

Southern Company's Experience with Large Electronic Loads

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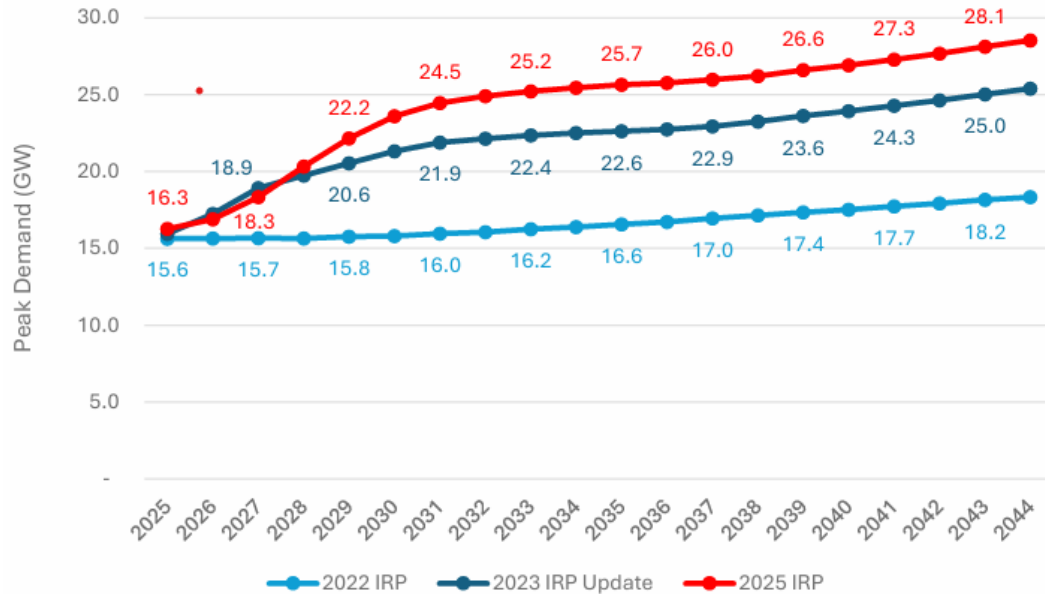
NASPI Working Group Meeting

9.23.25

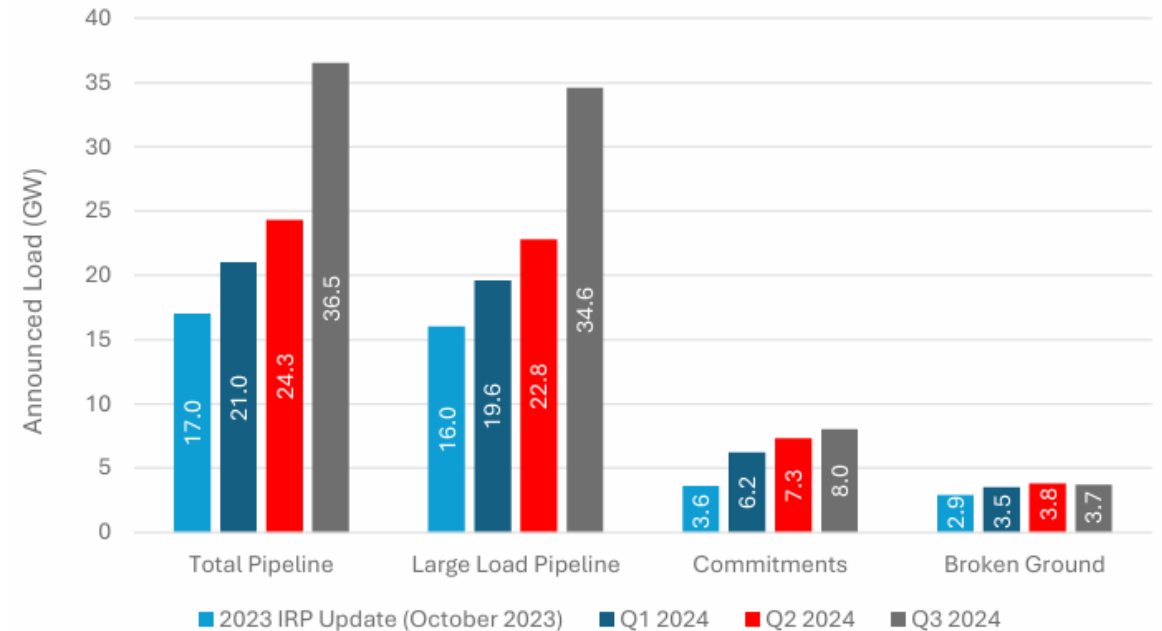


Large Load Growth Projections (Georgia Power)

