

IBR Model Verification Using Measurement Playback Method



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MANAGER, ADVANCED TECHNOLOGY SOLUTIONS



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

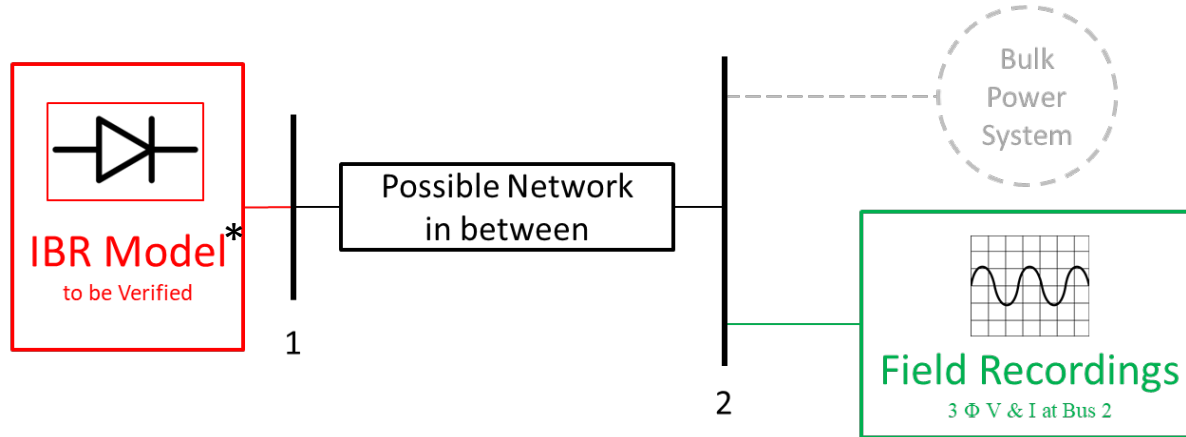
ISO-NE Business Needs

- 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.

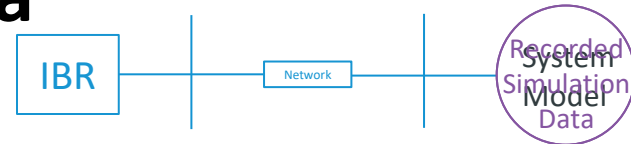


*Assuming all internal controls are known and are properly modeled.

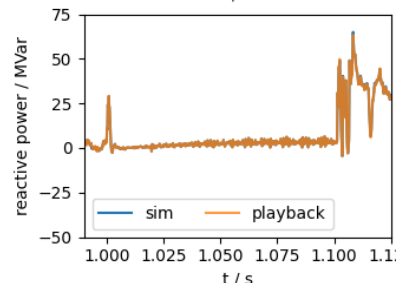
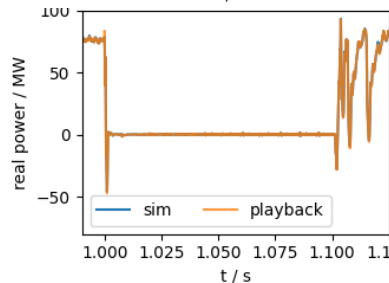
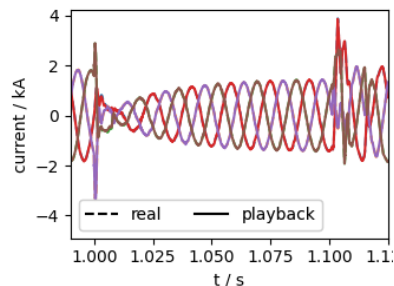
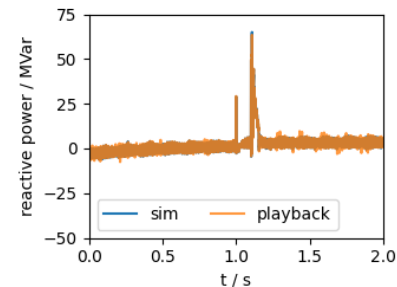
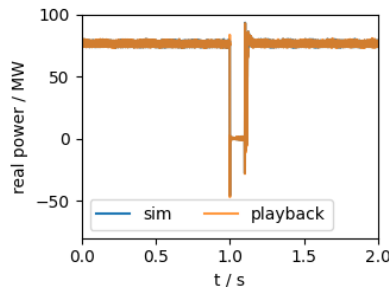
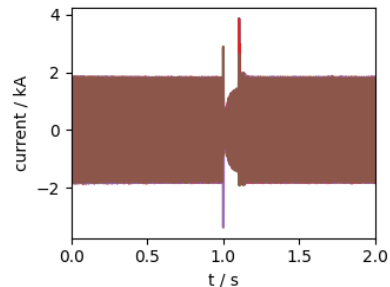
- Software: PSCAD
 - Available playback modules:
 - File read, ideal voltage source
- Data Source: DFR or Equivalent
 - Point-on-wave data
 - High sampling rate preferred



