Dominion Energy's Synchrophasor-Based Energy Management System

Synchrophasor Power Flow Methodology

NASPI

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About Dominion Energy

We've existed in one form or another since 1787.

3.5 million electric customers

31 GW of total electric generating capacity

2.2 GW of solar generation capacity

65,310 miles of electric transmission and distribution lines

1184 PMUs

849 relay PMUs

Thomas F. Farrell II Building
Richmond, VA

Need for Enhanced Monitoring

Largest concentration of data centers in the world

- Can cause harmonics on the transmission system

Significant Deployment of Renewables

- Large numbers of renewables require coordination to avoid oscillations

SCADA does not always see oscillations

PMUs at Dominion Energy

2009
Beginning of synchrophasor initiative

2012
Began standardized relay-based PMU deployment

2013
DOE SGIG Demonstration; Linear State Estimator (LSE) v1.0 released as open-source software

2017
DOE FOA970 demonstration (LSE v2.0), Digital Fault Recorder PMU conversion begins

2019
Go-live of cloud-hosted PingThings Predictive Grid platform

2020
Kick-off for PMUs in the Control Center Proof-of-Concept

2026
Go live for synchrophasor based EMS

Vision Statement

To provide operator use of PMU data to support real-time decision making and enhanced system visibility

Mission Statement

Provide our Operations Personnel with new energy management applications that can reveal system changes undetectable through traditional SCADA/EMS. New applications will allow rapid, robust, and redundant analysis that will potentially include wide-area network monitoring, oscillation, and islanding detection, etc.

Benefits

Provide 'Spare Tire' capabilities: system observability during EMS degradation

Allow operations staff to have an independently calculated estimation of the grid's state and review events in much greater detail

Increase situational awareness, reliability, and accuracy of SOC decisions with the introduction of PMU-based telemetry

Provide a foundation to develop applications and displays for managing increasing renewables resources

Challenges

Data quality

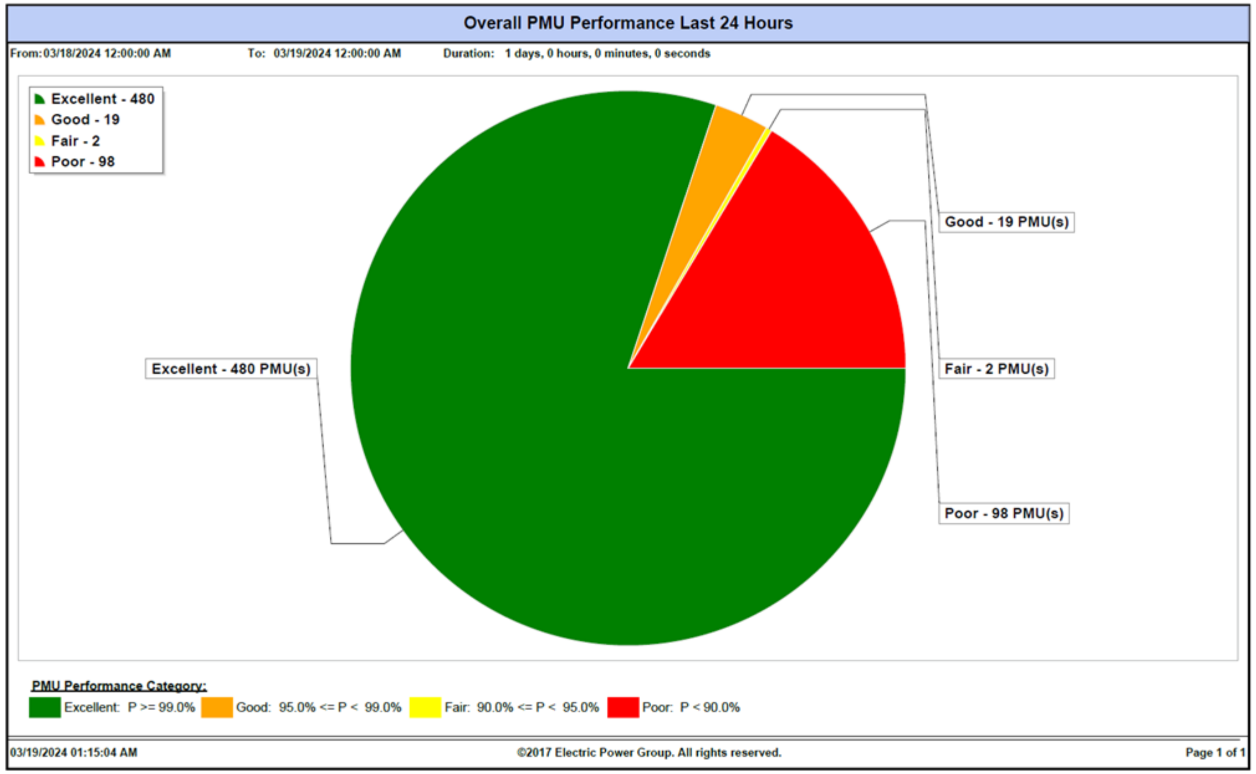
- PMU projects previously used historical data
- With no real time monitoring, overtime the data degraded
- PMU data needed cleanup