Projected Winter Peak Demand



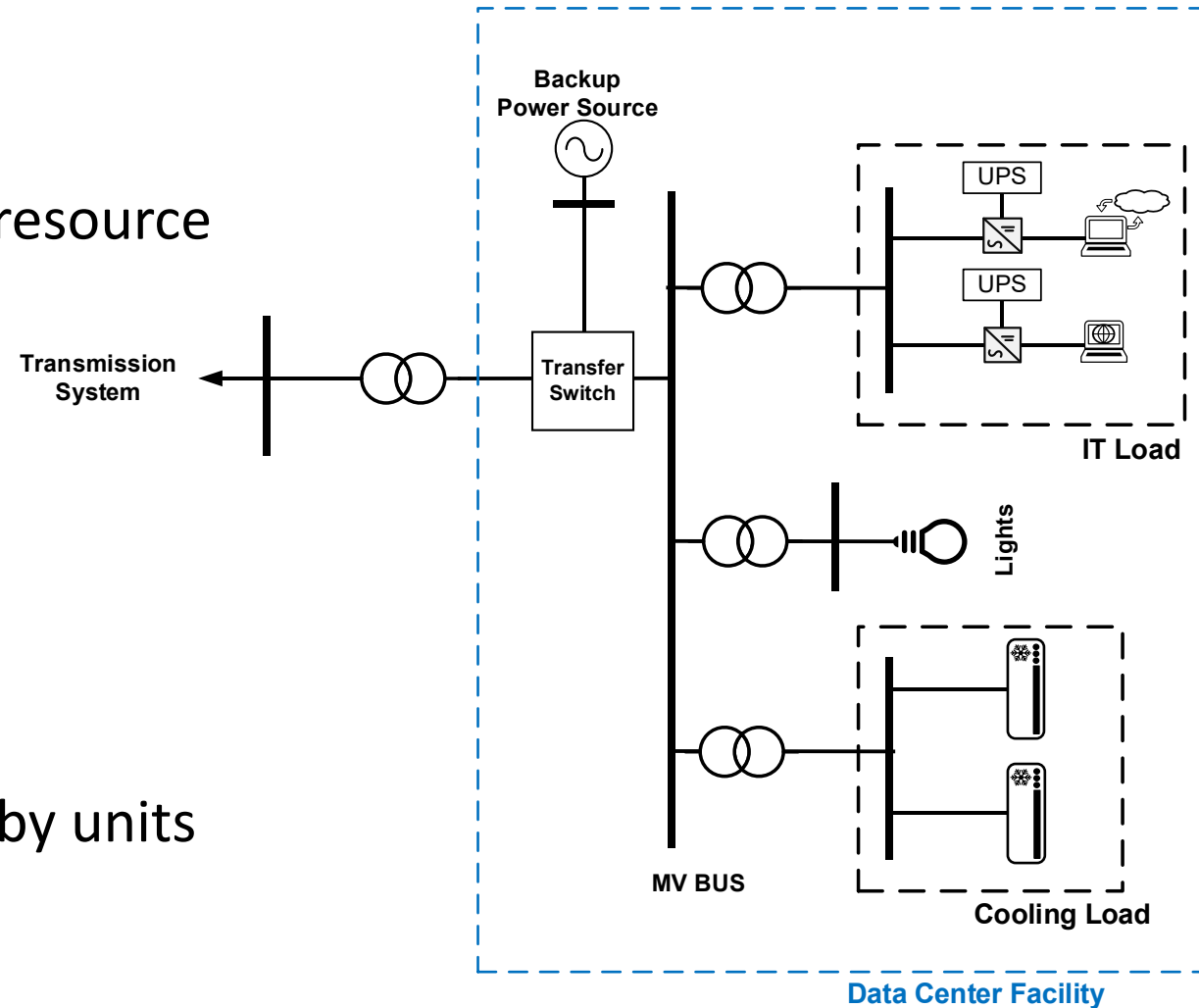
Long-Term Pipeline Growth



Significant growth is projected for transmission connected large loads (TCLLs)

