SUNGROW’s GFM Capabilities and Perspective on ERCOT’s Advanced Grid Support Requirements for ESR

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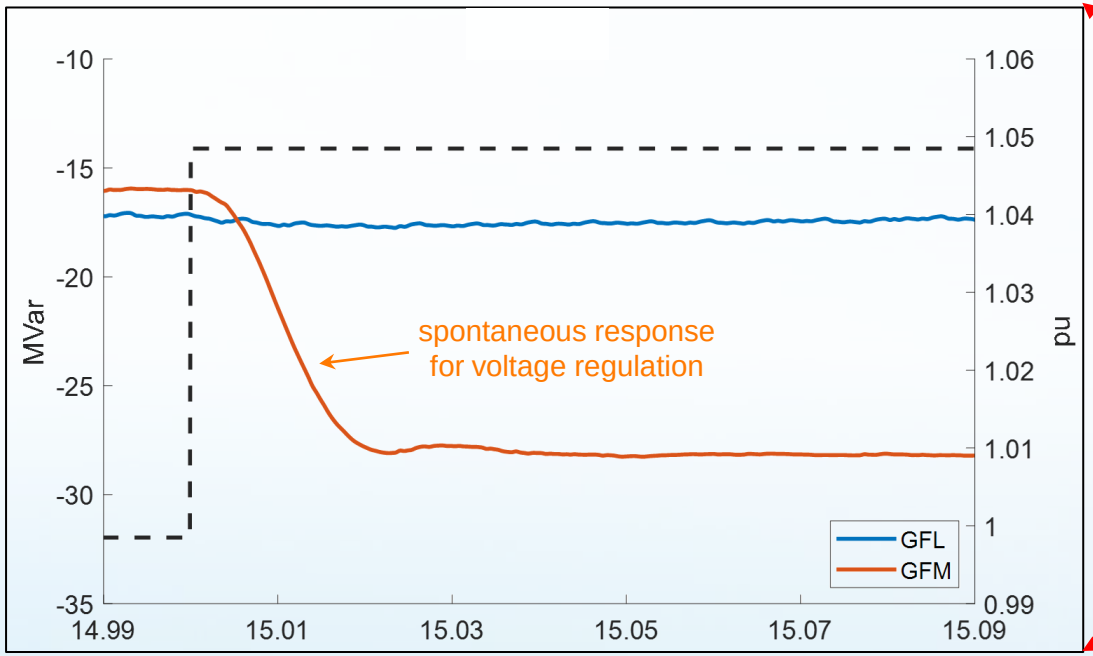
Sungrow USA