Synchrophasor EMS benchmark establishment

- SCADA, SE, or PMU data for comparison

Integrating slow speed and PMU data

- Still installing PMUs to have full system observability



Synchrophasor EMS Components

- Wide Area Monitoring System
- Linear State Estimator
- Synchrophasor Power Flow
- Contingency Analysis
  - Real-time and Study Mode (What-if simulator)
- Unified display platform with One-lines, tabulars and dashboards

Why is a Synchrophasor-Based EMS needed?

- Grids have been operated with large amounts of synchronous generation.
- The modern power grid is transitioning to renewables and Inverter Based Resources (IBRs) with dynamic changes, bi-directional power flows, oscillations, variability in power output, declining inertia, declining system strength
- System loads are more dynamic with addition of sensitive data center loads
- Operators need dynamic intelligence to maintain grid reliability, stability, power quality

Managing today's modern grid requires a smart EMS

What is a Synchrophasor-Based EMS?

- Platform for managing smart grids
- Independent from EMS SCADA
- Based on high-speed time synchronized data
- State Estimation always solves at high-speed with LSE
- Provides assessments of power system dynamics
- Faster and time-synchronized platform for contingency analysis and real-time assessments

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Why Synchrophasor power Flow (SPF) ?

- **Need**
  - Fast calculation time
  - Based on LSE which Always Provides a Solution even during extreme events
  - Platform for Synchrophasor EMS

