

GRID EMT

SIMULATION INITIATIVE

EMTWG Work Item #6 - IBR Aggregate Plant Model Benchmarking

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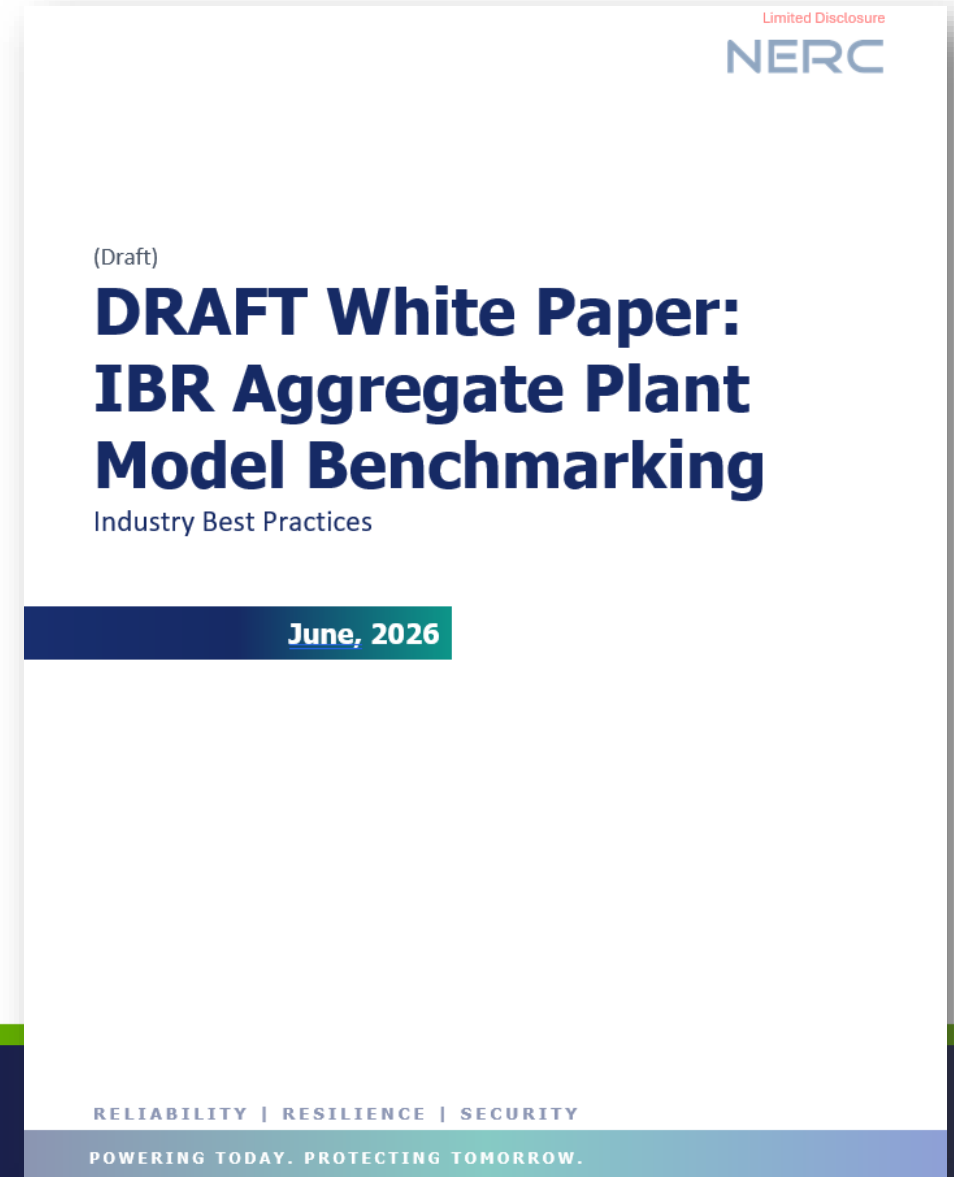


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Paper Overview

- EMTWG Work Item #6
- To addresses the gap of less powerful Positive Sequence Phasor-Domain (PSPD) simulations and more powerful Electromagnetic Transient (EMT) simulations
- Provides a structured methodology for benchmarking IBR plant models between EMT and PSPD simulation environments



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Motivation

- Rapid growth of inverter-based resources (IBRs) has significantly increased the importance of accurate plant-level modeling for power system studies
- Industry currently relies heavily on PSPD representations due to historical development and investment; however, they still can remain useful
- To ensure that PSPD representations of IBR plants remain reliable for system-level studies via EMT benchmarking



What are the Difference Between EMT vs PSPD Simulations

Electromagnetic Transient (EMT)	Positive Sequence Phasor-Domain (PSPD)
<ul style="list-style-type: none">• Capture fast transients and harmonic behaviors<ul style="list-style-type: none">• EMT tools use microsecond time steps• Captures fast inner control loops, switching, and unbalanced faults• Can model high-frequency oscillations, detailed converter controls, and DC-side dynamics<ul style="list-style-type: none">• Requires large computational resources	<ul style="list-style-type: none">• Represent fundamental-frequency dynamics<ul style="list-style-type: none">• PSPD tools use millisecond time steps• Balanced phasors at nominal system frequency• Cannot directly simulate sub-cycle events such as instantaneous surges, phase asymmetry, sub-synchronous oscillations<ul style="list-style-type: none">• Requires minimal computational resources• Heritage tool investment across industry



Paper Outline

- Industry Drivers for IBR Plant Model Benchmarking
- EMT vs PSPD Capabilities and Limitations
- Benchmarking Methodologies, Validation, Metrics and Fidelity
- Case Studies
- Practical Considerations, Fidelity, Tuning, and Trade-Offs
- Challenges and Recommendations
- NERC Resources



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Metrics

- The Whitepaper defines a structured set of benchmarking metrics to assess model fidelity
- Metric Families:
 - Steady-State Power-Flow Alignment
 - Short-Circuit and Fault-Current
 - Error Band
 - Dynamic Step Response
 - Waveform Shape and Control



Benchmarking Tests

- The whitepaper provides an example set of benchmarking tests to assess model fidelity utilizing previously defined metrics

Test Domain	Test Numbers
Model Setup, Initial Robustness, and Step Change	1 - 10
Frequency Response	11 – 13
Unbalanced and Balanced (Multi) Fault Ride-Through Capability	17 – 41
LVRT and HVRT Capability	43 - 50
PQ Capability Curve	51 - 56



MOD-26-02

- MOD-26-02 contains EMT specific requirements for the creation, verification, and validation of detailed dynamic models for inverter-based resources (IBRs), HVDC systems, and FACTS devices to accurately represent their behavior during grid disturbances
- The standard ensures that models used in planning and reliability studies accurately reflect the actual performance of in-service equipment during voltage or frequency excursions
- Requires PSPD models to be benchmarked against EMT models for large signal disturbances





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