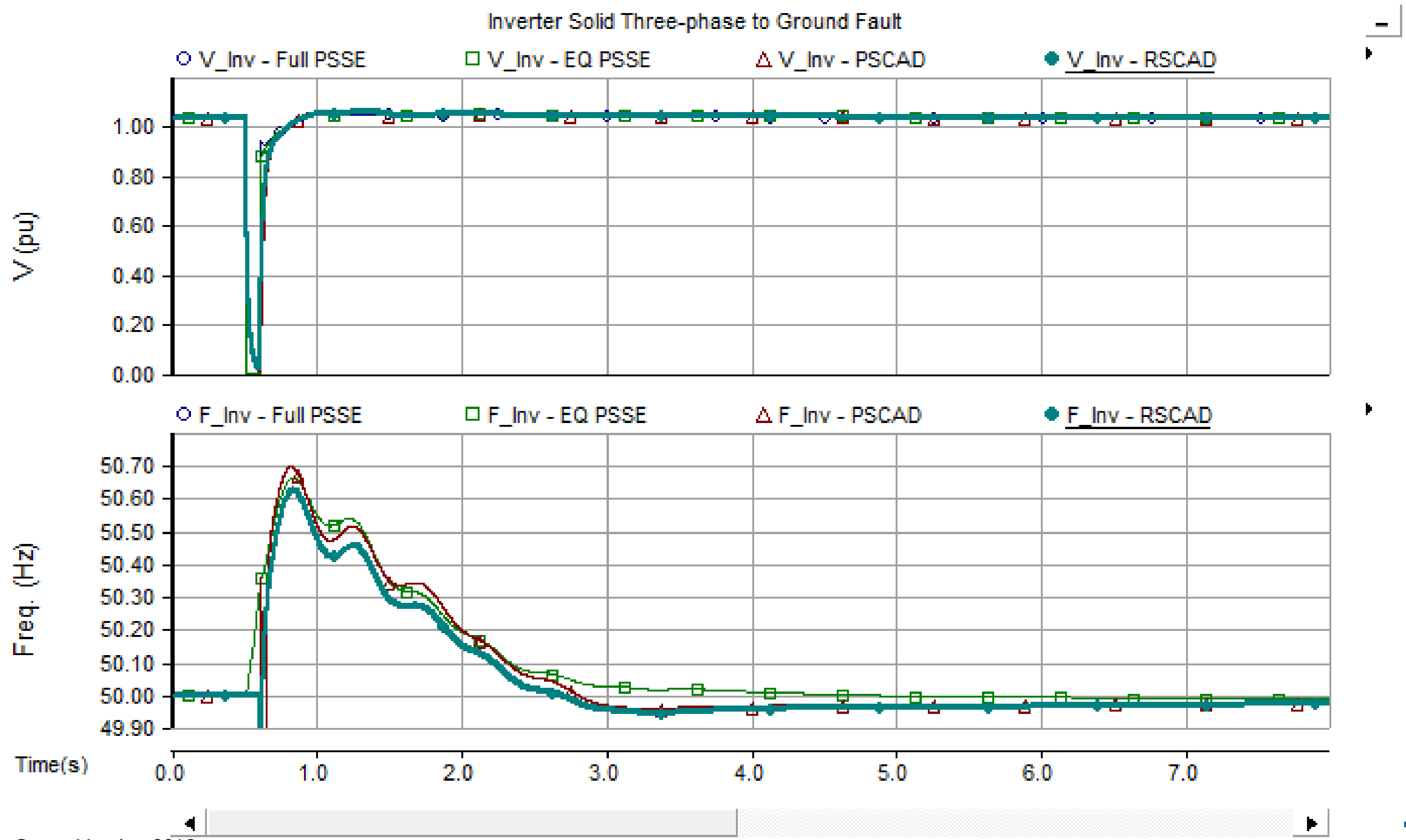
Response for Three-phase to Ground Fault at System-A (Rectifier)