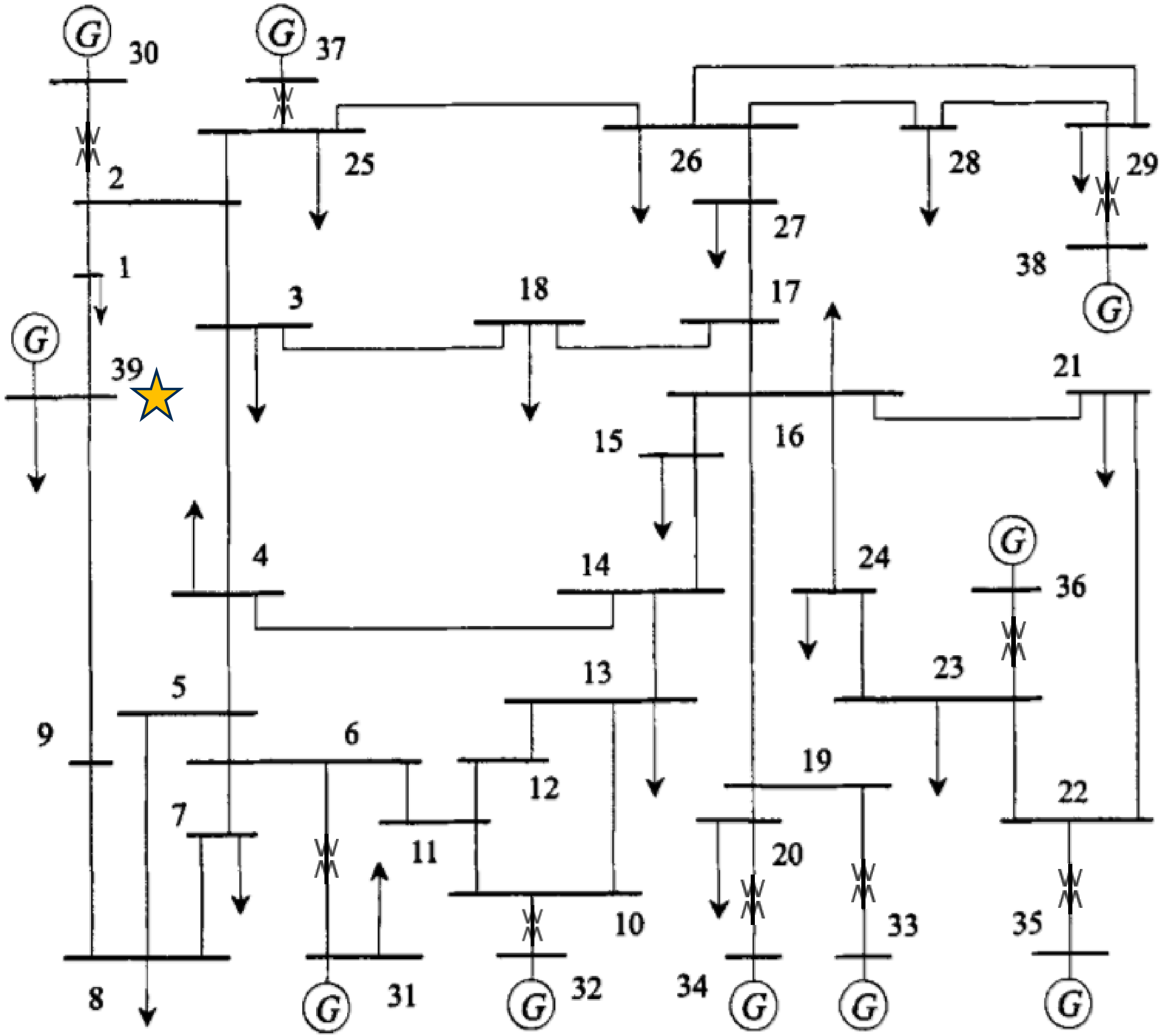
Approach
  - Utilize Linear State Estimator (LSE) to generate a base case for near-real time assessments
  - Power Flow driven by Linear State Estimator data, **providing full system observability and the most up to date state of the grid**
  - Integrate high speed Synchrophasor data and slow speed SCADA data to address PMU coverage limitations during transition to full PMU coverage

While transitioning to full PMU coverage, the Synchrophasor Power Flow case is generated with Synchrophasor data complemented with available SCADA data and other systems for full observability