Benchmark with Simulation Data



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



Technical Innovation

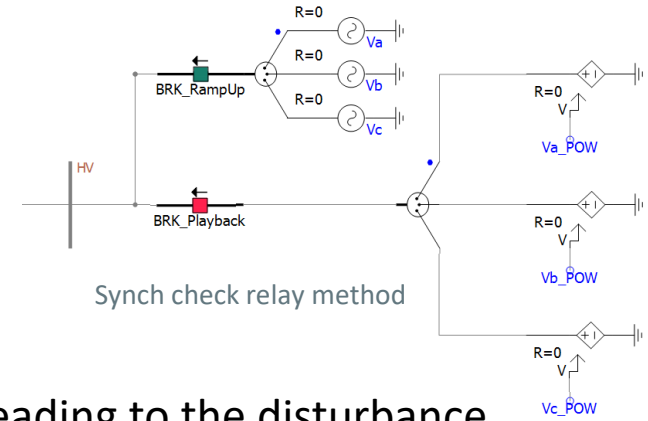
- Ramp-up methods

- Challenges:

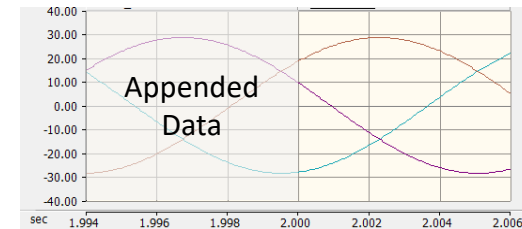
- IBR may need a few seconds to ramp up
 - DFR data usually have a short time window leading to the disturbance

- 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

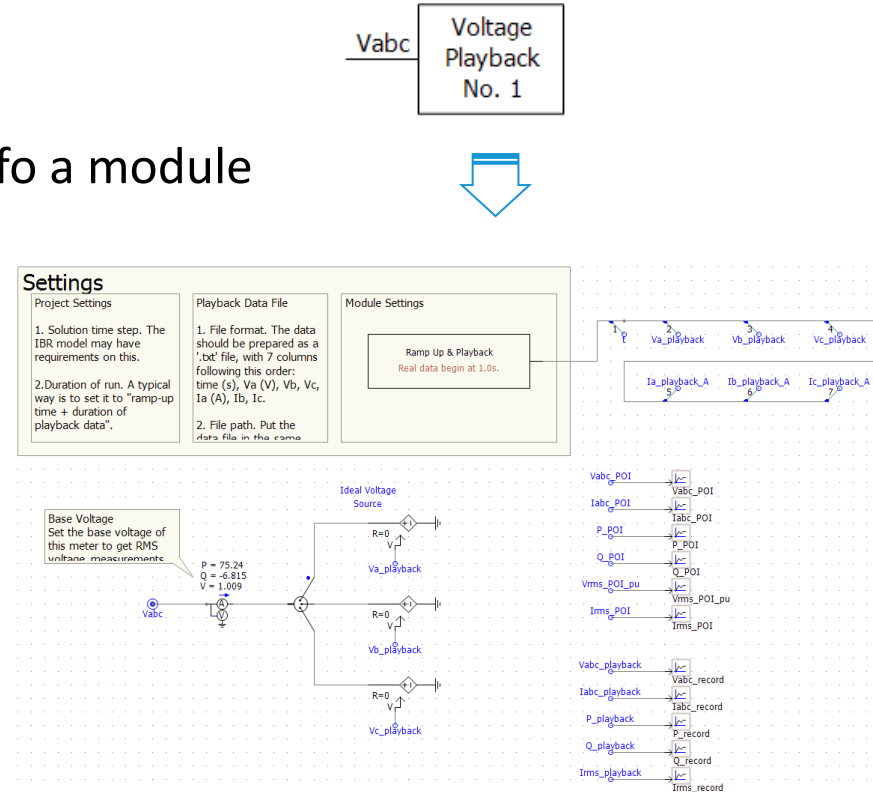


Append DFR data file method



Software Development

- Pro-version playback module
 - Packaged all playback functions into 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

The screenshot displays the 'EMT Playback Tool GUI' with the following sections:

