IBR EMT Model Validation

Using Point-on-Wave Data & Playback Method

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EMT MODEL VALIDATION

Using Point-on-Wave (POW) Data Playback

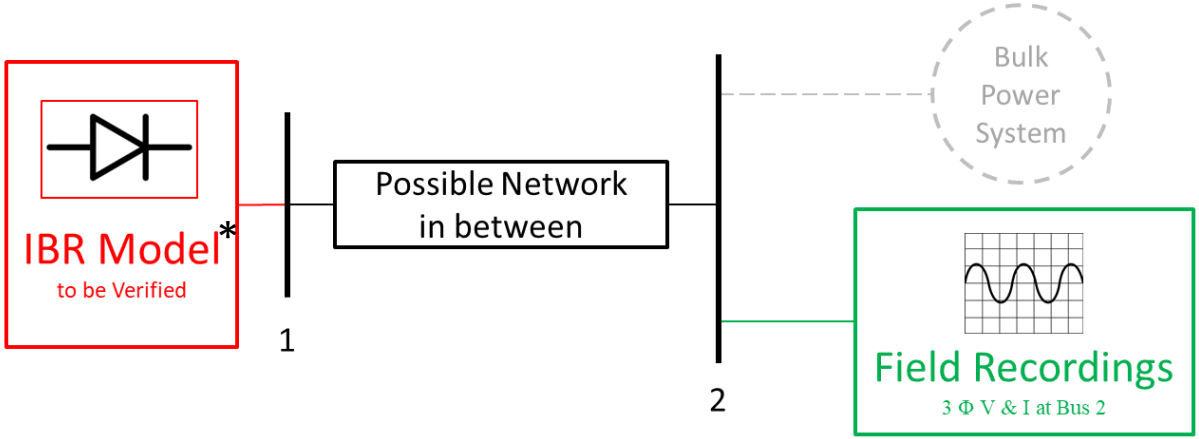
-- Developed by our former intern Haoyuan "Harry" Sun from UTK

ISO-NE Business Needs

- ISO-NE has well documented EMT model requirements, defined in Planning Procedure No. 5-6
  - Model accuracy, usability, and efficiency
- ISO-NE is also in the process to adopt IEEE P2800-2022 for IBR performance requirements
- The accuracy of the EMT models is key to our Planning and Operations studies
- However, we lacked an automated tool and process to validate EMT models against field measurements following a grid disturbance

Problem Formulation

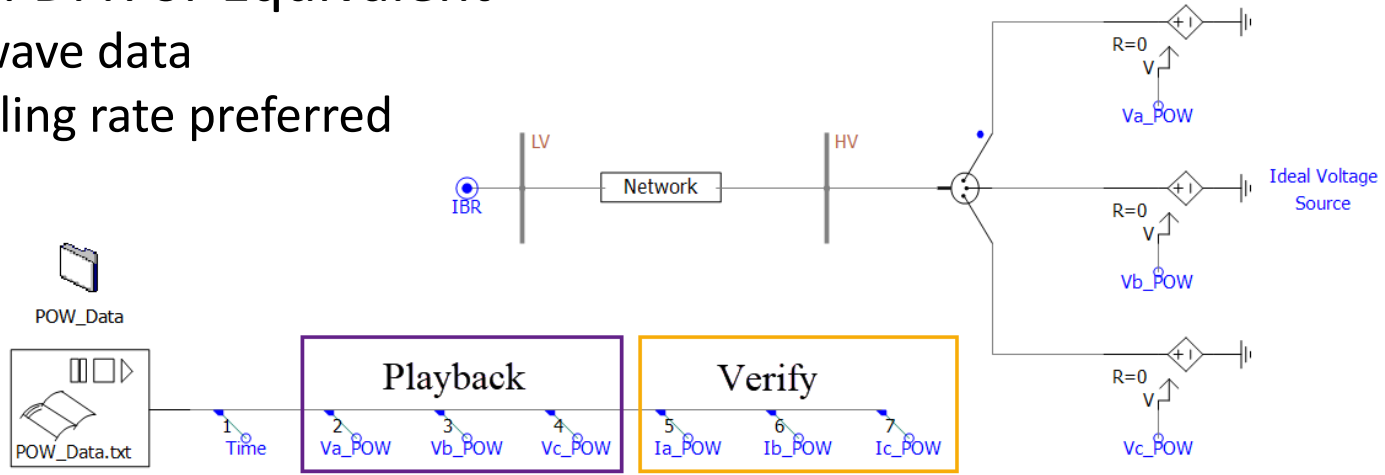
- IBR – (Radial Network) – System.
  - Similar to the power plant model validation for phasor models.