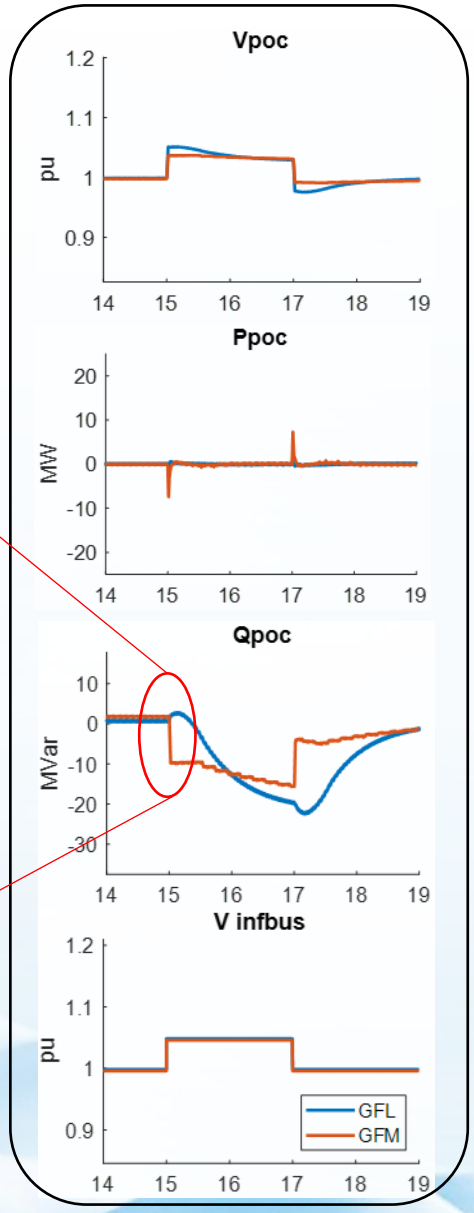
2025.2.21

CONTENT

GFM Technology and Benefits

- Autonomously and instantaneously respond to voltage / frequency fluctuations

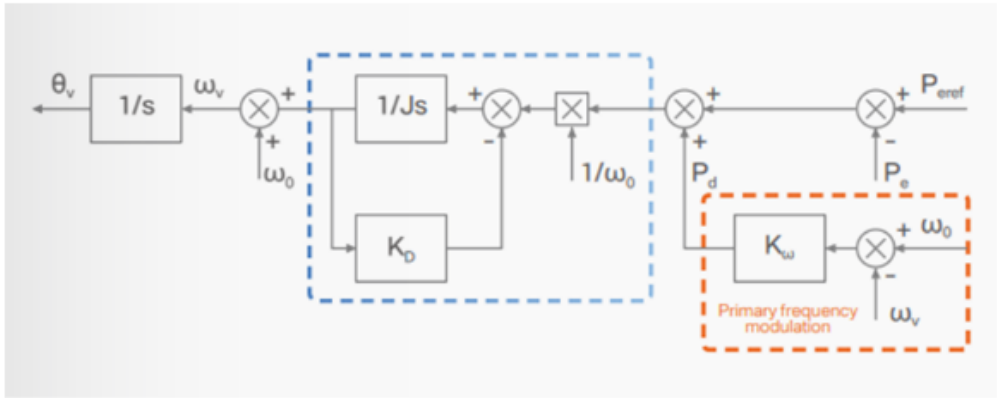




GFM Technology and Benefits_Conti.

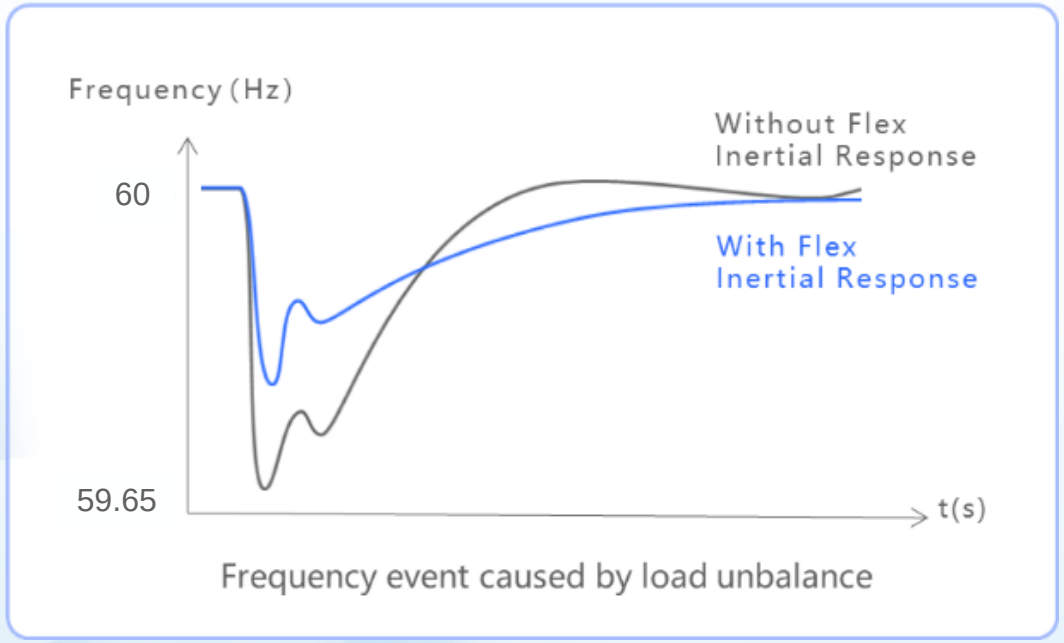
- Flexible inertia control and improved primary frequency response control to enhance frequency stability