- 1. Paths**
 - PSCAD model and real data folder (full path): [Text Field]
 - Workspace name: [Text Field]
 - Project name: [Text Field]
 - Output folder (full path): [Text Field]
 - Start PSCAD and load project [Button]
- Current status: [Awaiting initialization]
- 2. Playback Initialization**
 - === Select Case === [Dropdown]
 - POI bus power inflow (Positive direction = away from source)
 - P = [Text Field] MW Q = [Text Field] MVar [Initialize Button]
- 3. Playback Settings**
 - === Select Preset === [Dropdown] [Load Preset Button]
 - Simulation time step: [Text Field] μ s Base frequency: [Text Field] Hz
 - Ramp-up time: [Text Field] s Playback data duration: [Text Field] s
 - [Update Parameters Button]
- 4. Playback Module Configuration**
 - [Detect Button]
 - Index: [Text Field] Base Voltage (L-L RMS): [Text Field] kV Playback data file name: [Text Field]
 - [Configure Button]
- 5. Playback Simulation**
 - Folder name for this run (to differentiate multiple runs): [Text Field]
 - [Run Button] [Stop Button]
- 6. Plot Results**
 - ☒ Voltage instantaneous ☒ Current instantaneous
 - ☒ Real power ☒ Reactive power
 - ☒ Voltage RMS ☒ Current RMS
 - ☐ Zoom in plot [Text Field] s ~ [Text Field] s
 - Figure size: [Text Field] x [Text Field] dpi [Text Field]
 - [Plot Button] [Open figure folder Button]
- 7. Benchmark with PSSE Playback Results**
 - Coming soon!

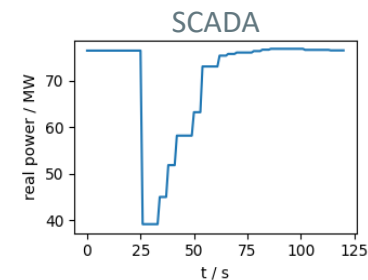
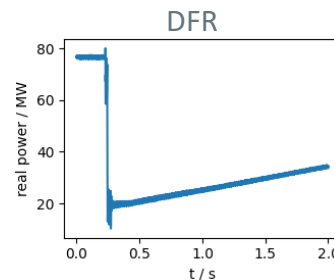
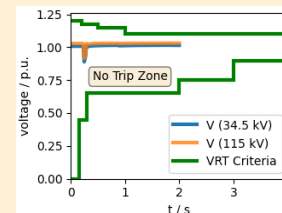
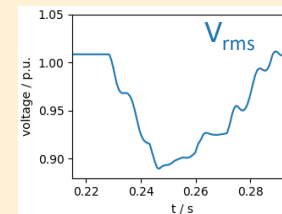
EMT MODEL VERIFICATION

– *Case Study*

Case Info

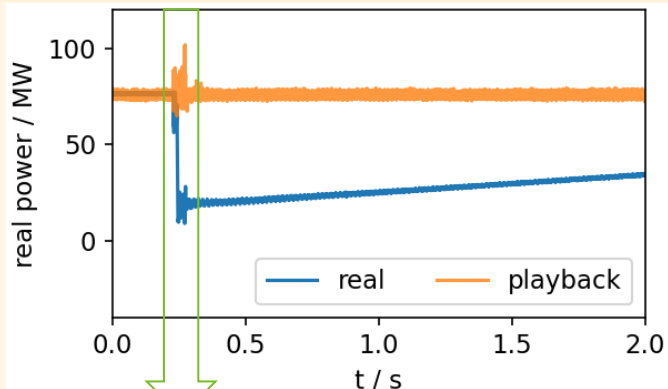
- Subject IBR:
 - ~80 MW solar power plant
- Event:
 - Fault on a bus and tripped a station
 - A few buses away from the IBR
 - Several 115 kV lines were tripped
- IBR Performance:
 - Failed to ride-through the event
 - Output dropped to 20 MW (DFR)
 - Recovery took ~50 seconds (SCADA)

Derived RMS Voltage



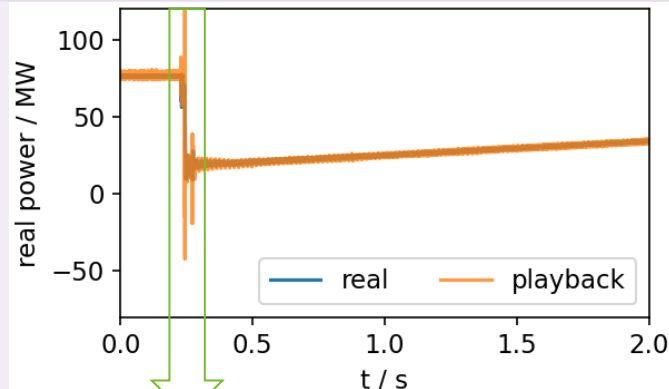
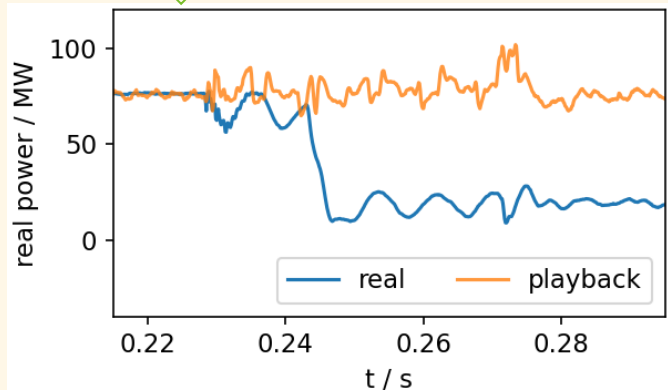
EMT Playback Results

