

GRID EMT

SIMULATION INITIATIVE

Benchmarking Solutions for Smoothing Data Center Load Peaks

Cesar Galvez
Siemens Energy
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Why Data Center Modeling Matter?

- Data centers are not just load interconnection projects, but it can impact in the power system stability

Industry Needs

- AI data center projects are scaling to GW-level demand
- Competitive pressure requires customers to deliver:
 - **Faster time-to-market** projects
 - Technically proven, **reliable designs**
 - **Cost-effective** solutions across varying operating conditions
 - **Repeatable, scalable** architectures
 - Access to power and grid connection

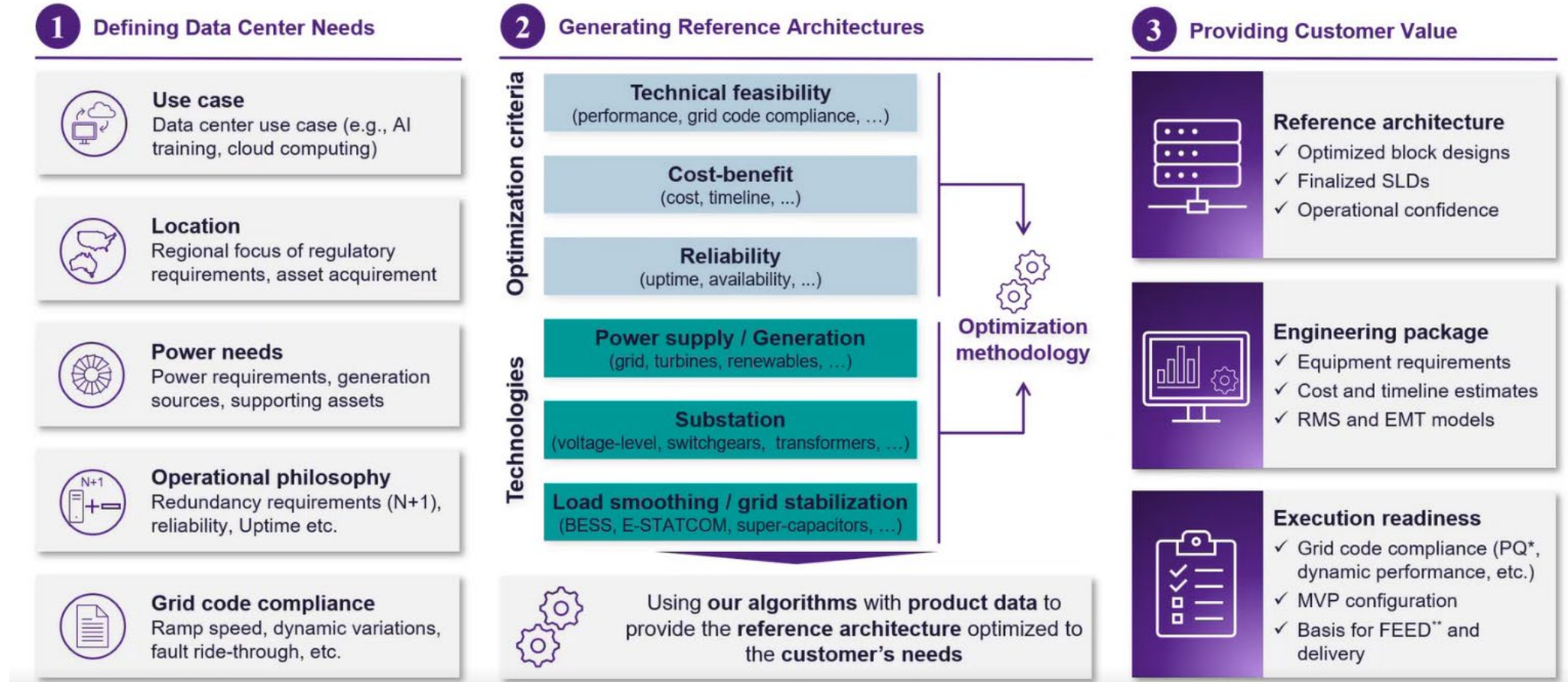
Current Challenges

- *Current reality*
 - Unpredictable and highly fluctuating AI data center load
 - Grids already at edge
 - Fragmented project-specific approach by OEMs
- *Real business impacts*
 - Delays and higher engineering costs
 - Elevated project risks
 - Reduced customer confidence



Siemens Energy Methodology

- Modular approach for repeatable and scalable solutions



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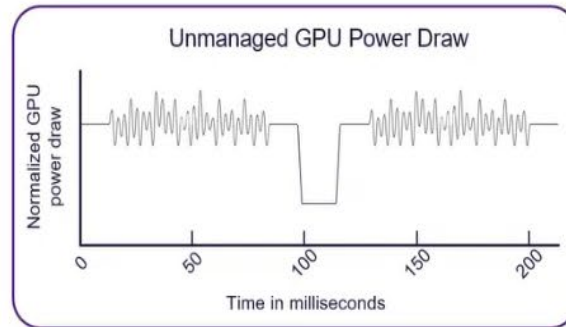
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Technology deep-dive

- Picking the right load smoothing strategy

Operational challenge

AI workloads exhibit periodic behavior with sharp load variations and voltage swings



Load profile issues:

- Fast transients
- Ramping demand

Technology options

Two complementary technologies address different fluctuation timescales

E-STATCOM

<5 ms reaction with seconds of energy; reactive power and voltage support; no cycling degradation; higher cost