The Technique



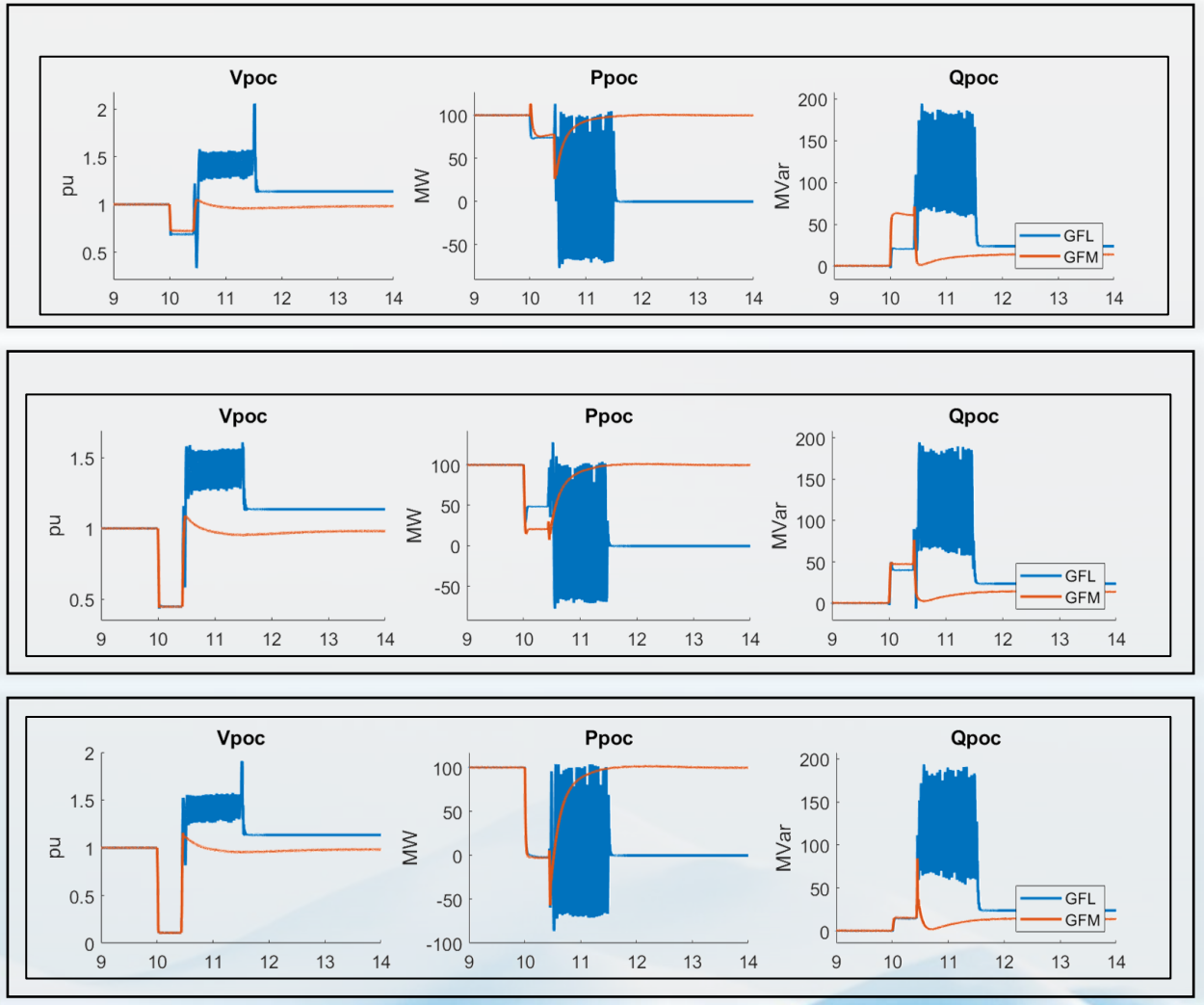
Performance

Response time	Moment of Inertia
Millisecond	Flexible



GFM Technology and Benefits_Conti.

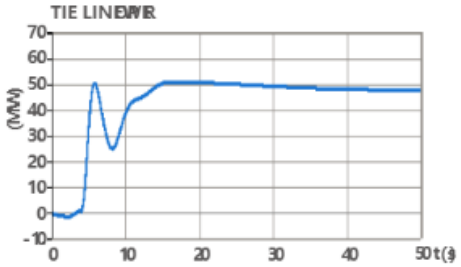
- Ride through capability under extremely weak grid condition
  - LVRT Ride Through – with Different Voltage Dip Depth



GFM Technology and Benefits_Conti.

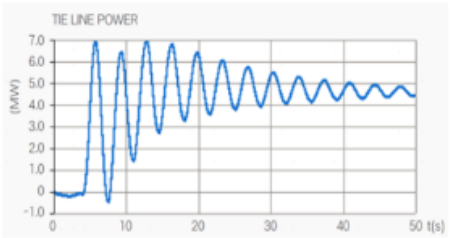
- Oscillation damping capability to enhance stability at different operation levels – IBR Unit, IBR site and beyond

Performance ➡ **0.1Hz-2.5Hz**
Oscillation proactive supression



GFM

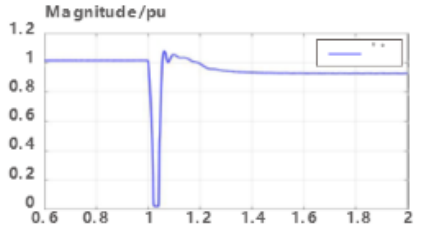
- Oscillation cancellation within cycles
- Normal operation maintains



GFL

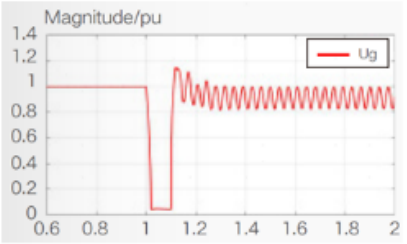
- Slow damped 0.3Hz oscillation for 50 seconds

