IBR Model Verification Using Measurement Playback Method

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ISO-NE PUBLIC

Outline

- EMT model verification using point-on-wave data playback
- EMT model verification case study
- Transient stability (positive sequence phasor) model verification using PMU data playback
- Conclusion and future work

EMT MODEL VERIFICATION (NEW IN 2023)

Using Point-on-Wave (POW) Data Playback

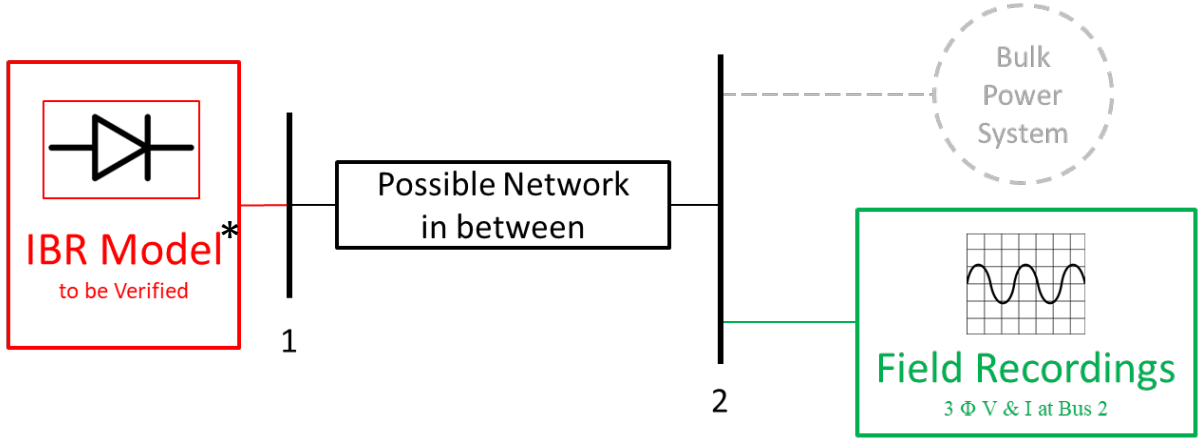
-- Developed by our intern Haoyuan "Harry" Sun from UTK

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

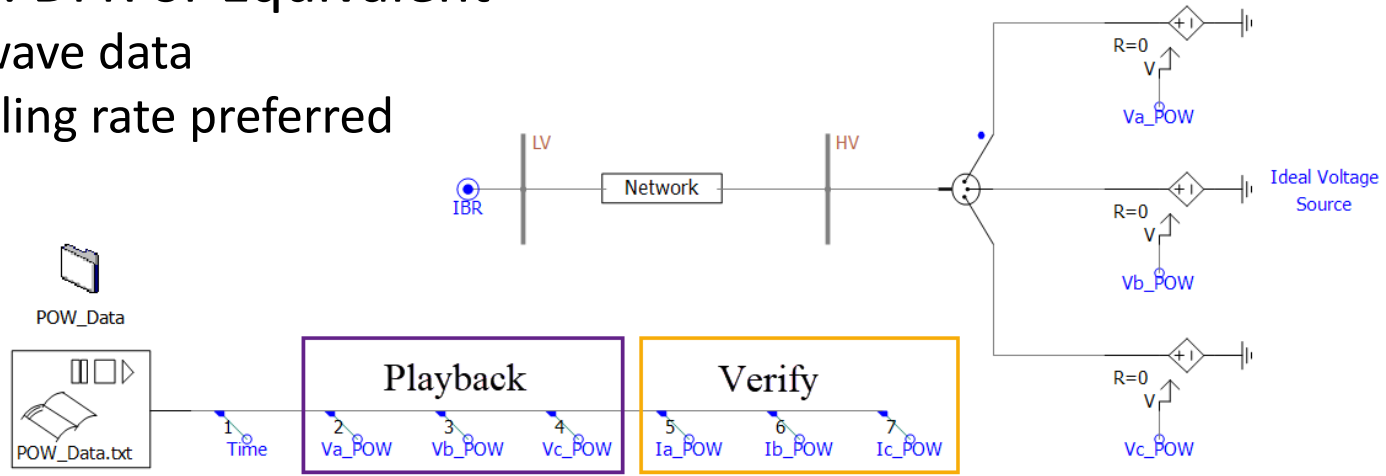
- IBR – (Radial Network) – System.
  - Similar to transient stability model power plant model verification.