BESS

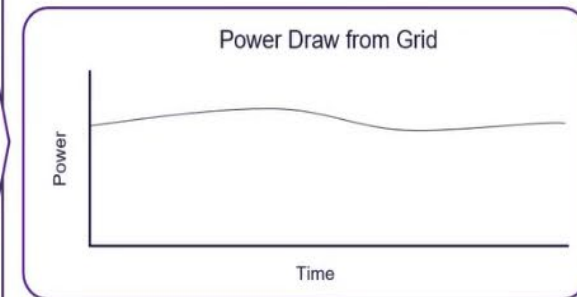
Seconds to hours energy; ramp-rate control; energy buffering; peak support; grid services; lower cost

UPS

<1ms reaction, seconds to minutes of energy, Load isolation, ride-through, mid cost

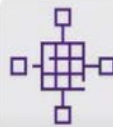
Optimized outcome

The customer objectives, operating profiles, and grid requirements inform the best technology selection



Optimized technology combination:

- ✓ Reduced load variability
- ✓ Improved system stability



Siemens Energy's methodology **evaluates technologies** to identify the **optimal solution** for each **unique customer**

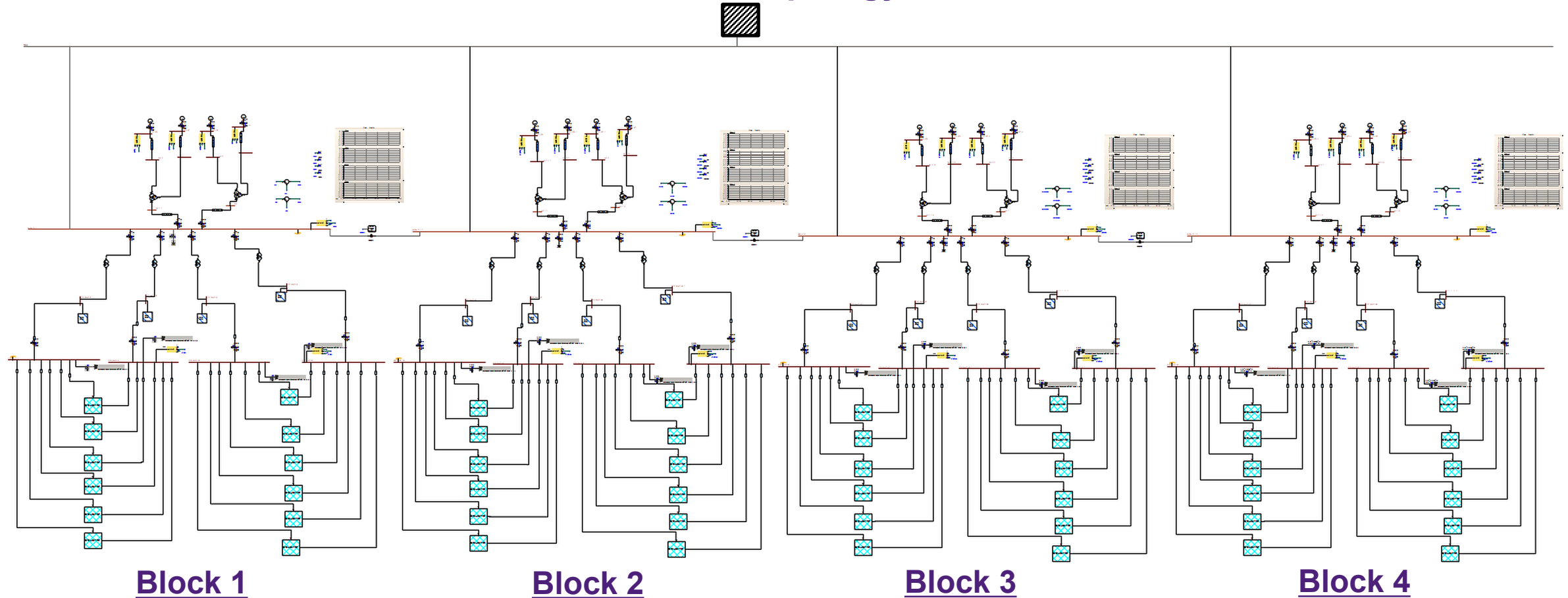


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Data Center Topology

- Data Center: Four Blocks with the same topology

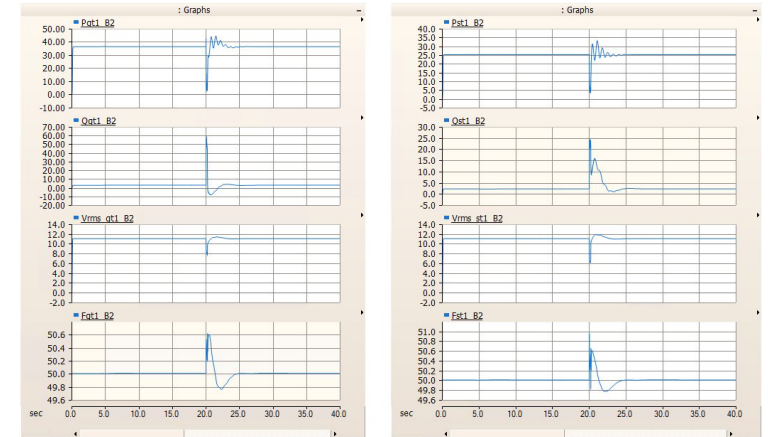
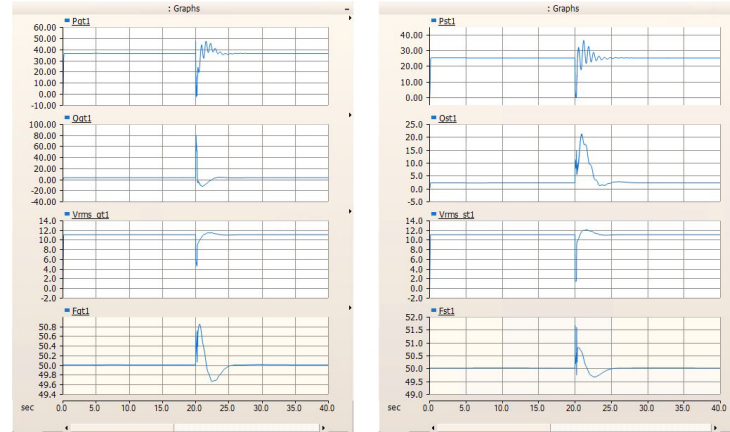
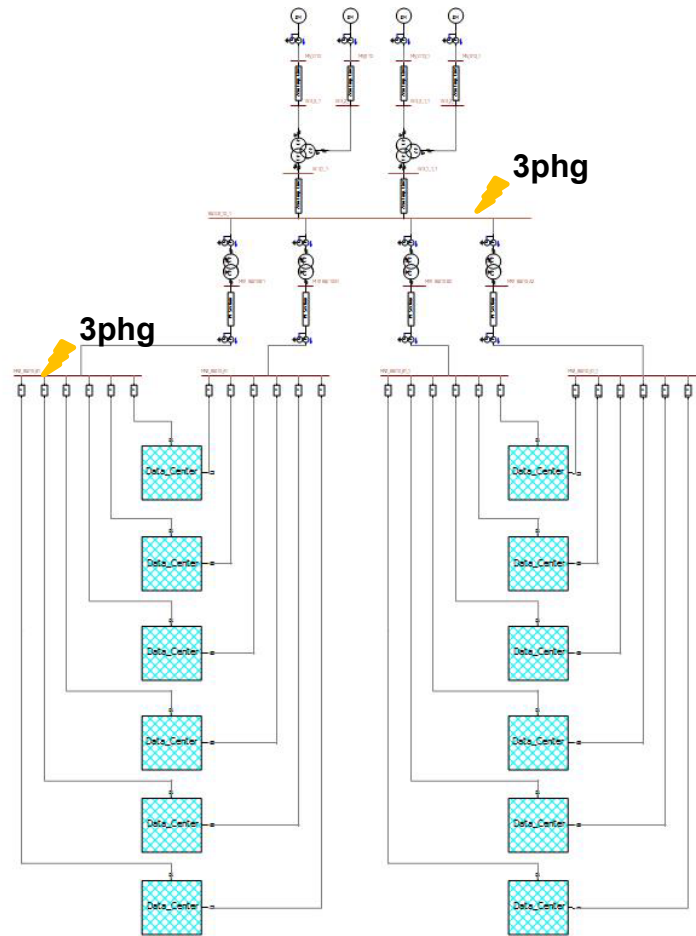