Performance ➡ **2.5Hz-2.5kHz**
Oscillation proactive supression



GFM

- Oscillation cancellation within cycles
- Normal operation maintains



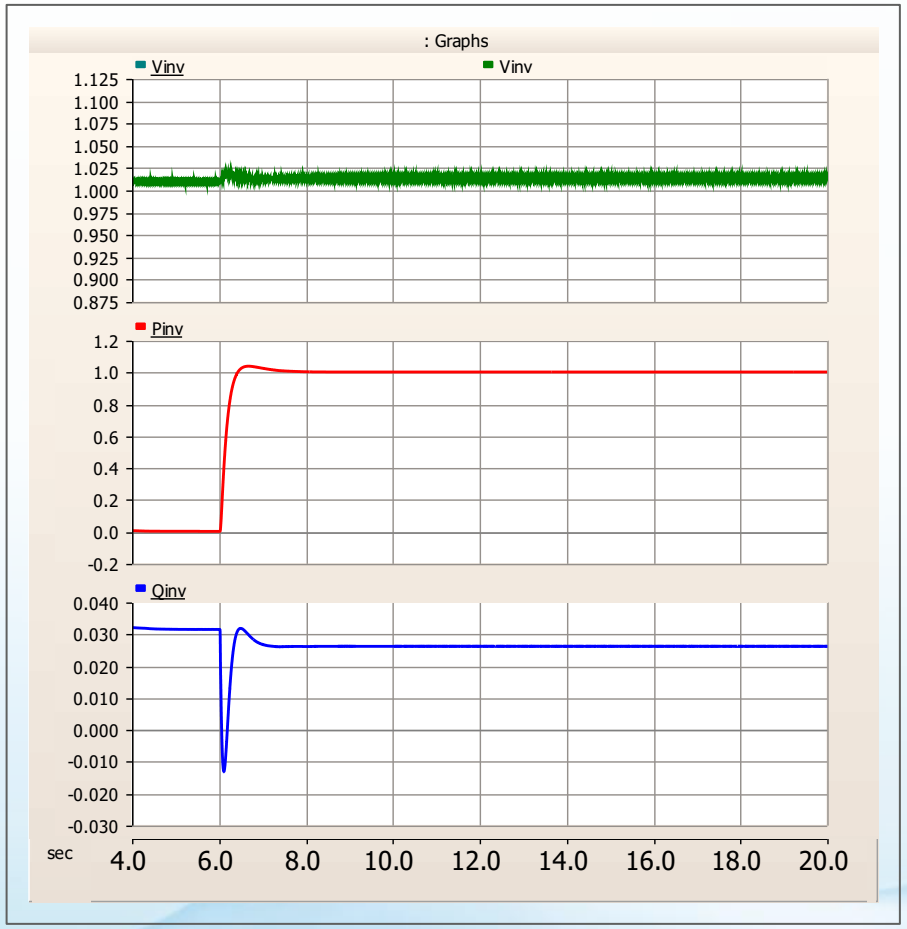
GFL

- Undamped 30Hz oscillation
- Lead to unit tripping

CONTENT

GFM Model Test Results

Flat Start Test					
Test Case Name	Test Bench	P pu	Q pu	SCR	X/R
Flat Start Test	TB1	1	0	3	6



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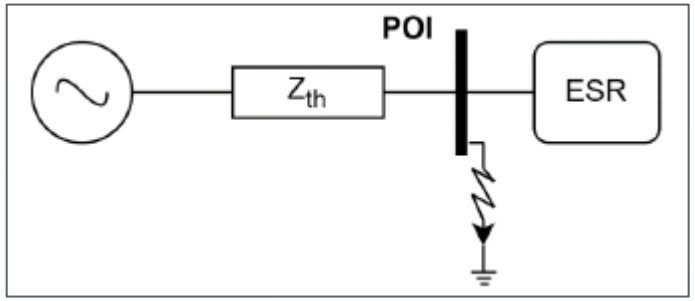