Large Data Center Loads – Key Considerations

- Power Quality
 - Harmonics, Voltage fluctuations/flicker
- Steady State
 - Thermal loading, line capacity constraints, resource adequacy
- Transient Stability
 - Voltage recovery, frequency
- Small Signal Stability
 - Forced oscillations at low frequencies
- Resonance Stability
 - Exciting torsional modes (5- 30 Hz) of nearby units
- Other
 - Ramping rate, ride-through requirements



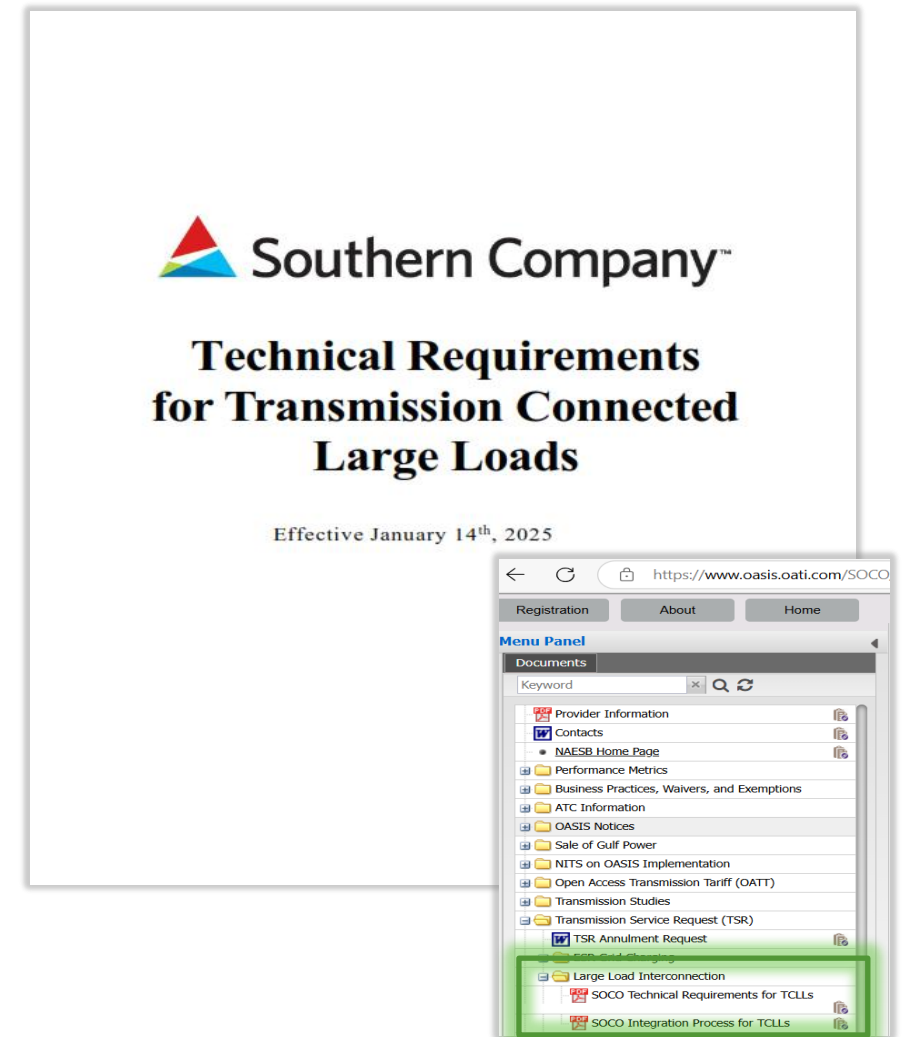
TCLL Technical Requirements

Objectives

- ① Identify and mitigate critical reliability risks that may be introduced by Large Loads
- ② Provide Customers upfront clarity on design and performance to satisfy reliability expectations