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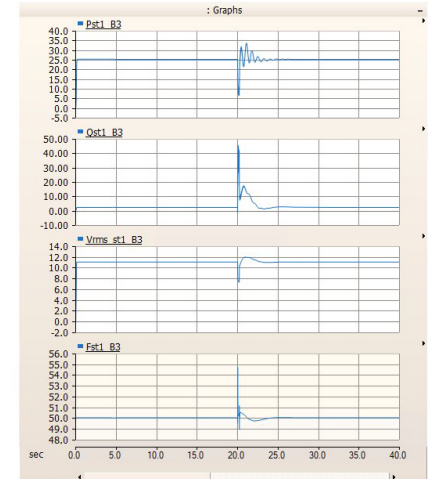
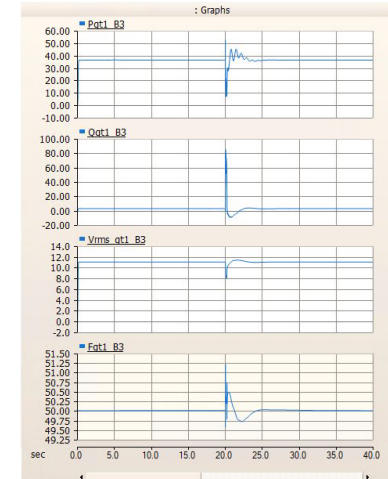
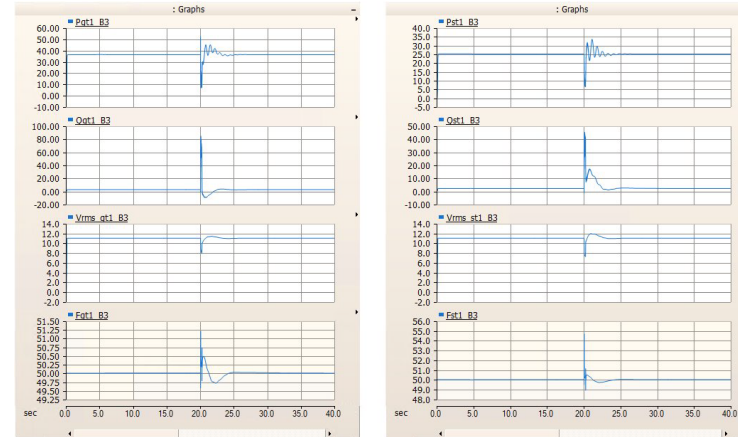
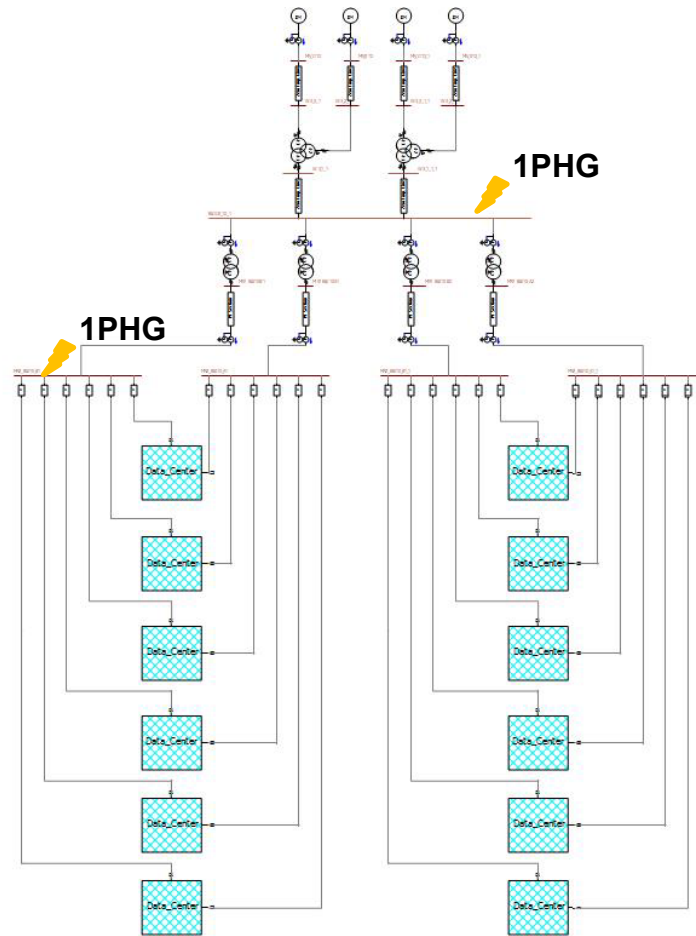
Synchronous Generator Ride-Through Fault