Sample of ERCOT Acceptable Results

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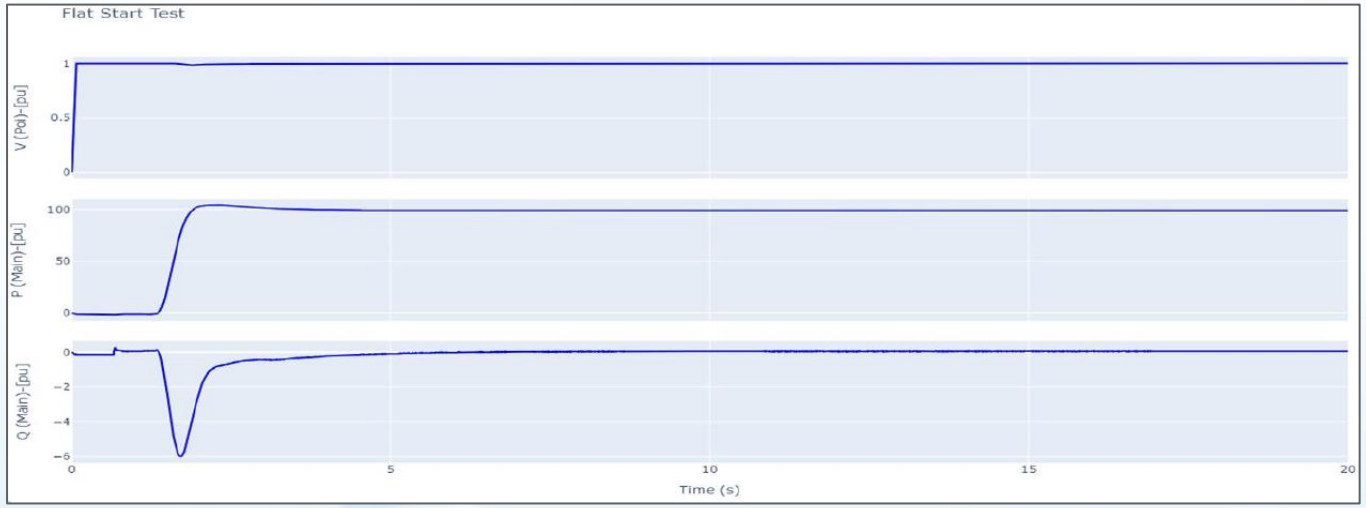
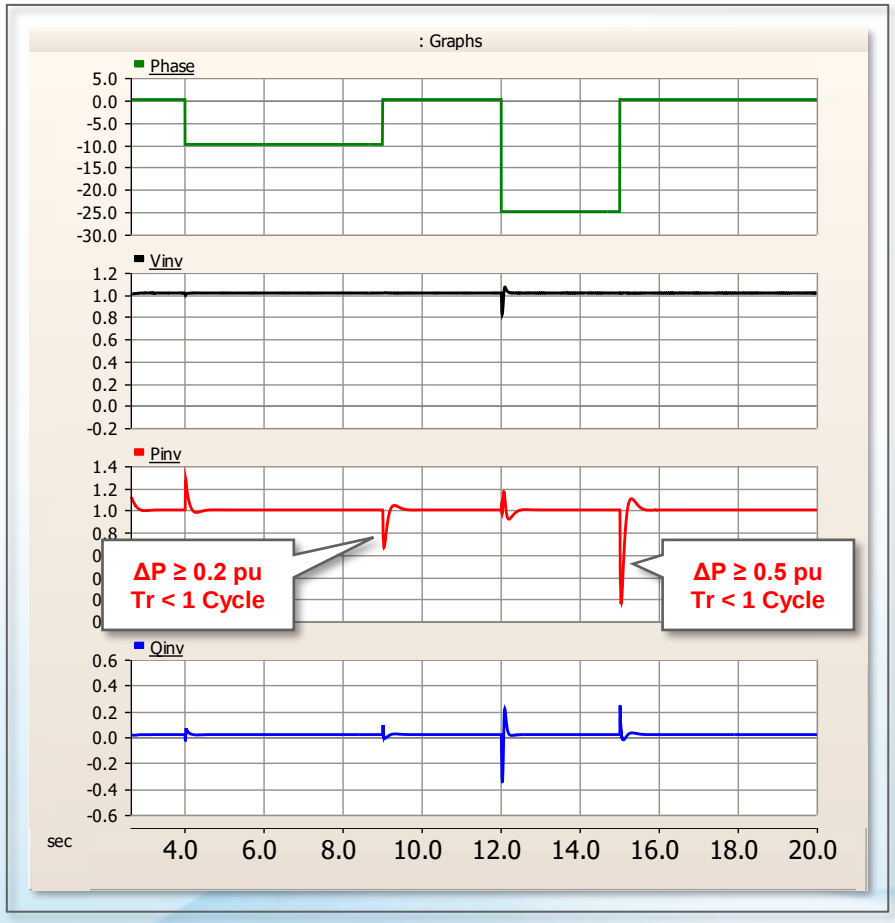


* Advanced Grid Support Energy Storage Resource， (AGS-ESR) Functional Specification and Test Framework for the ERCOT Grid, Version 1.0, September 2024

** ERCOT AGS ESR Requirements， Poria Astero, Sun Wook Kang， Dynamic Studies, ERCOT， IBRWG/DWG Joint Workshop， October 11, 2024

GFM Model Test Results_Conti

Phase Angle Jump Test					
Test Case Name	Test Bench	P pu	Q pu	SCR	X/R
Phase Angle Jump Test	TB1	1	0	3	6



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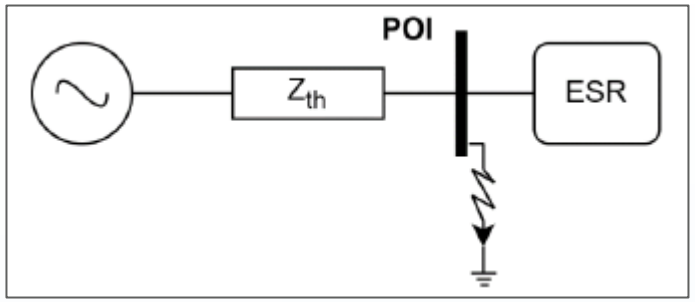