Vanilla
Playback



w/

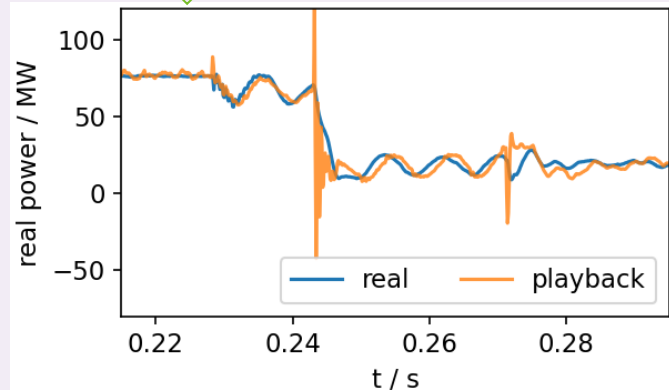
Original
Model
(Routine)



Chocolate
Playback

w/

Hypothetic
Controls
(Explore)



TS MODEL VERIFICATION (SINCE 2018)

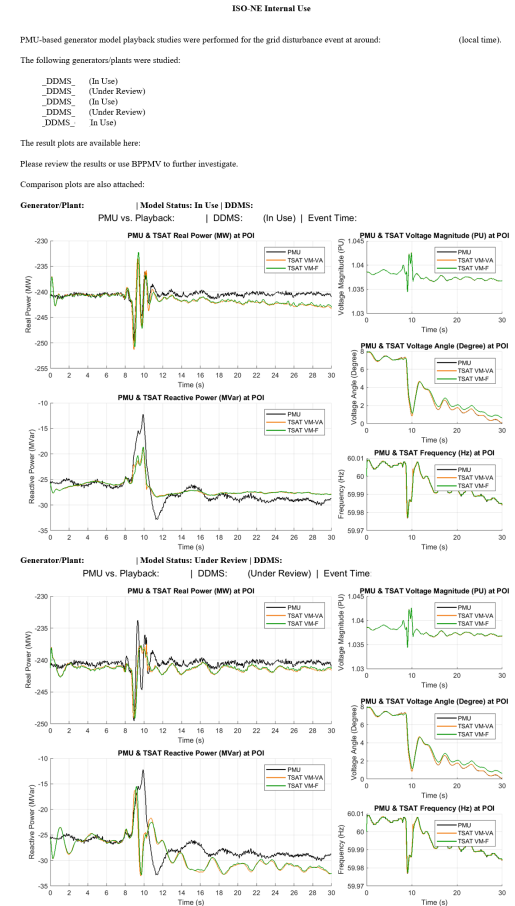
Using PMU Data Playback

-- 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



BPPMV – Offline GUI Tool

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

The screenshot displays the BPPMV Offline GUI Tool interface, which is organized into several functional panels:

- All Generator List:** Contains buttons for "Request Selected Generators", "Request All Generators", and a list box labeled "All Generator List".
- Requested Generator List:** Contains buttons for "Cancel Selected Generators", "Cancel All Generators", and a list box labeled "Requested Generator List".
- Event Information:** Includes a "Disturbance Date & Time (Local Time Zone)" field with a date picker (mm/dd/yyyy), a time input (HH MM SS (HHMMSS)), and a "Case Memo" text area.
- Execution Commands:** Features a "Run" button (green play icon), "Plot Comparison for Selected", "Run Analysis for Selected", and "Close All Plots" buttons. It also includes an "Oscillation Analysis Window (Leave blank for automatic detection)" with "Start Time (sec)" and "End Time (sec)" input fields.
- Program Running Status:** A large area labeled "Program Running Status" for displaying the results of the execution.
- File Path Selection:** A section with six rows, each for a different file type: "tsat_batch.exe Path", "PSAT.exe Path", "Dynamic Model Path", "Zipped PFB Path", "Mapping Table Path", and "Output Path". Each row has a text input field, a "Browse" button, and a "Load" button.
- Parameter Settings:** A section with a "Set User Parameters" button.

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