- Block 1: Three phase to ground faults with data center constant load



Synchronous Generator Ride-Through Fault

- Block 1: SLG faults with data center constant load



DC Load Smoothing Strategy

- UPS
- E-STATCOM
- BESS-GFM

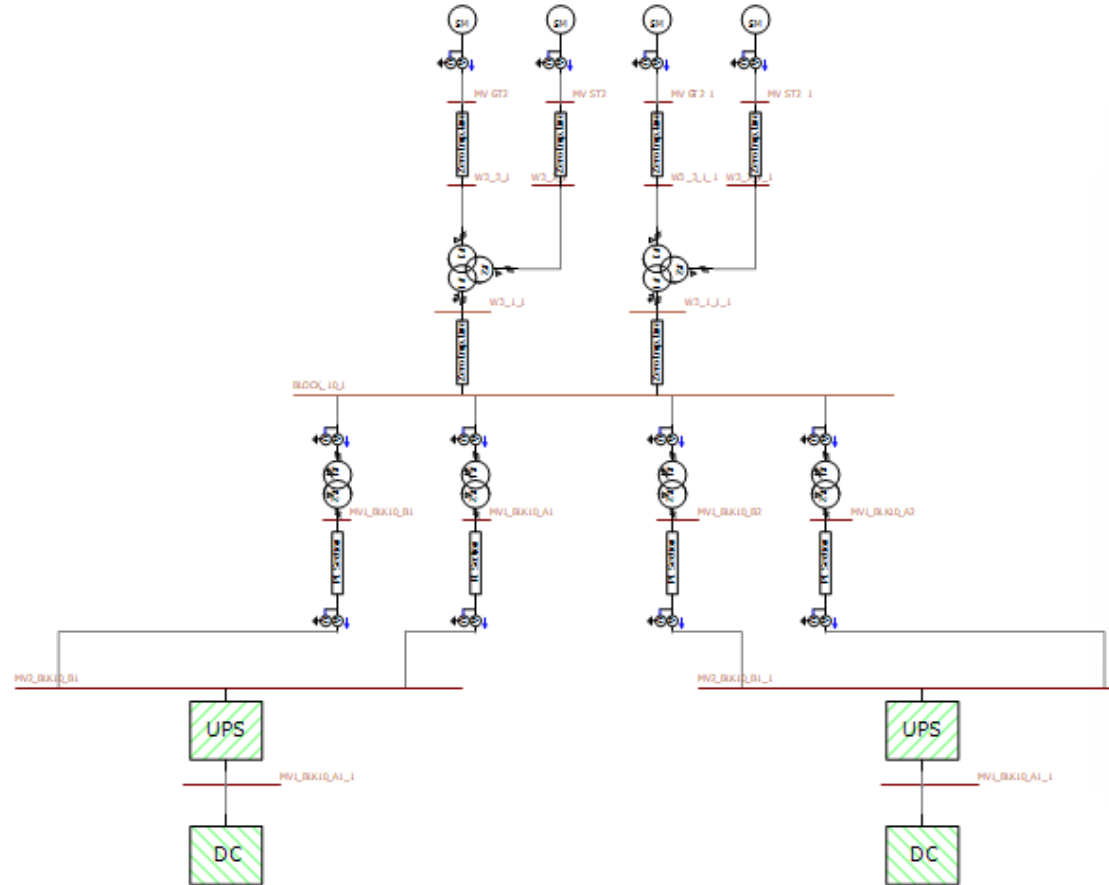


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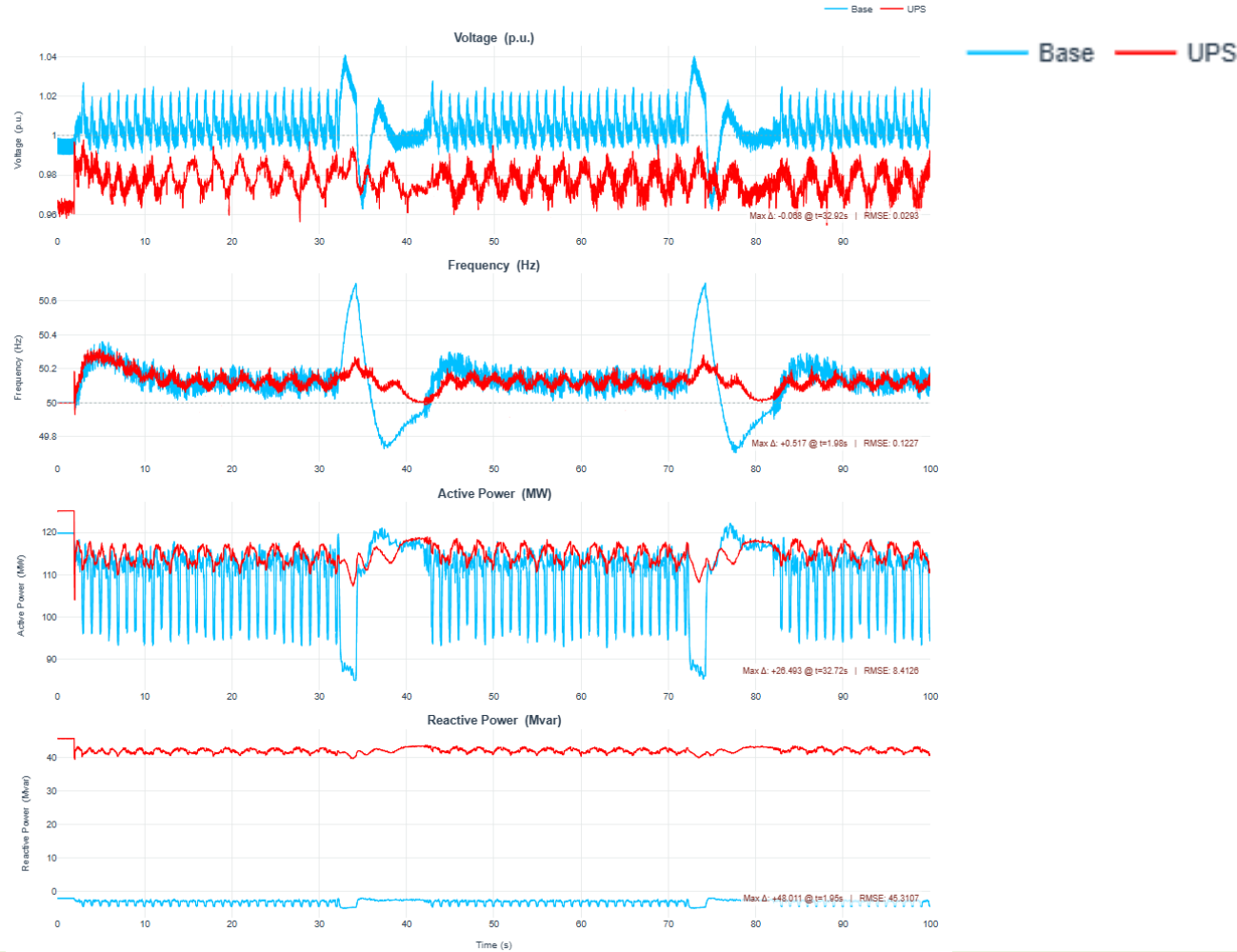
Generators + Data Center + UPS