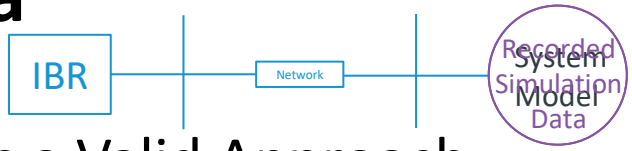
*Assuming all internal controls are known and are properly modeled.

Software Platform and Data Source

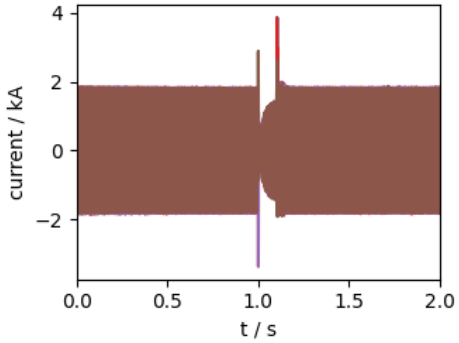
- Software: PSCAD
  - Available playback modules:
    - File read, ideal voltage source
- Data Source: DFR or Equivalent
  - Point-on-wave data
  - High sampling rate preferred

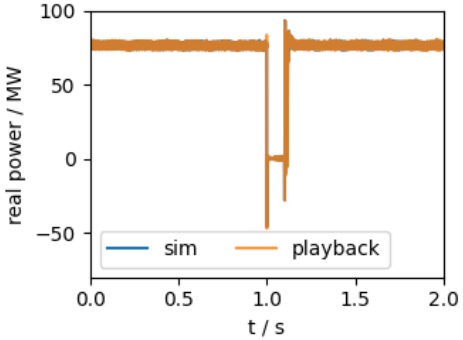


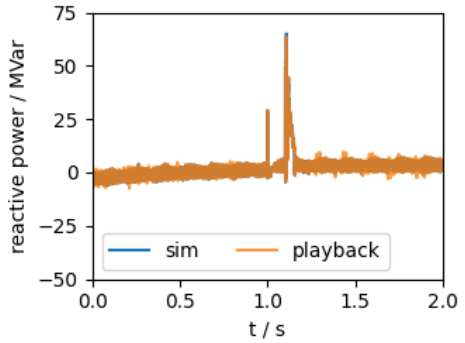
Benchmark with Simulation Data

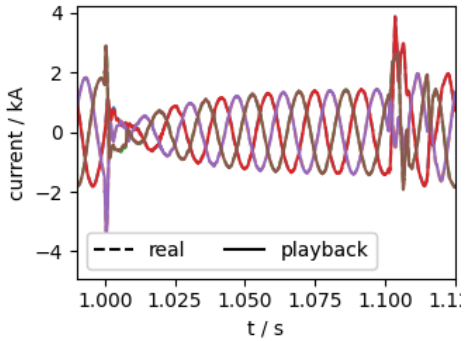


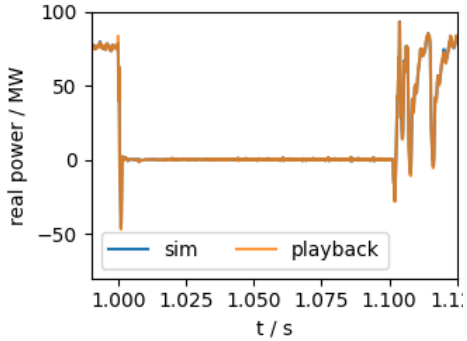
- Exact Match Verifies That EMT Playback is a Valid Approach.