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



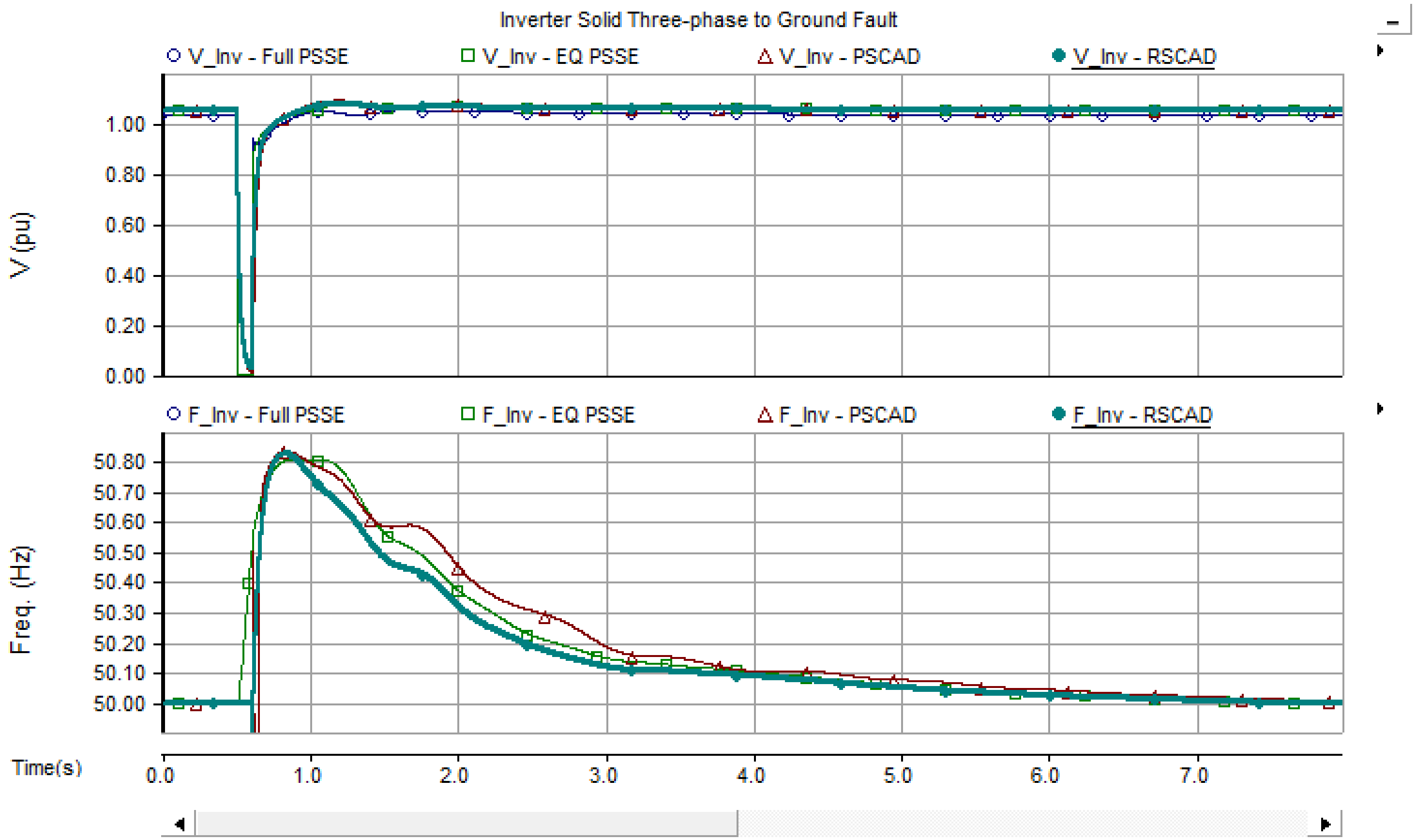
Response for Three-phase to Ground Fault at System-B (Rectifier)