- AI Data center load added to Block 1, testing UPS for smoothing load variation



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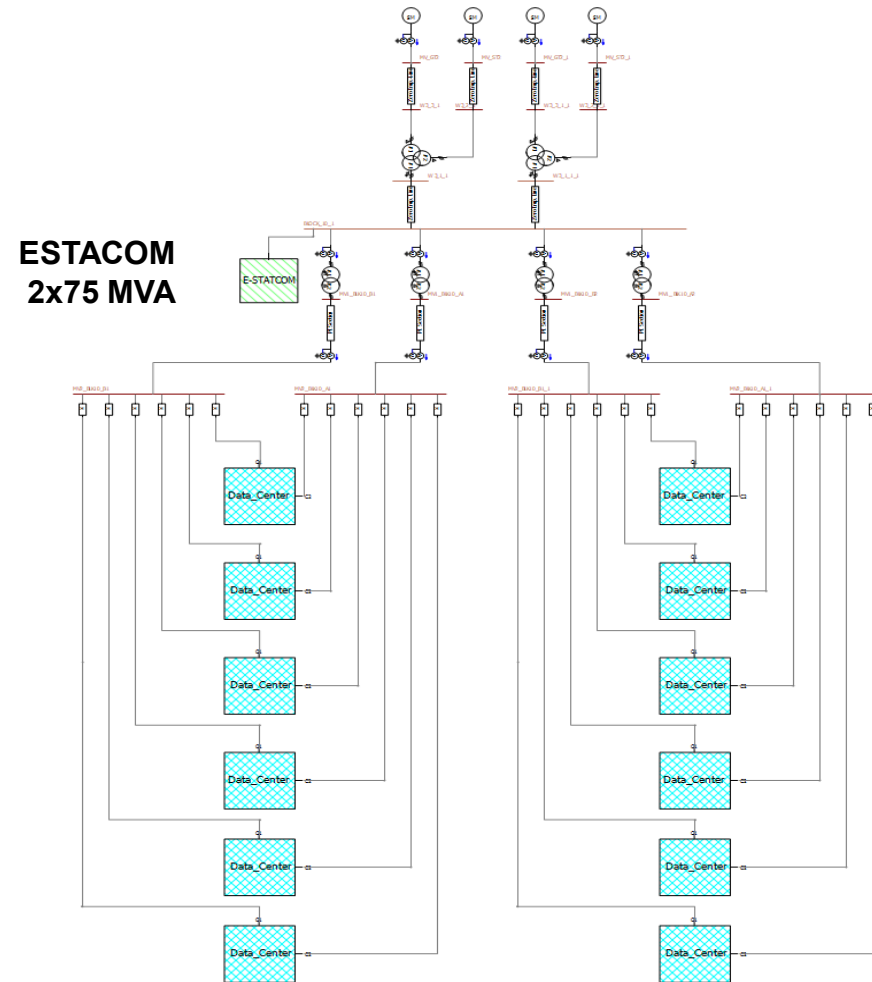


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Generators + Data Center + E-STATCOM