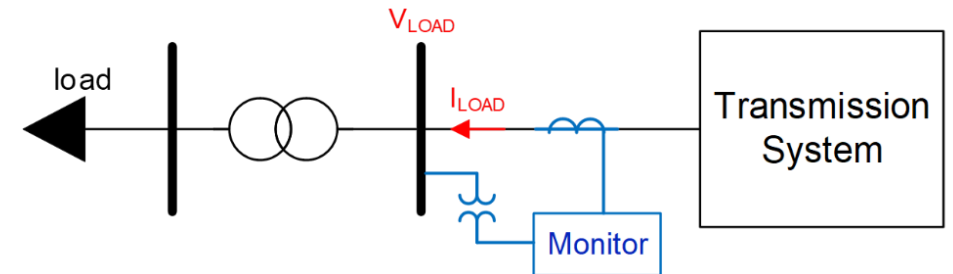
Key Contents

- Overview
- Protection and Coordination
- Capability and Performance
- Metering and Telecommunications
- Radio Frequency Interference
- Operational Measurement and Communications
- Curtailment and Dispatchability



TCLL Capability and Performance

- Power Factor (PF) Requirements
 - Provide expected PF at different loading levels
- Oscillation Mitigation
 - Requirement to minimize signal injections in certain low frequency ranges and avoid specific sub-synchronous frequencies on case-by-case basis
 - Monitoring equipment (e.g. PMU and ADFR) at POC
- Power Quality (Flicker/harmonics)
 - PQ meter at POC
 - Compliance with PQ Policy¹
- Ramp Rate
 - Maximum ramp rate (20 MW/min) for load increases and decreases when coming online, offline, and during normal operating conditions to ensure sufficient generating reserves to balance load and generation in real-time

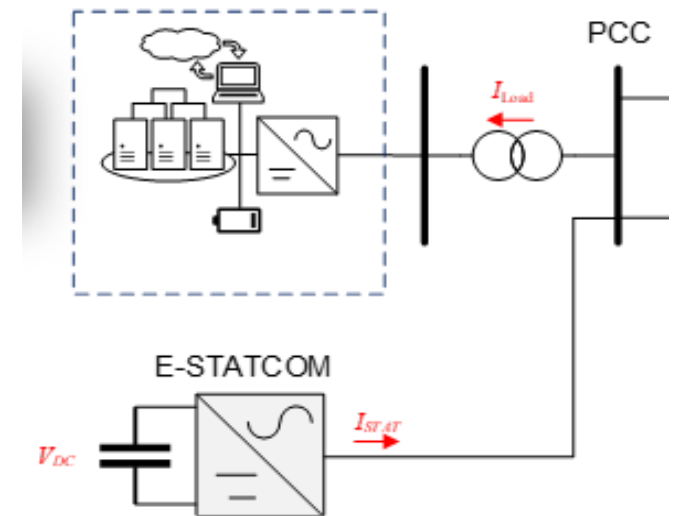
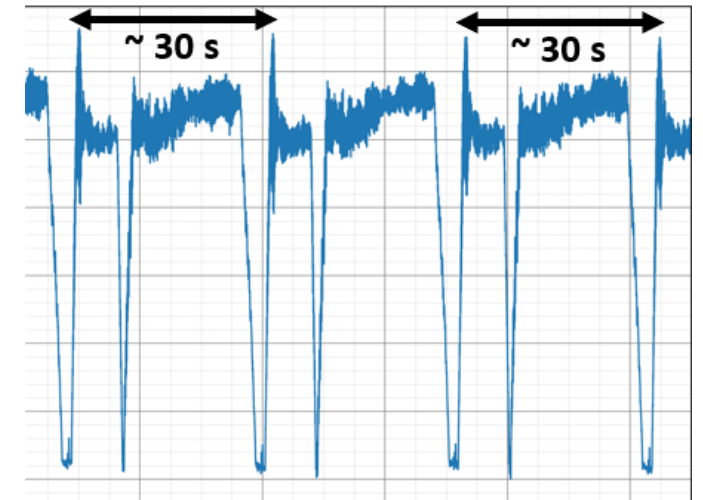
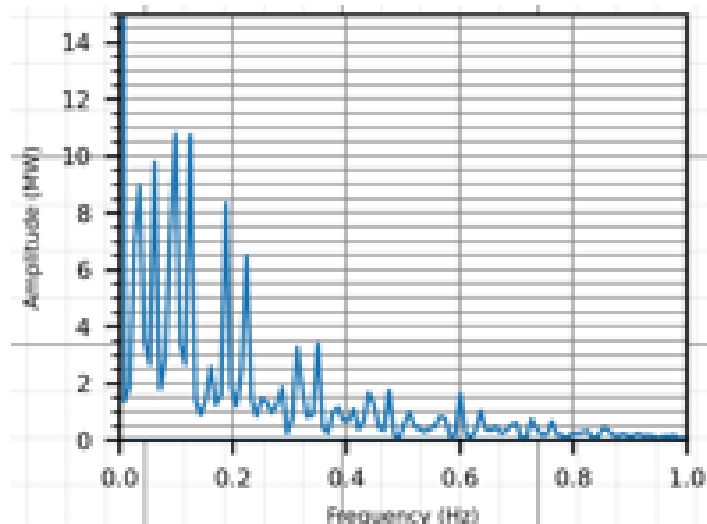