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



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

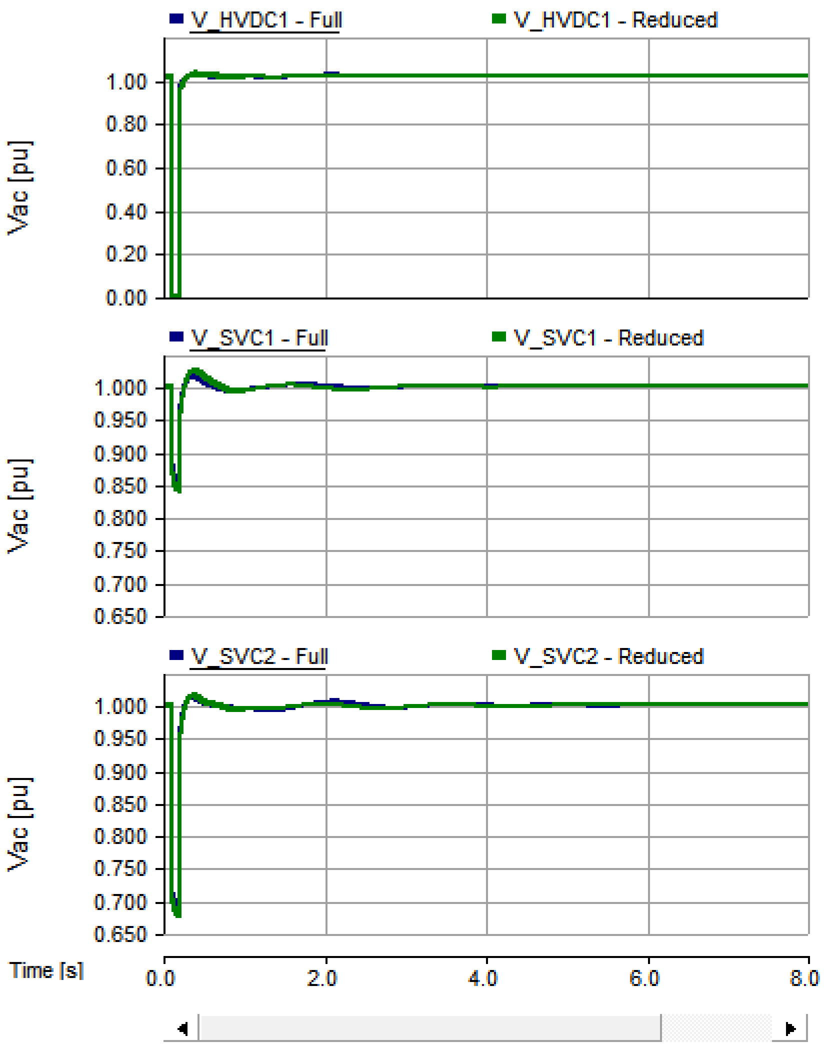
- 0 MW Power Transfer with Case 1 network configuration