SPF Methodology Example

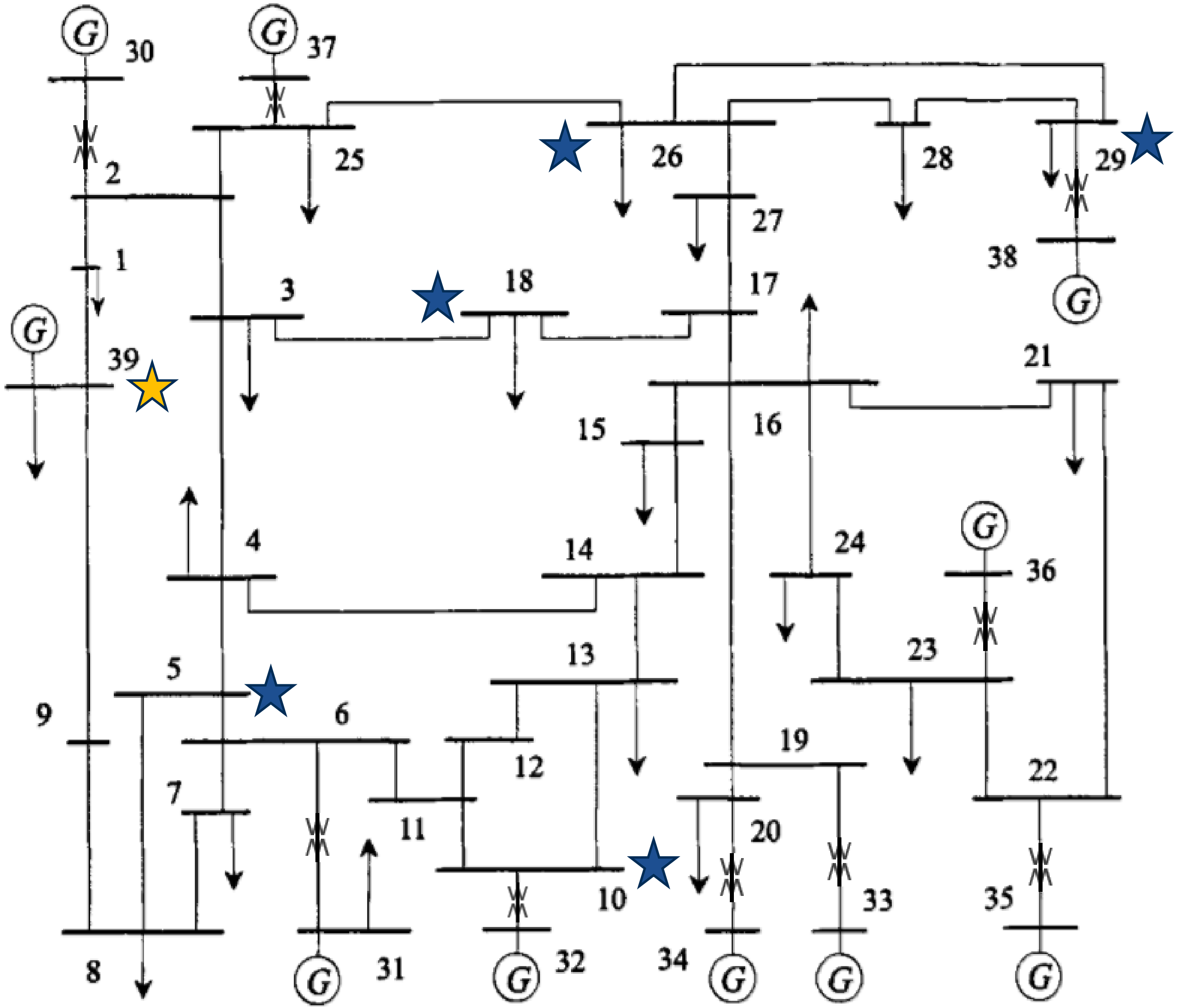
- For Illustration, we will be using the IEEE 39 Bus system model to explain EPG's approach to Generate the Synchrophasor CASE for S-EMS
- From slow-speed data
  - Model information
  - Telemetry:
    - Voltages (VM, VA)
    - Equipment/CB statuses
    - Load & Generation