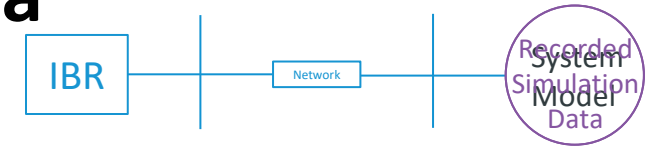
*Assuming all internal controls are known and are properly modeled.

Software Platform and Data Source

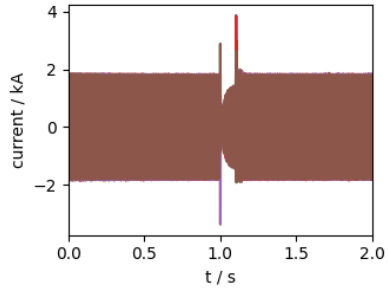
- Software: PSCAD
  - Available playback modules:
    - File read, ideal voltage source
- Data Source: DFR or Equivalent
  - Point-on-wave data
  - High sampling rate preferred

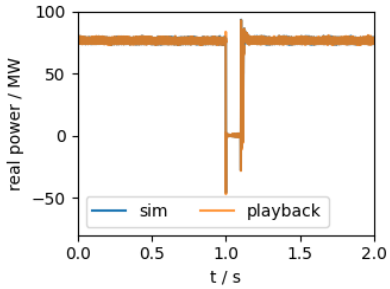


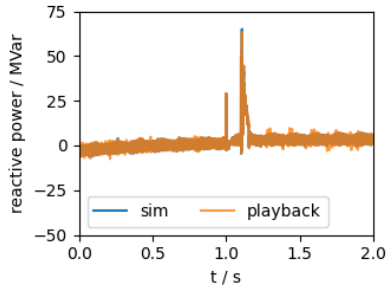
Benchmark with Simulation Data

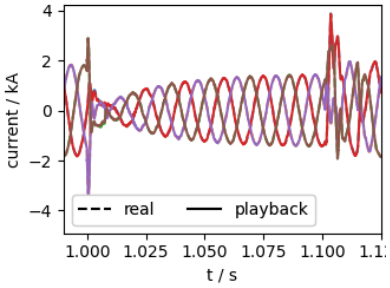


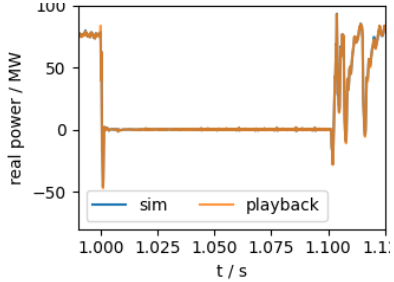
- Playback PSCAD simulation data
- Exact match shows that the EMT playback is a valid approach.