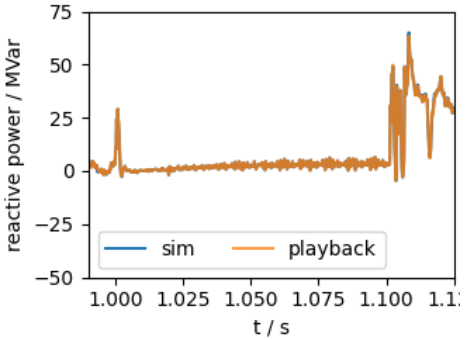






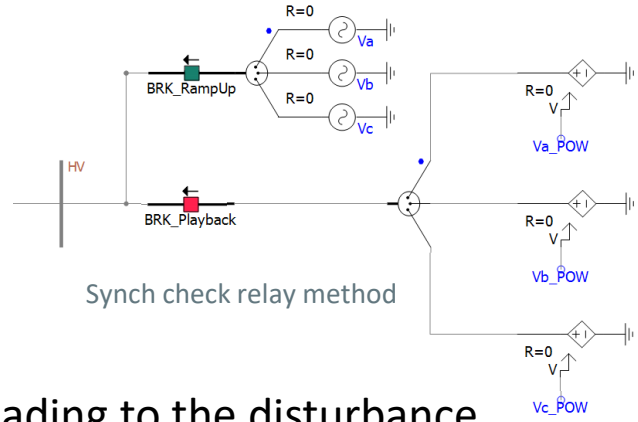






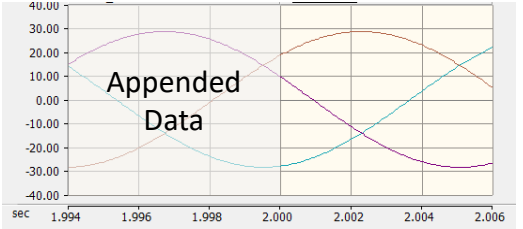
Technical Innovation

- Ramp-up Methods
  - Challenges:
    - IBR may need a few seconds to ramp up
    - DFR data usually have a short time window leading to the disturbance
  - Solutions:
    - Option 1: Use a sync check relay
      - Ramp up against an “ideal voltage source”
      - Switch to the “DFR-data voltage source” after steady-state
    - Option 2: Append the POW data file
      - Add seconds of ideal POW data in the beginning
      - Final implementation uses an automated version of this method for simplicity



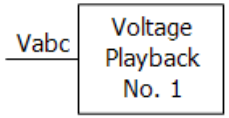
Synch check relay method

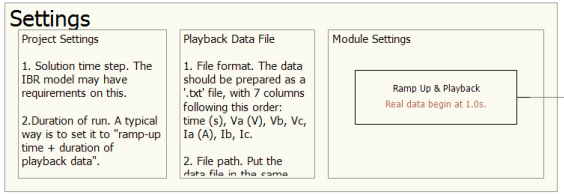
Append DFR data file method

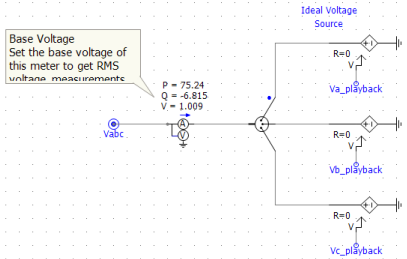


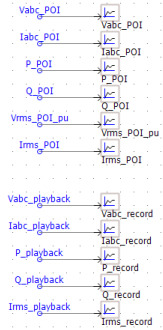
Software Development

- Pro-version Playback Module
  - Packaged all playback functions info a PSCAD module
    - Defined parameters
    - Wrote the script
  - Automatically assists the ramp-up
    - Outputs ideal voltage waveform during ramp-up period
    - Outputs DFR data from file after IBR reaches steady-state