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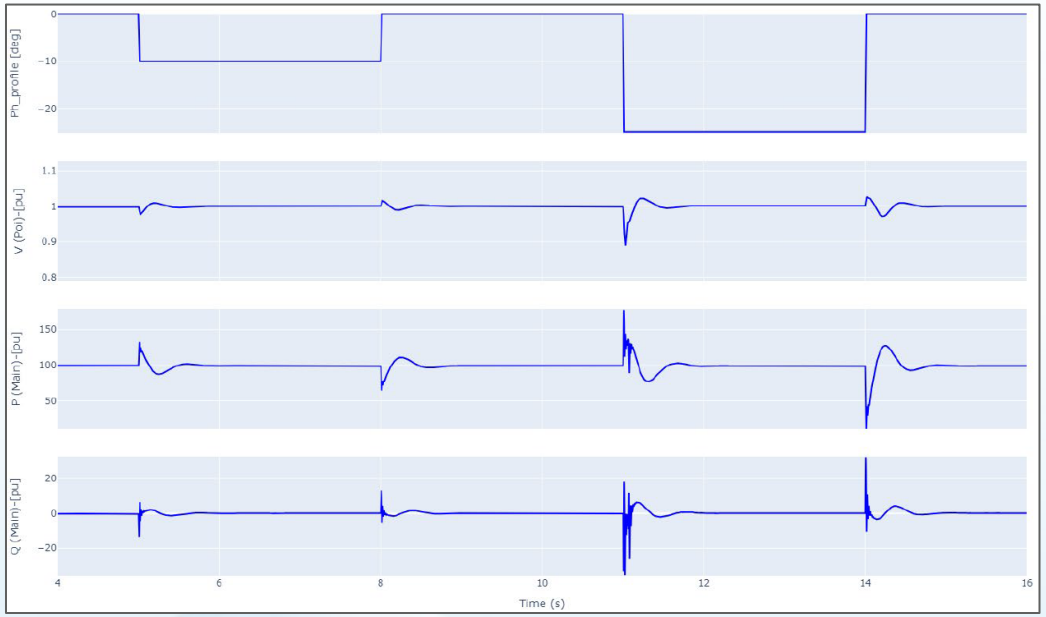

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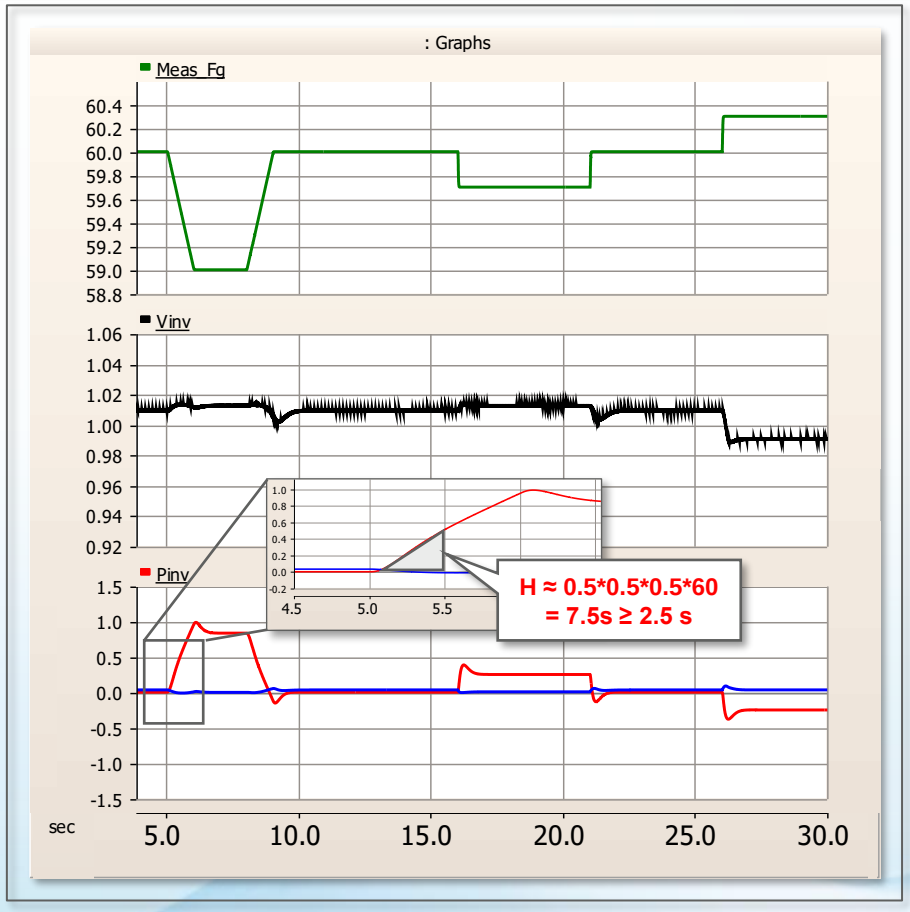
GFM Model Test Results_Conti

Frequency Change and Inertia Response Test					
Test Case Name	Test Bench	P pu	Q pu	SCR	X/R
Frequency Change and Inertia Response Test	TB1	0	0	3	6



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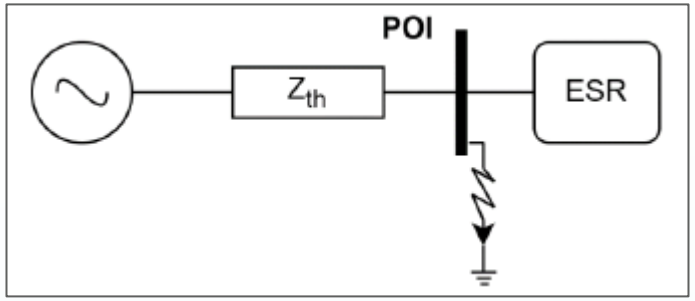