★ Swing Bus



Perform Linear State Estimation

- Model information
- CB statuses
- Voltage and Current phasors

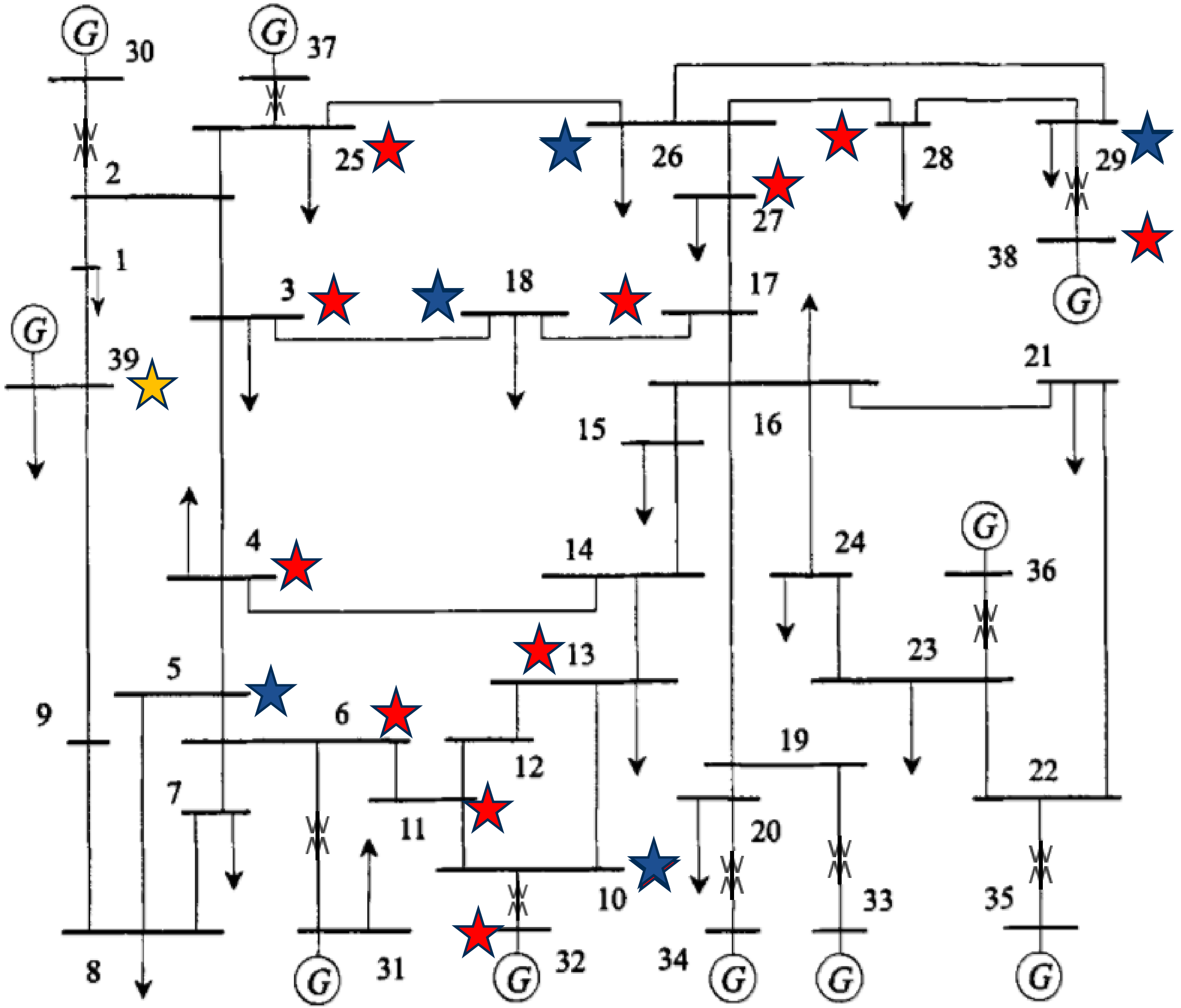


★ Swing Bus – w/phasor measurement

★ Bus with Synchrophasor measurement

Synchrophasor case generator

How to use the LSE voltages to drive the voltage profile in the power flow case?