- E-STATCOM used to mitigate the AI DC load fluctuations

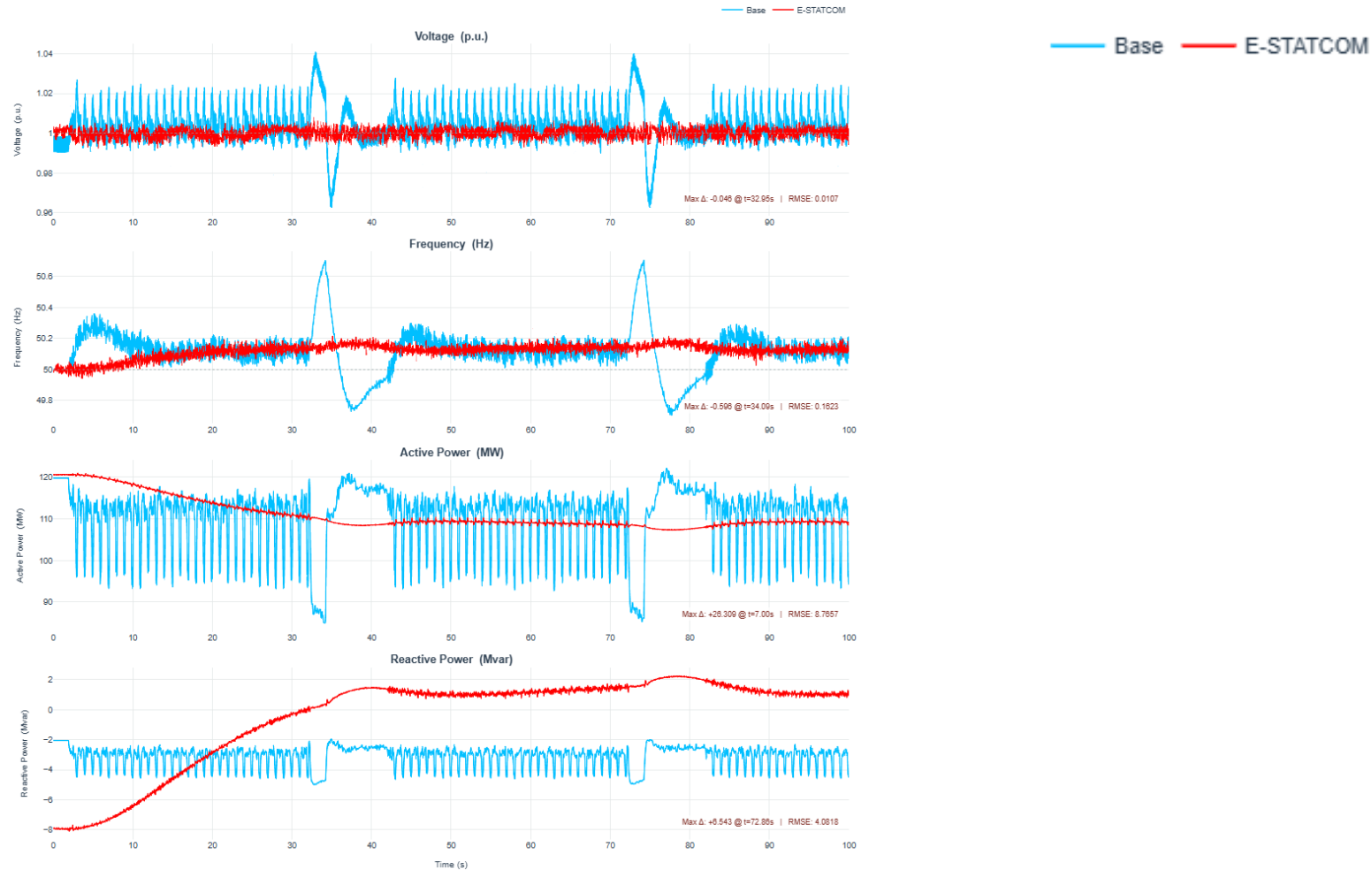


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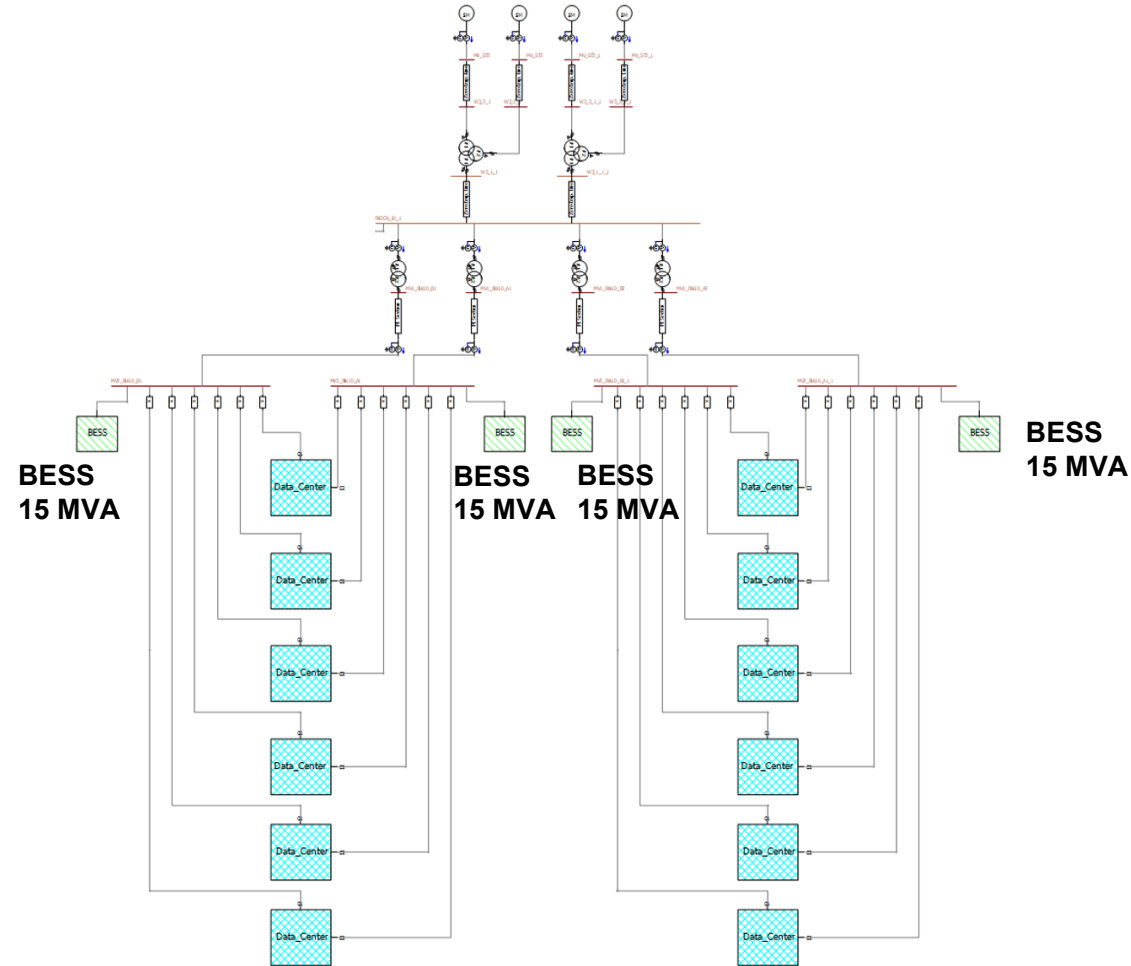


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Generators + Data Center + BESS-GFM

