PMU Based Inertia Estimation and Monitoring

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Motivation - Reducing Inertia
Increased Penetration of Inverter Based Renewables

Increasing integration of renewable generation displaces synchronous generation → system inertia reduction

Challenges

- Rate of Change of Frequency (RoCoF)
- Equipment Withstand
- Protection Maloperation
- Reserves Response Time
- Operational Security Standards
- Frequency Nadir
- Customer Load Shedding

Inertia Monitoring Methods

Unit commitment - Monitoring
- Sum of online generation inertia constant (GVAs)

Continuous signal - Estimation
- Real time analysis of known stimulation
- Real time analysis of natural small perturbations

Event driven - Estimation
- Post-mortem analysis of large events
- Real time analysis of large events

Most utilities/ISOs that estimate inertia use Unit Commitment Monitoring
At R&D or demonstration status
Most utilities/ISOs perform some form of ad-hoc event-based estimation

Source: EPRI White Paper
‘Online Inertia Estimation & Monitoring: Industry Practices & Research Activities’
Regional Inertia

Regions of the system may emerge that have low inertia and are weakly coupled to the rest of the system and its inertia.

Reduction in inertia is not spatially uniform, which can result in regions of disproportionately low inertia.

If low inertia regions are poorly coupled to the system, they will swing around the center of inertia frequency.

Potential severe regional frequency and RoCoF response under local infeed loss.
Framework for Assessing Reduced Inertia

I don't have any inertia problems

I need an inertia floor and EMS inertia estimation

Do I have regional Inertia? Is it a problem?

Do I need measurement based estimation?

Is demand-side inertia significant?

I need WAMS based, regional, real time inertia estimation

How to navigate this path?
Region Identification Method

Regionalization

• Determine whether regions with different inertial response exist in the system
• Identify regions with different inertial response
• Based on online generation status and topology
• Graph theory & spectral clustering
• No time domain simulations

Synthetic Texas System
PMU Measurement Based Inertia Estimation

Regional PMU-Based Inertia Estimation

- PMU Measurement Based
- PMUs within region and at interface lines
- System Identification using ambient data
- Considers region load impact

\[ H_{sys} = 5 \]
Together...Shaping the Future of Electricity