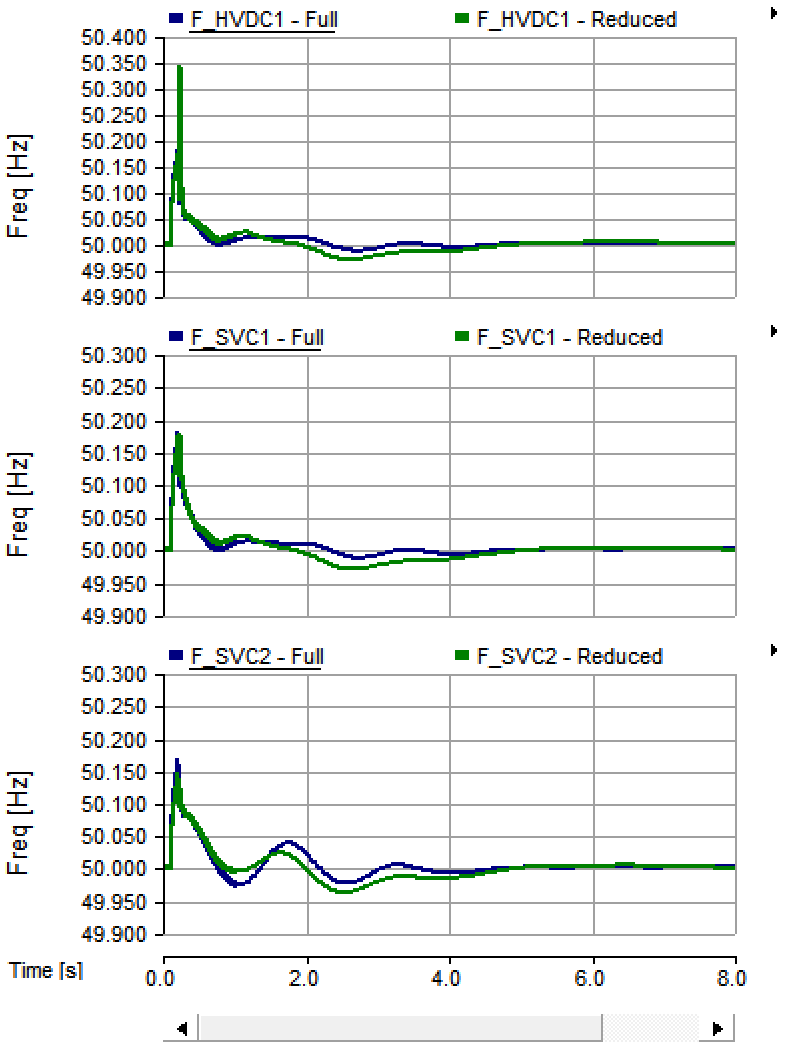


Example 2: AC system Model of a Large Power System

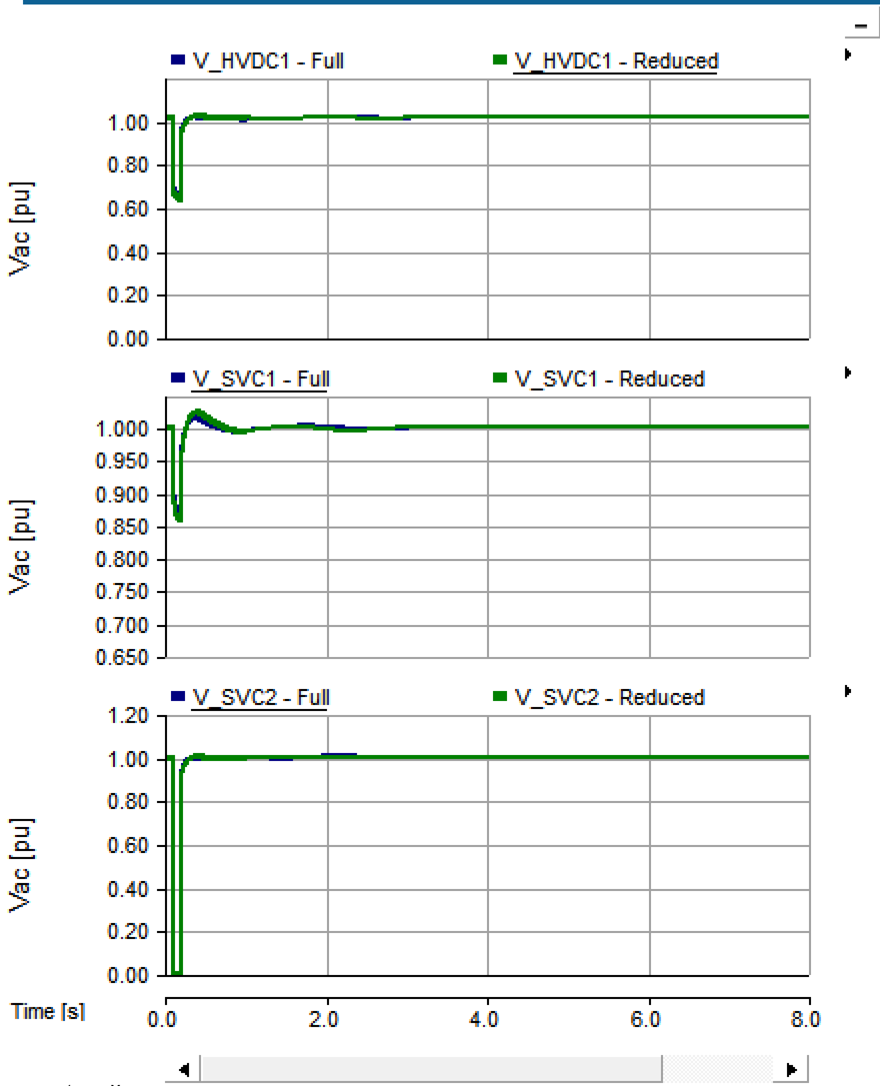
- A large Power System to be modelled
  - Number of buses needed to be reduced by about 90%
  - Around 30 HVDC FACTS terminals was needed to be modelled
  - The steady-state and dynamic responses at all the terminals needed to be matched with the full system