- BESS-GFM used to mitigate the AI DC load fluctuations

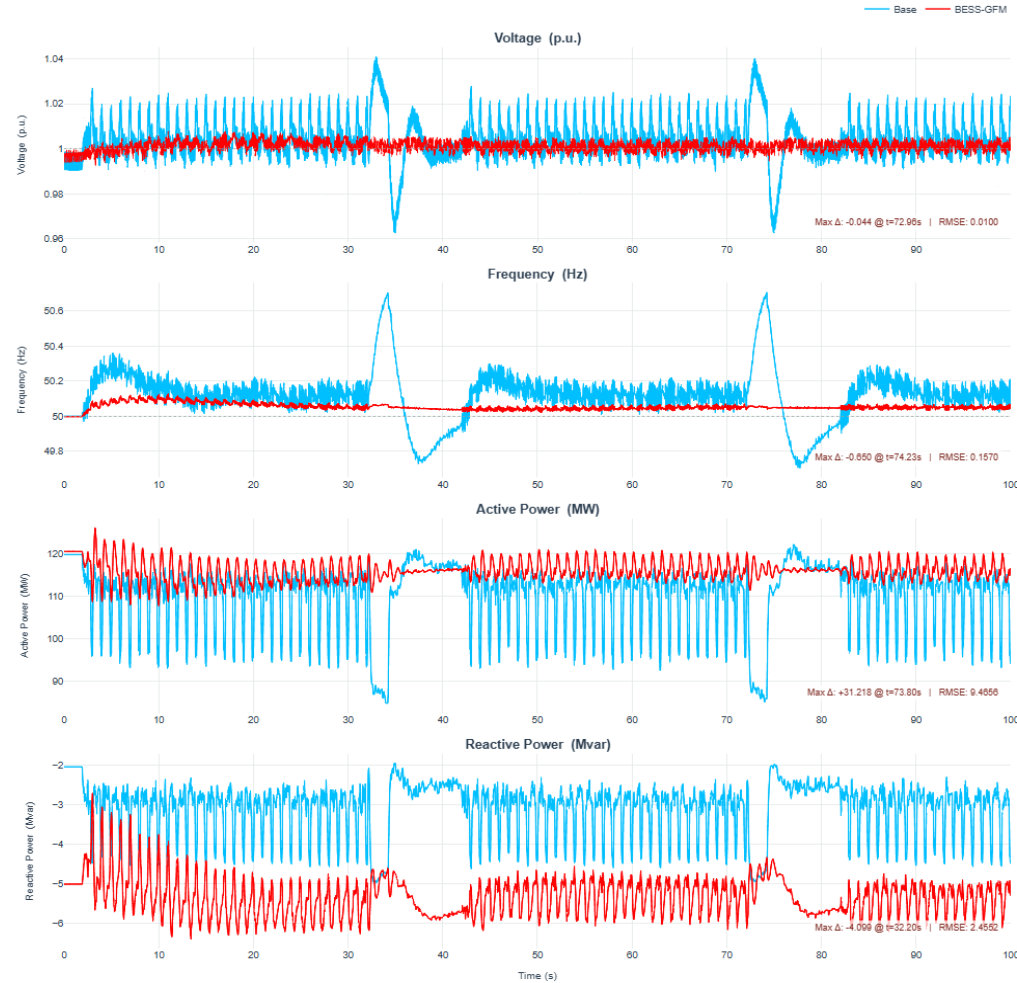


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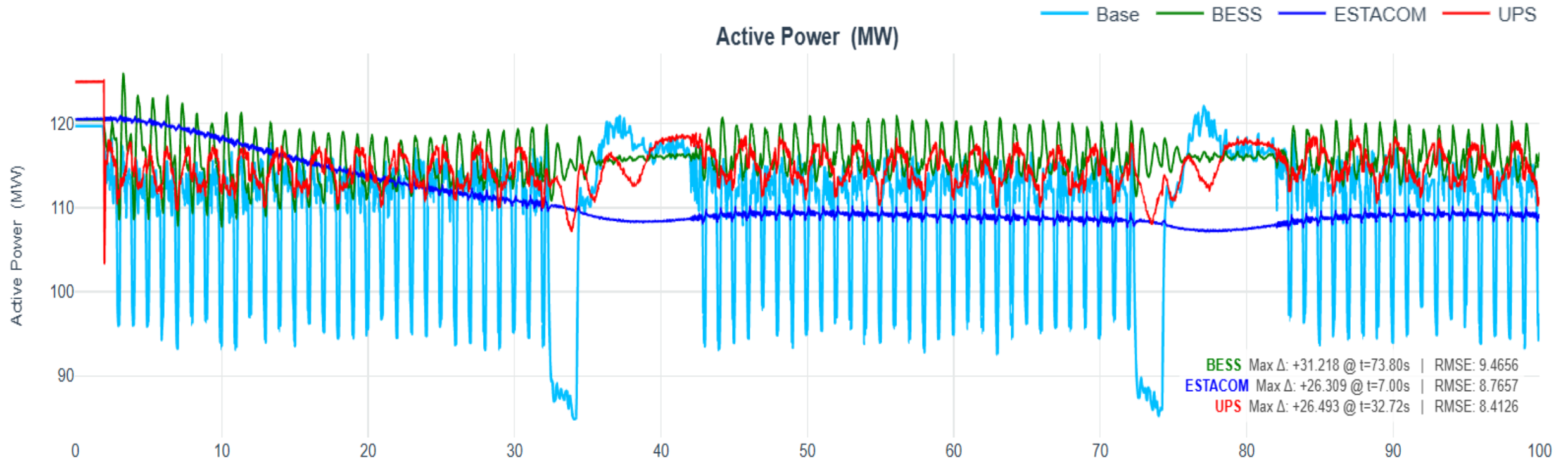


— Base — BESS-GFM



Comparison of Solutions

- Base vs BESS, E-STATCOM and UPS



Conclusions/Next Steps

- The Data Center (DC) network model was developed and validated through fault ride-through testing, confirming acceptable dynamic response from the gas and steam turbine synchronous generators under the studied fault conditions.
- The UPS is able to smooth data center (DC) load fluctuation spikes; however, this finding should be considered preliminary. The load profile provided by the OEM was referenced at the grid interconnection point, meaning it already reflects the assumption that the UPS has mitigated fast DC load fluctuations.
- With its current settings, the BESS-GFM does not adequately mitigate DC load fluctuations. Performance can be improved by retuning the GFM droop gain and enabling/adjusting P/f droop control at the PPC level..
- The E-STATCOM provided the best mitigation performance among the alternatives evaluated for DC load variation. Based on these results, a unit size of 2×75 MVA has been selected for the project.



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