PMU– Phasor Measurement Unit
ADFR – Advanced Digital Fault Recorder

¹ <https://www.oasis.oati.com/woa/docs/SOCO/SOCOdocs/SoCo-Power-Quality-Policy.pdf>

Forced Oscillations Concerns with Data Centers

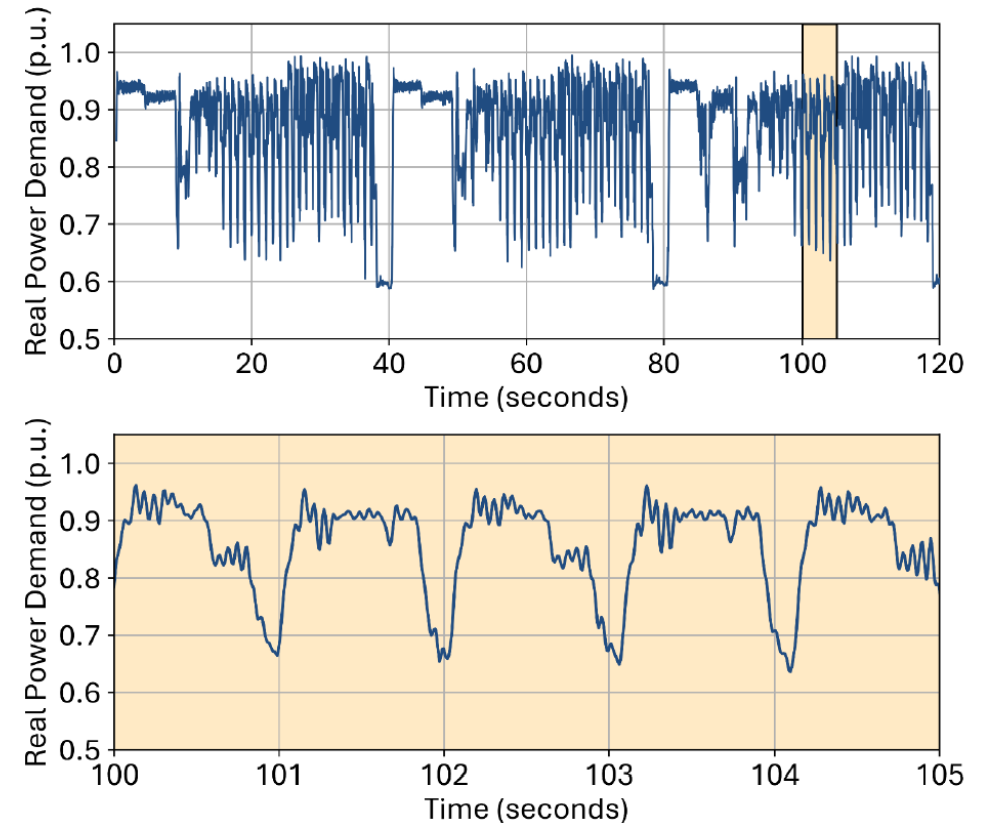
- Potential for forced oscillations in system due to periodic changes in active power
- Can interact with natural modes of power system (Interarea: 0.1-0.5 Hz, Sub-regional: 0.5-0.8 Hz, Local: 0.8-2.0 Hz)
- Potential solutions - Technologies like E-STATCOM/Batteries