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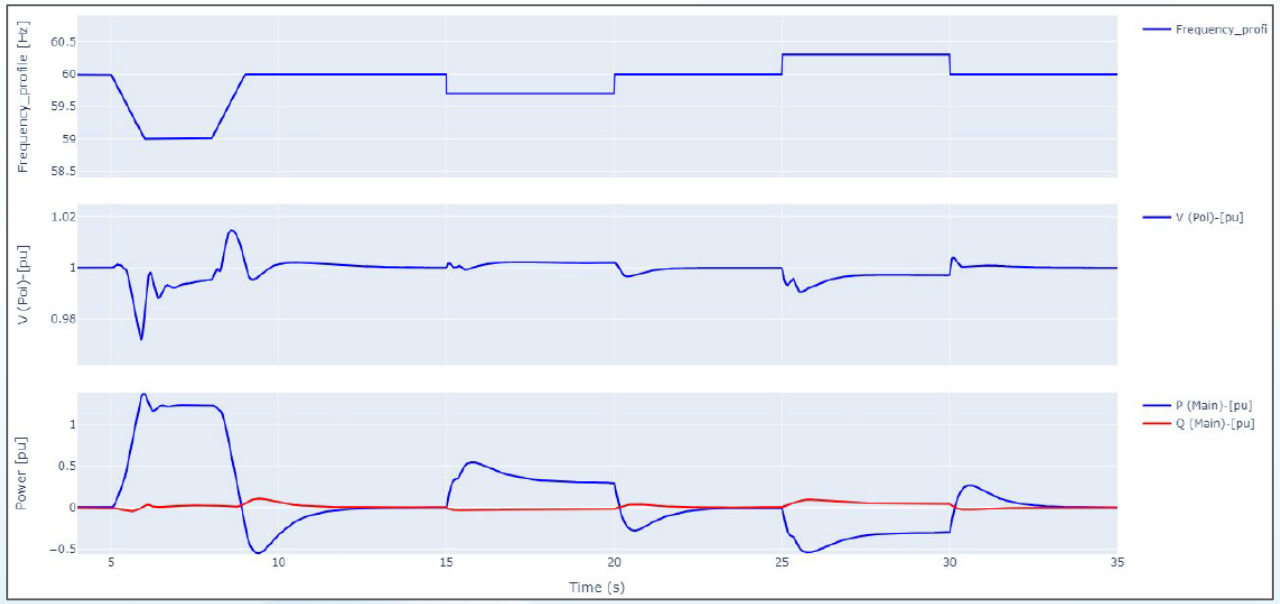

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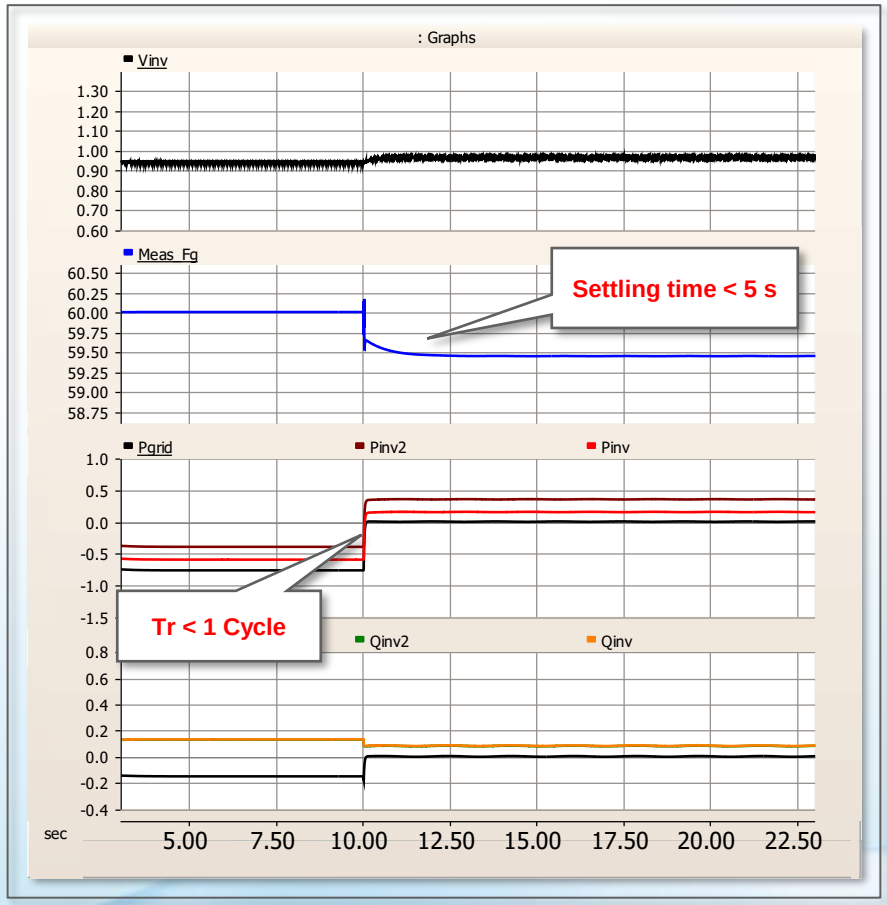
GFM Model Test Results_Conti.