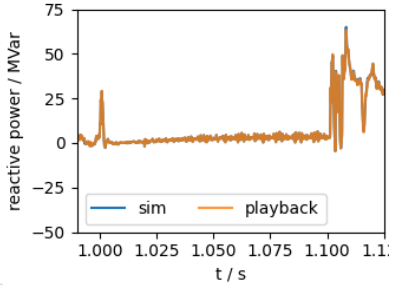






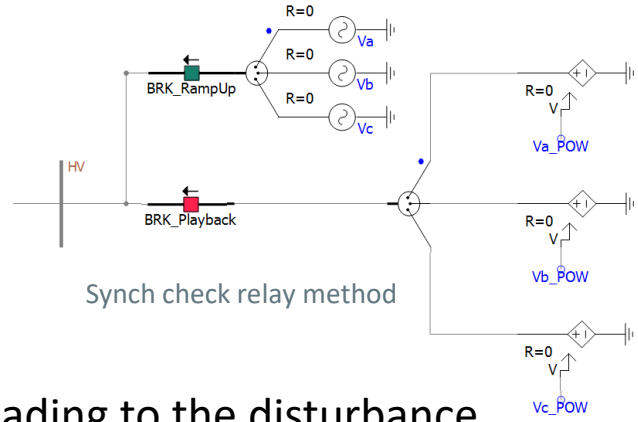






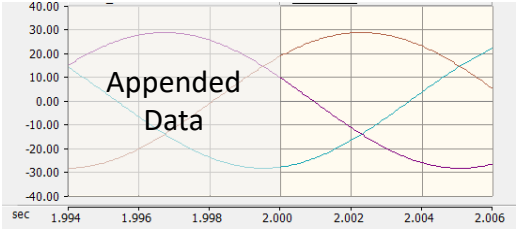
Technical Innovation

- 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



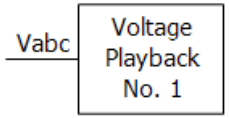
Synch check relay method

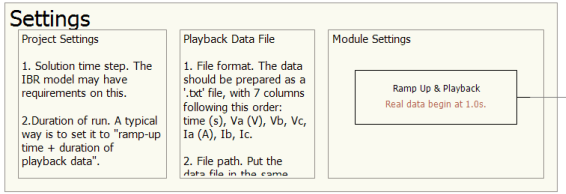
Append DFR data file method

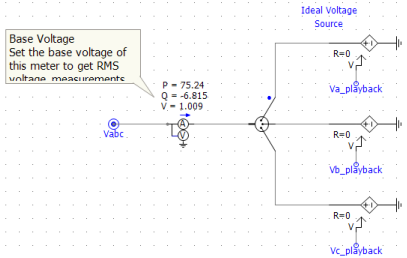


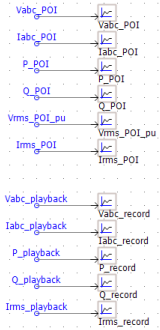
Software Development

- Pro-version playback module
  - Packaged all playback functions info a 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 steady-state



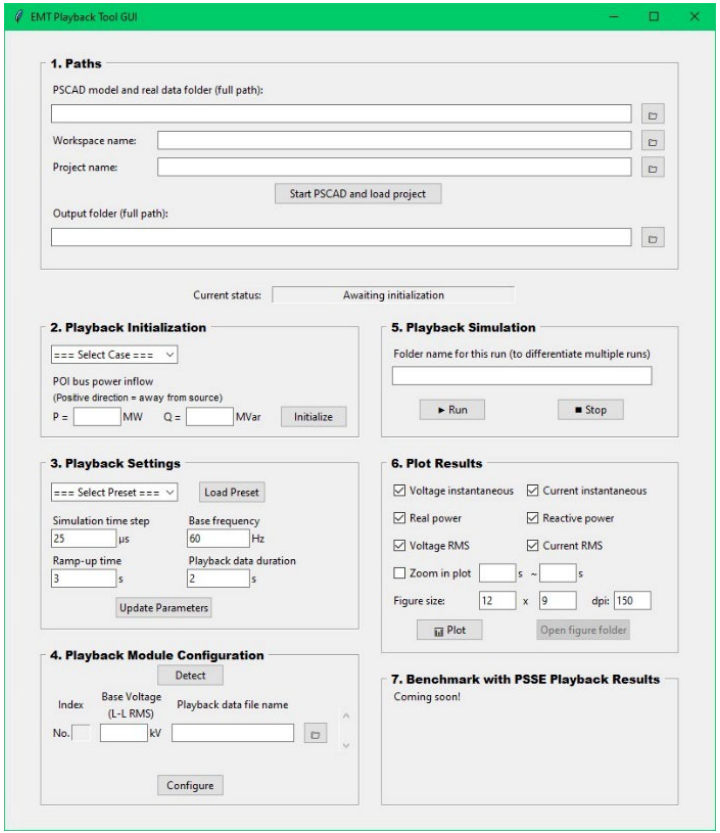






Software Development(Con't)