Swing Bus

Bus with synchrophasor measurement

Bus with LSE observability

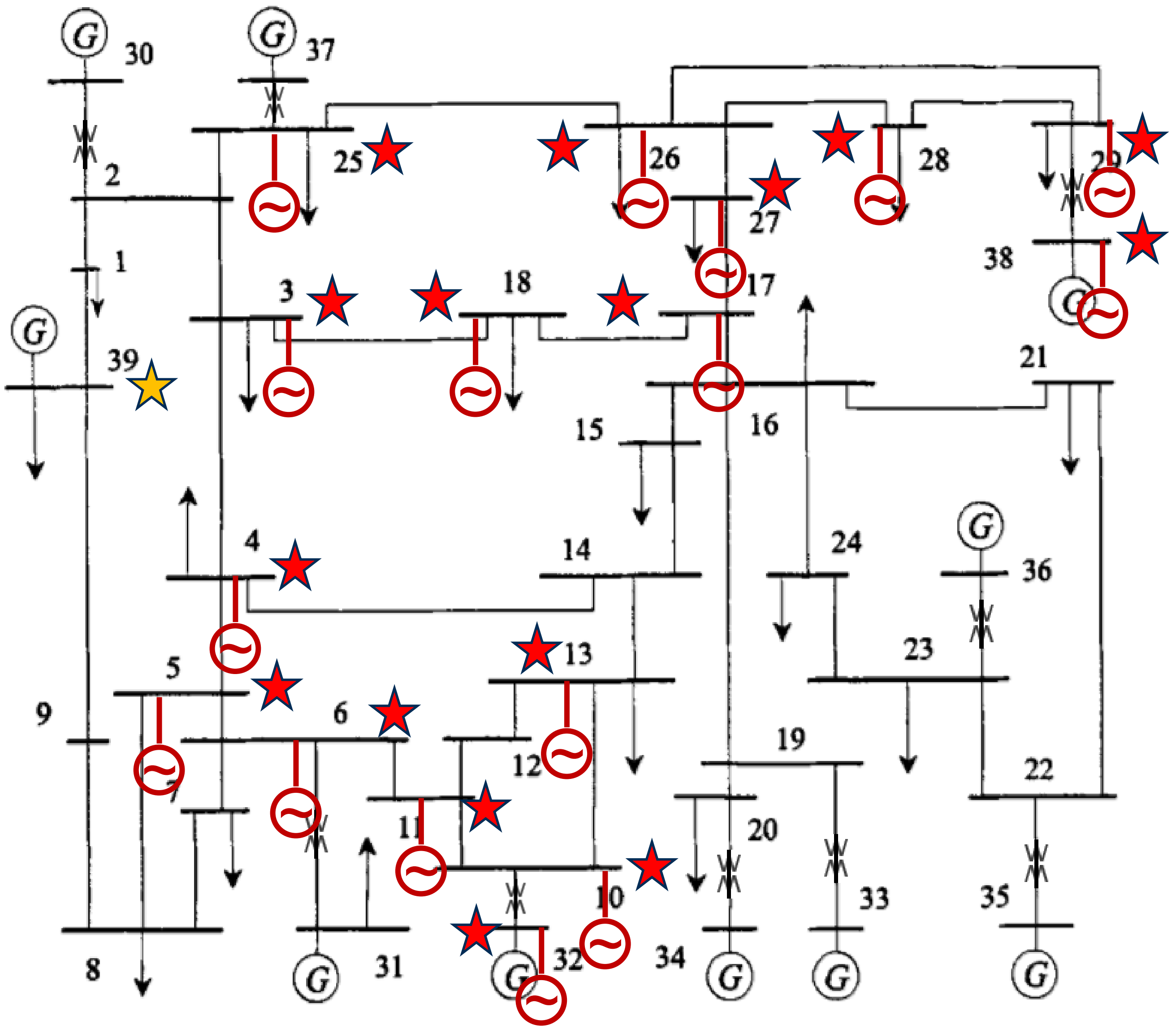
Synchrophasor case generator

- Change bus type to PV bus
- Add LSE generator
- Solve case

Swing Bus

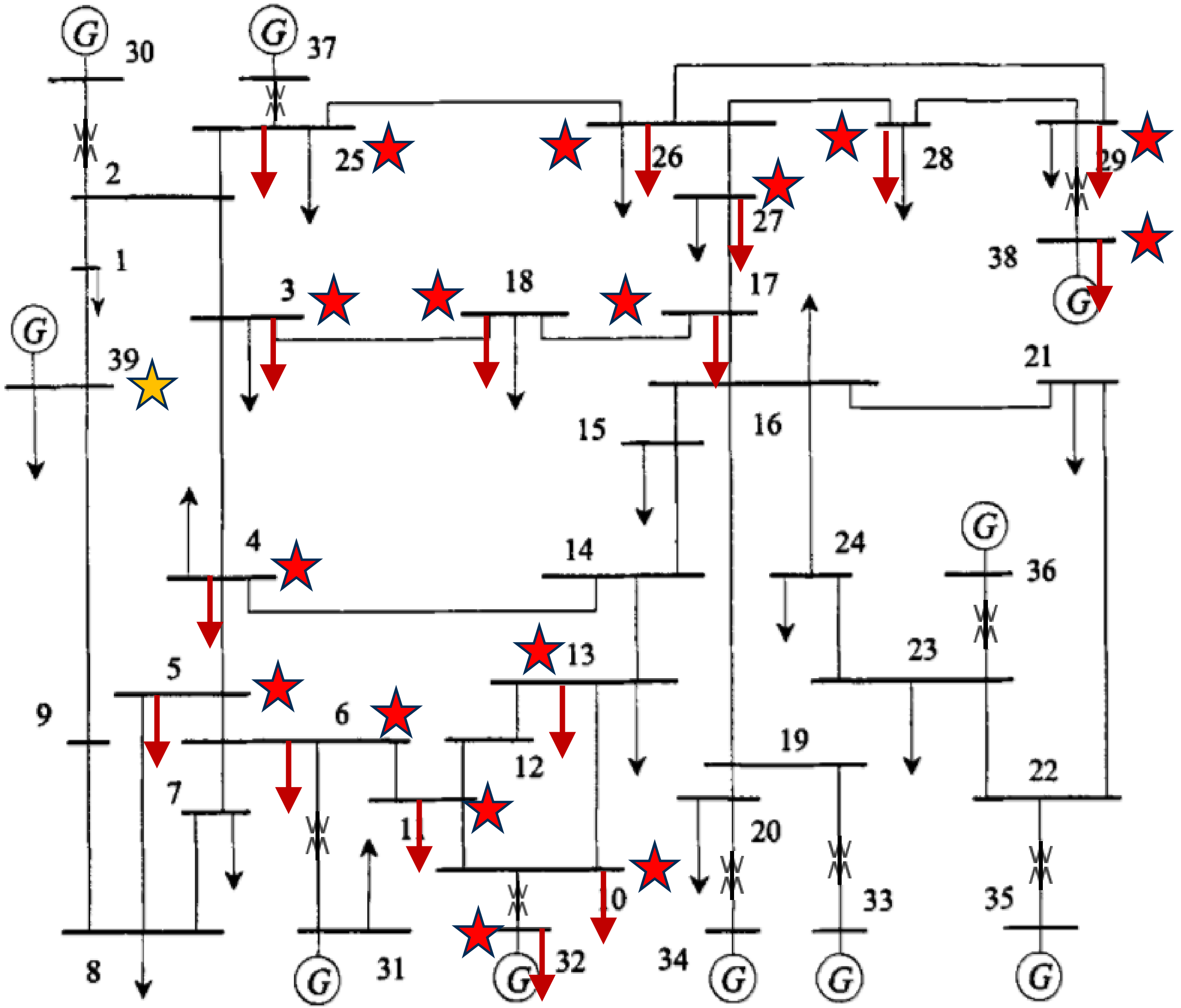
Bus with LSE observability

LSE generator



Post-processing

- Change bus type to load
- Add compensation load
- Solve case



☆ Swing Bus – w/phasor measurement

★ Bus with LSE observability

LSE generator

CONCLUSIONS

The Synchrophasor-based EMS allows operators to manage today's modern grid

- Platform for managing smart grids
- Independent from EMS SCADA
- Based on high-speed time synchronized data
- State Estimation always solves at high-speed with LSE
- Provides assessments of power system dynamics
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Q&A