Customer Load Data Requirements

- Questionnaire has been adapted from NERC's Data Center Information Collection Form
 - To be filled by customers
- Total rated load (MW and PF) with the split for individual load components
 - IT equipment (computing/server)
 - Cooling load (motors and drives)
- Voltage and frequency ride through response of the IT equipment and the Cooling load during supply voltage/frequency excursions
- Ramp rate and load profile showing variations in power

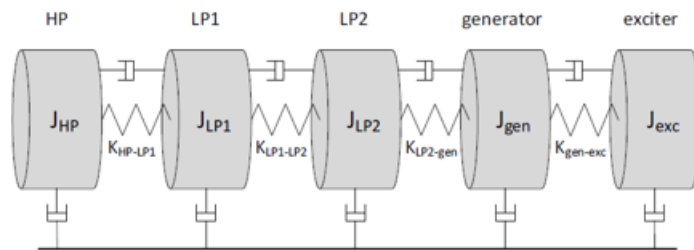
Example DC Load Signature¹



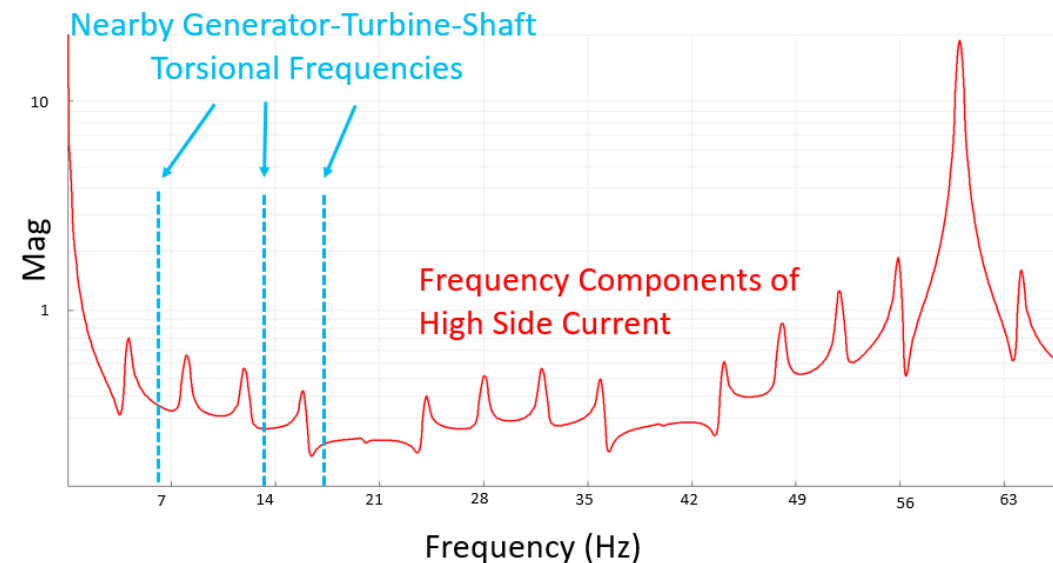
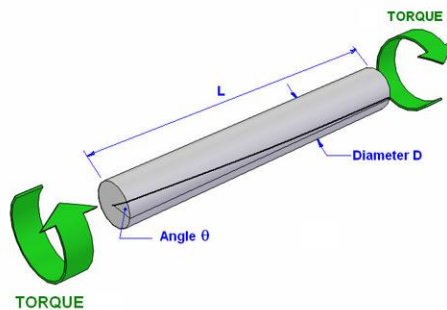
¹ NERC LLTF Draft Whitepaper on Characteristics and Risks of Emerging Large Loads