- 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



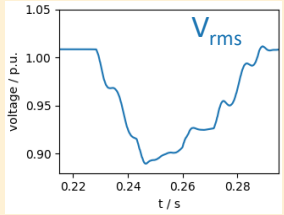
EMT MODEL VERIFICATION

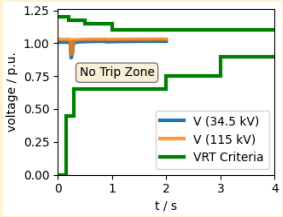
– Case Study

Case Info

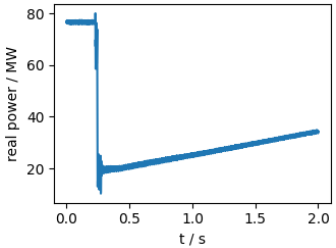
- Subject IBR:
  - ~80 MW solar power plant
- Event:
  - Fault on a bus and tripped a station
    - A few buses away from the IBR
  - Several 115 kV lines were tripped
- IBR Performance:
  - Failed to ride-through the event
  - Output dropped to 20 MW (DFR)
  - Recovery took ~50 seconds (SCADA)

Derived RMS Voltage

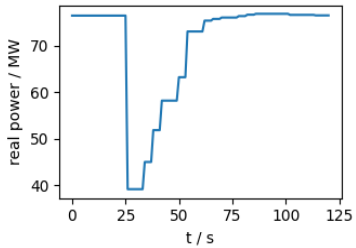




DFR



SCADA

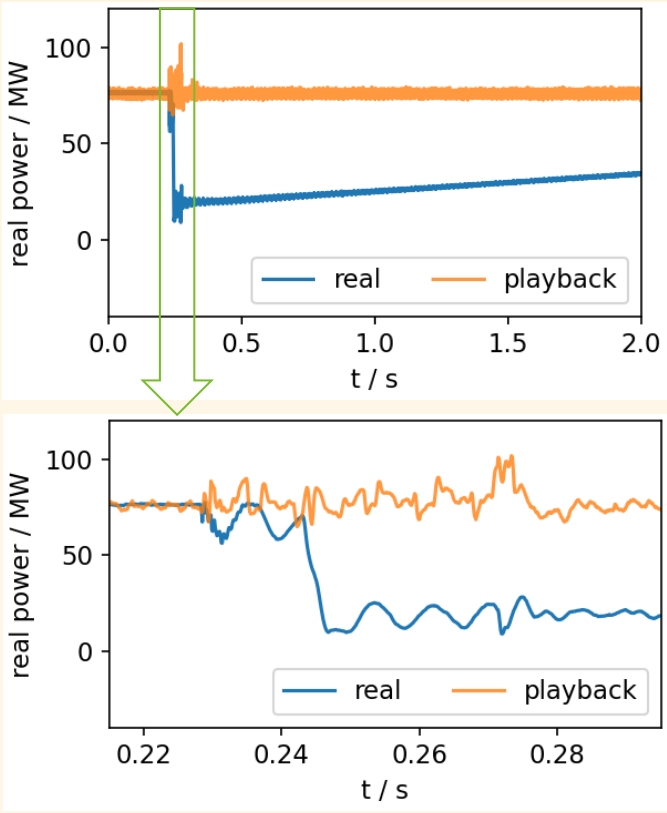


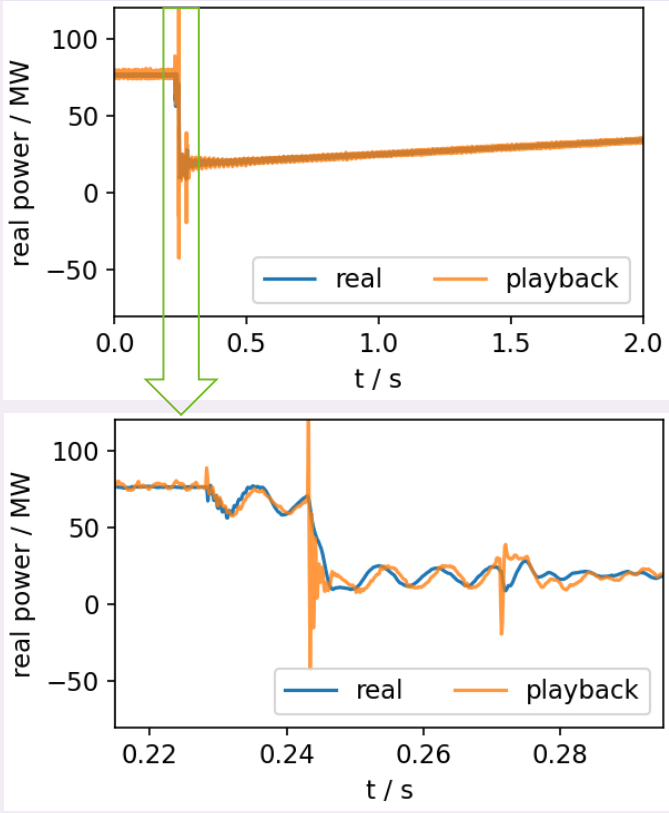
EMT Playback Results

Vanilla Playback