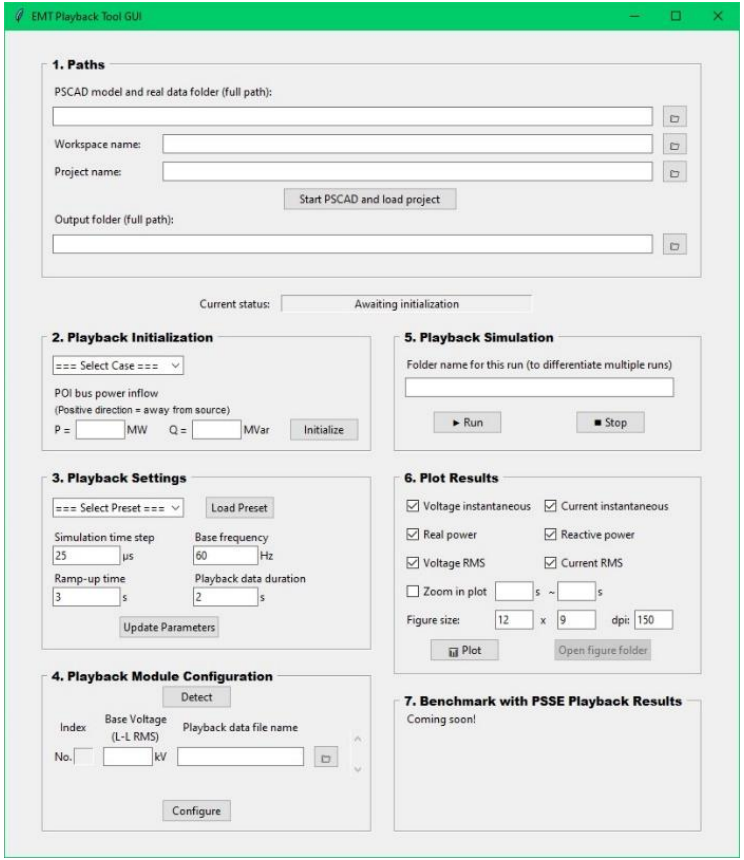






Software Development

- Auto-version Playback GUI
  - Python GUI
  - Requires a one-time manual PSCAD case setup
    - Copy the pro-version module to the case
  - Calls PSSE to solve gen output
  - Calls PSCAD to setup and run playback
  - Plots results



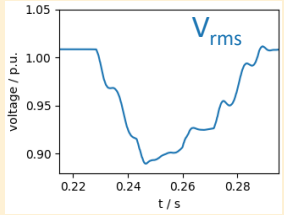
EMT MODEL VALIDATION

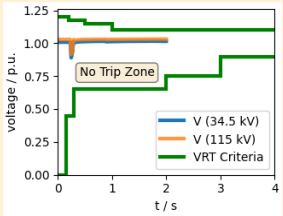
– Case Study

Case Info

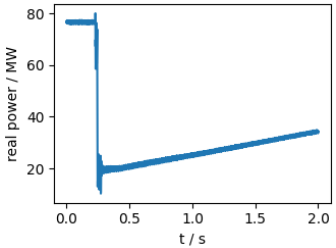
- Subject IBR:
  - ~80 MW solar power plant
- Event:
  - Fault on a bus and tripped a station
    - A few buses away from the IBR
  - Several 115 kV lines were tripped
- IBR Performance:
  - Failed to ride-through the event
  - Output dropped to 20 MW (DFR)
  - Recovery took ~50 seconds (SCADA)