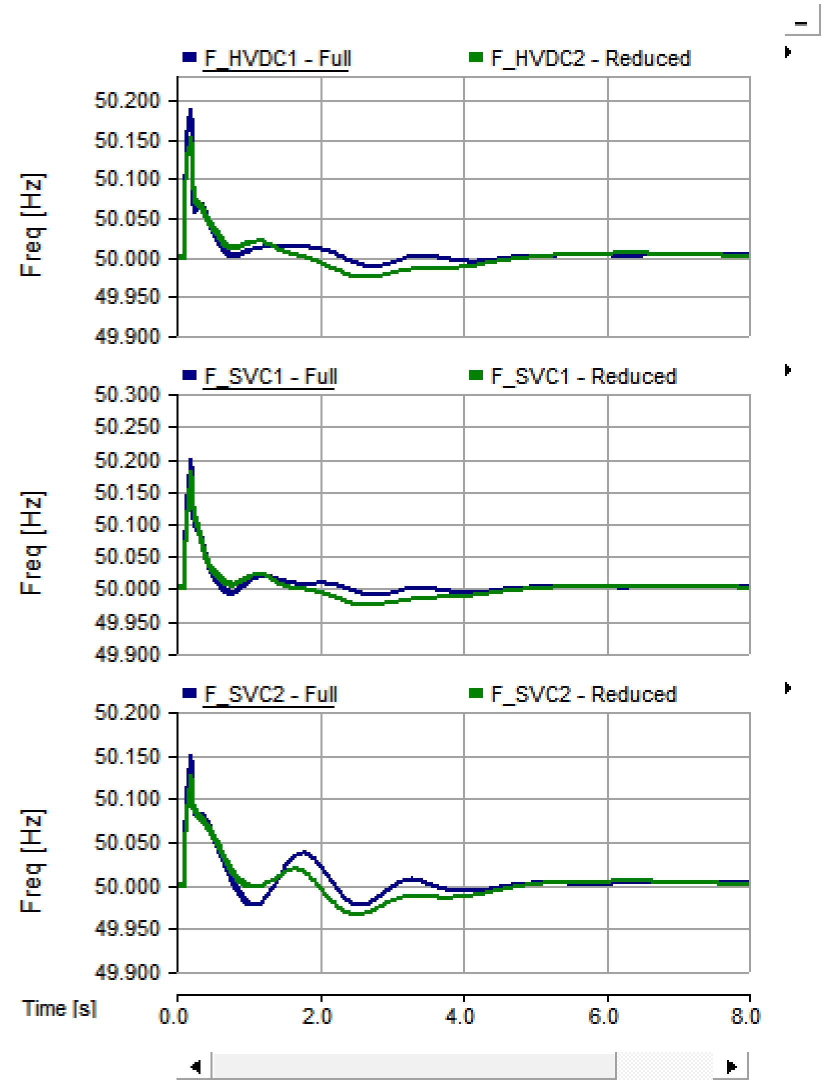
Response for Three-phase to Ground Fault at HVDC1 Terminal 1





Response for Three-phase to Ground Fault at SVC 2 Terminal





Summary

- The need to model a large power system in RTDS is increasing because of the presence of non conventional devices
- It's a challenge to create a small AC system which can fit into the available RTDS
  - Need to match the steady-state performance
  - Need to match the dynamic response
- Dynamic equivalents can address both these requirements successfully

Thank you!

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