w/

Original Model (Routine)





Chocolate Playback

w/

Hypothetic Controls (Explore)

TS MODEL VERIFICATION (SINCE 2018)

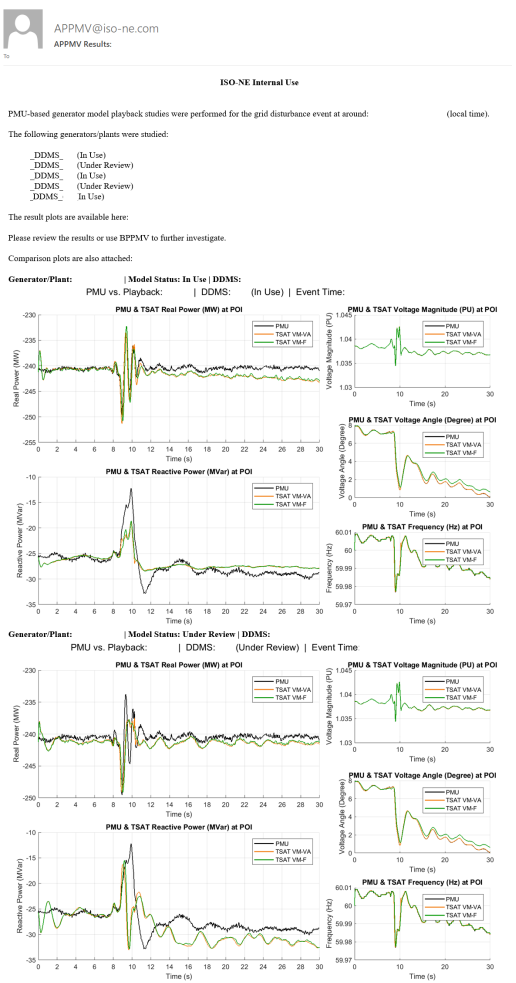
Using PMU Data Playback

-- Developed by our interns "Marie" Meng Wu (ASU), Weihong Huang (NYPA)

APPMV – Online Service

- Automatic Power Plant Model Verification
  - Transient model
  - Playback PMU data during grid disturbances
  - Multiple model versions for each plant

- Automation
  - Runs 24*7 as a service
  - Runs PPMV for (real) grid disturbances
  - Sends out results through email


APPMV@iso-ne.com
APPMV Results:

ISO-NE Internal Use

PMU-based generator model playback studies were performed for the grid disturbance event at around: (local time).