Derived RMS Voltage

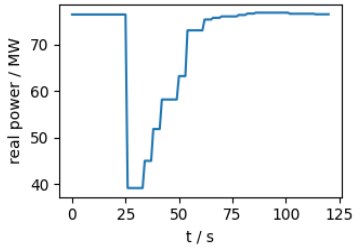




DFR



SCADA



EMT Playback Results

Plain Playback

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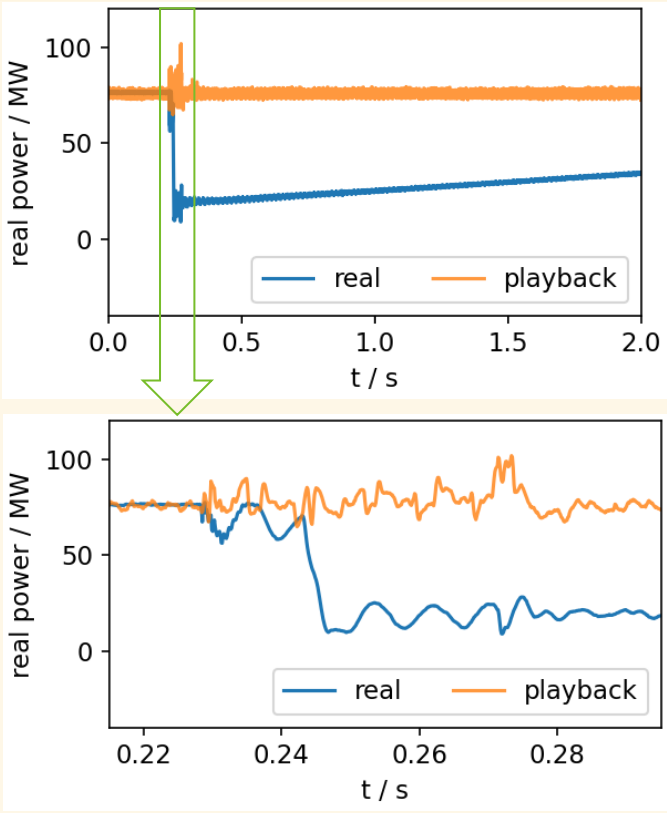
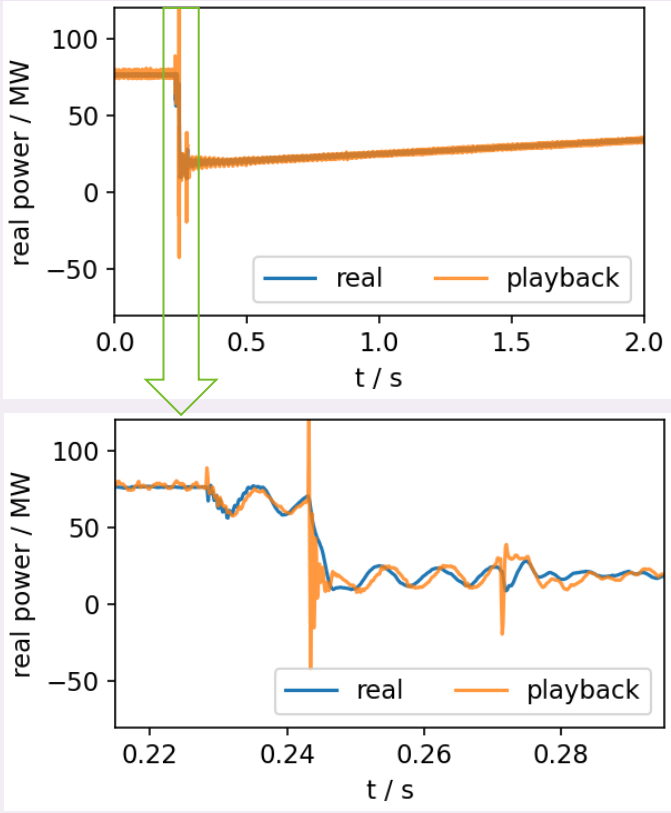
Original Model (Routine)





Tuned Playback

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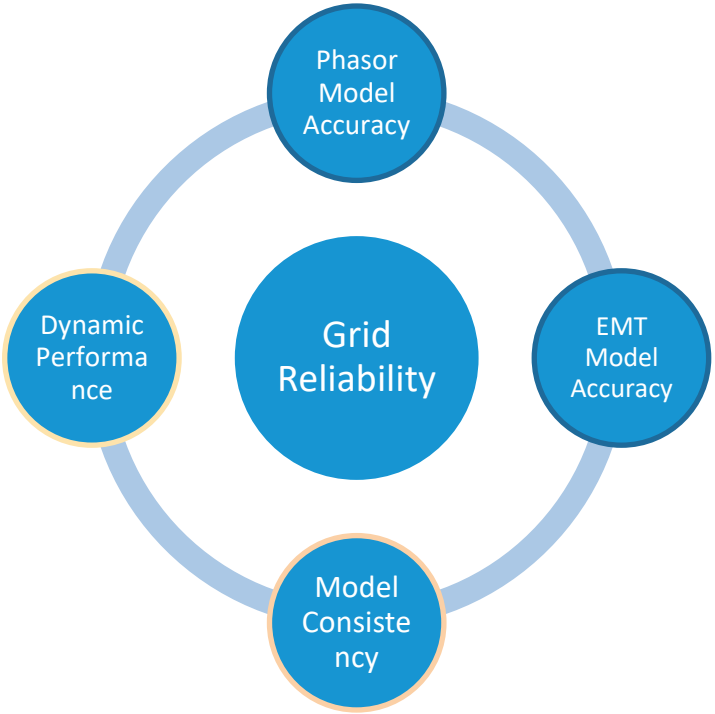
Hypothetic Controls (Explore)

Four Elements To Complete The Circle

- Two Missing Pieces
  - Phasor – EMT Model Consistency
    - Life-cycle management
  - Field Asset Dynamic Performance



Questions