Resonance Stability – Sub Synchronous Resonance

- Potential for sub-synchronous components in facility's current to excite natural frequencies of nearby generation unit's turbine shaft systems
- Eigen analysis needs to be carried using generator's mass-spring model to compute natural torsional frequencies
- Need to avoid signal injections at natural torsional frequencies



Generator Mass-Spring Model



PMU Requirements

- PMUs are required at POC of TCLLs
- DFRs are programmed to record outputs of all the CTs and CCVTs in the substations (30 samples per second)
- The inputs from all the PMUs gets fed to a centralized PDC (Phasor Data Concentrator)

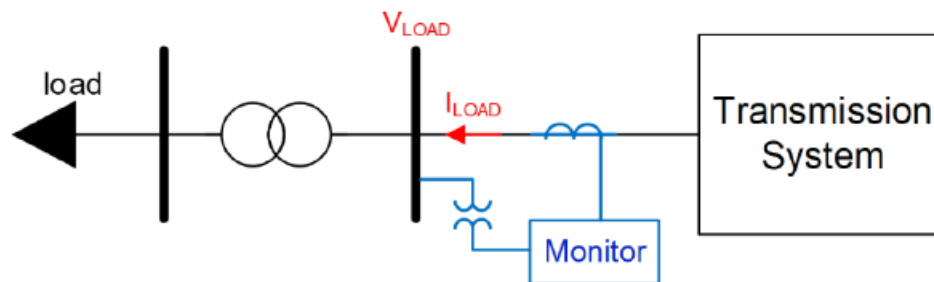
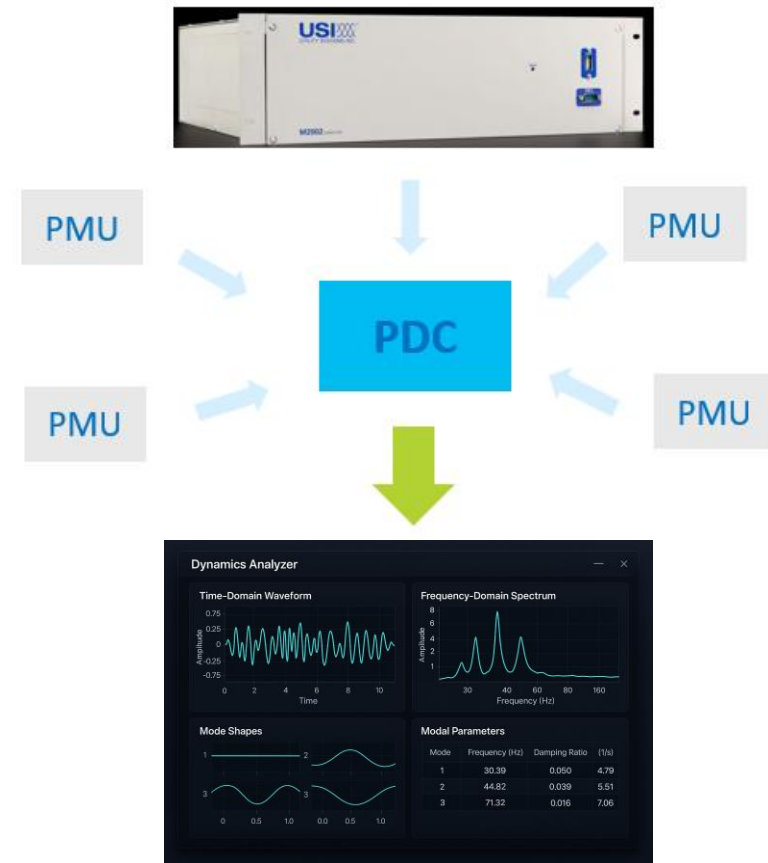


Figure 2. Example Location of Monitoring Equipment



Dynamics Analyzing Software

Summary

- Large loads such as data centers have the potential to create or aggravate power quality and system stability issues
- Technical requirements have been developed to provide upfront clarity to potential customers on design and performance requirements
- Detailed and comprehensive analysis is important to identify the risk of potential issues and evaluate mitigation options, if needed
- Pre and Post commissioning monitoring is important to ensure the load operates as expected and meets applicable requirements



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