The following generators/plants were studied:

DDMS (In Use)
DDMS (Under Review)
DDMS (In Use)
DDMS (Under Review)
DDMS In Use)

The result plots are available here:

Please review the results or use BPPMV to further investigate.

Comparison plots are also attached:

Generator/Plant: | Model Status: In Use | DDMS:
PMU vs. Playback: | DDMS: (In Use) | Event Time:

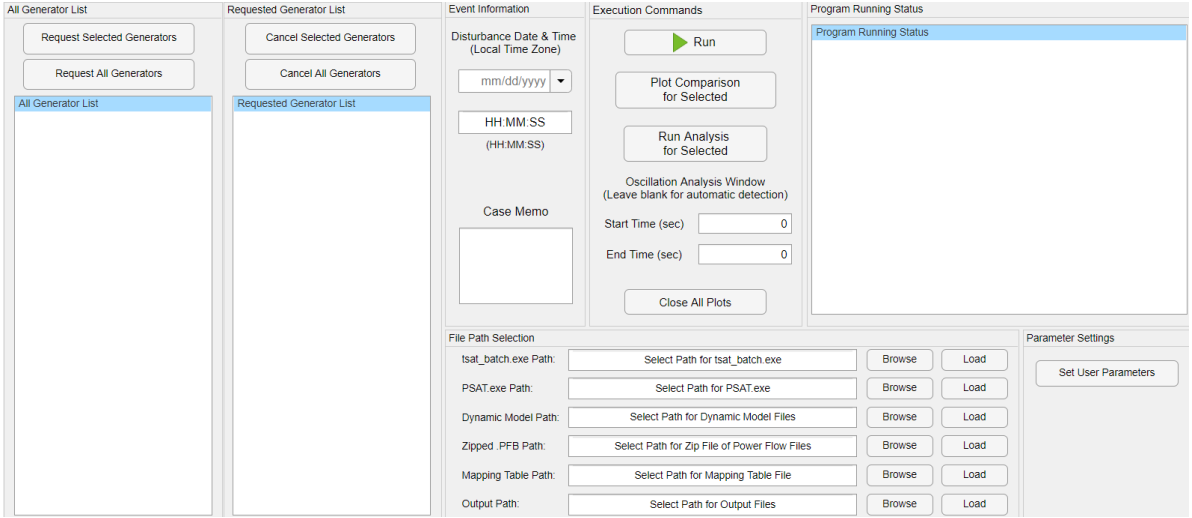
PMU & TSAT Real Power (MW) at POI
PMU & TSAT Voltage Magnitude (PU) at POI
PMU & TSAT Voltage Angle (Degree) at POI
PMU & TSAT Reactive Power (MVar) at POI
PMU & TSAT Frequency (Hz) at POI
PMU
TSAT VM-VA
TSAT VM-F
Time (s)

Generator/Plant: | Model Status: Under Review | DDMS:
PMU vs. Playback: | DDMS: (Under Review) | Event Time:

PMU & TSAT Real Power (MW) at POI
PMU & TSAT Voltage Magnitude (PU) at POI
PMU & TSAT Voltage Angle (Degree) at POI
PMU & TSAT Reactive Power (MVar) at POI
PMU & TSAT Frequency (Hz) at POI
PMU
TSAT VM-VA
TSAT VM-F
Time (s)

BPPMV – Offline GUI Tool

- Batch Power Plant Model Verification
  - One-click verifies multiple models for the same grid event
  - Enables detailed offline studies



Future Work

- Plan to add more IBRs into the TS model verification process
- Plan to compare/validate IBRs' TS models with EMT models using field measurements following a grid disturbance
- Working with Compliance group to integrate both tools into the business process of model verification

Questions