Loss of Synchronous Machine Test						
Test Case Name	Test Bench	P1/P2 pu	Q pu	Load pu	SCR	X/R
Loss of Synchronous Machine Test	TB2	0.6(Charging) 0.4(Charging)	0	0.7	N/A	N/A



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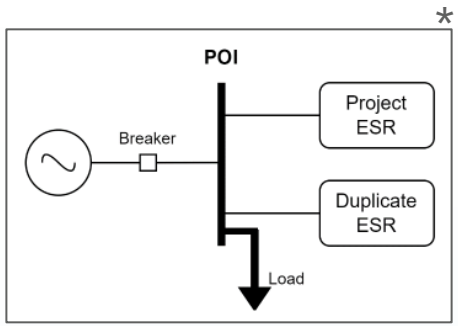

Sample of ERCOT Acceptable Results

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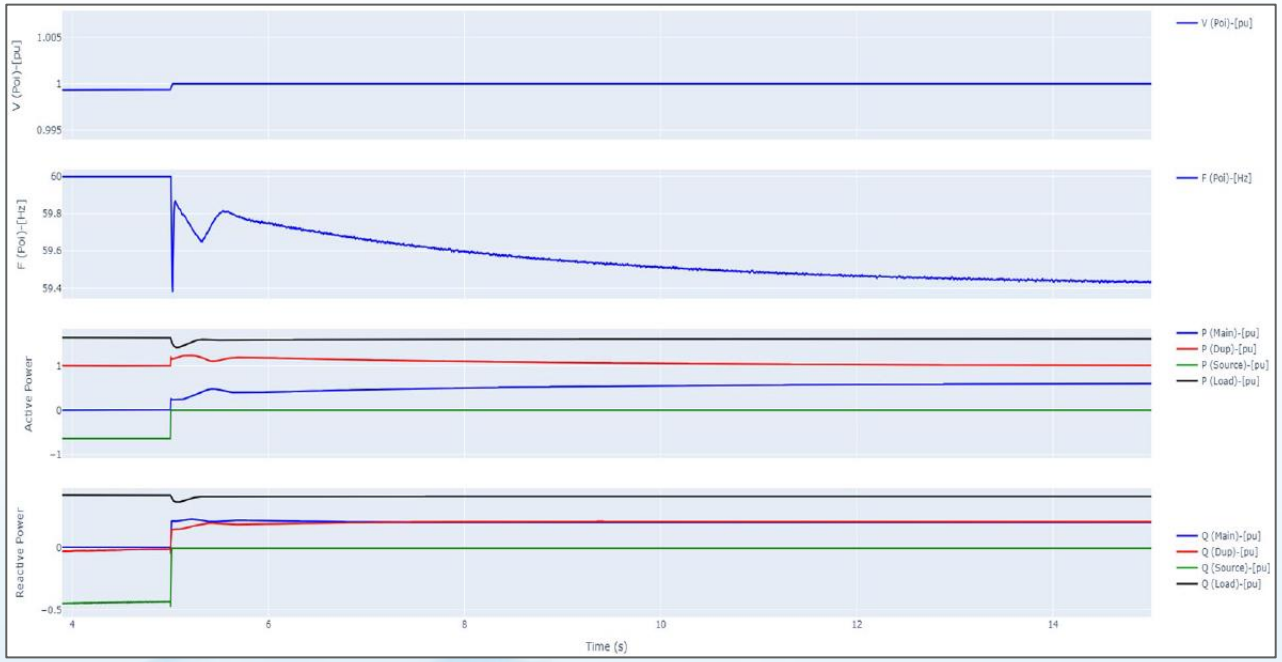

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Further Clarification and Discussion on AGS-ESRs requirements

ERCOT Proposed AGS-ESRs Requirements ***

- ERCOT proposed AGS-ESRs requirements
  - Provide support when resources have available capacity/state of charge (SOC) and are within the design capability
  - Don't require additional short circuit current capability
  - Don't need to maintain available capacity/SOC in real time
  - Require to meet the proposed model quality and unit validation tests as stated in the PGRR121
  - Require to meet the same performance requirements as the existing IBRs

- ERCOT's proposal is to have the minimum requirements without requiring ESRs to provide additional hardware or energy reserves to provide specific short circuit current or inertia contribution
- The primary benefit AGS-ESRs provide to the ERCOT grid is the system strength improvement and grid stability

*** NOGRR272/PGRR121 Advanced Grid Support Requirements for Inverter Based ESRs， Shun Hsien (Fred) Huang，ERCOT Operations Support， ERCOT Reliability and Operations， Subcommittee (ROS) Meeting February 6, 2025

CONTENT

1. GFM Technology Interpretation
2. GFM Model Test Results
3. **SUNGROW GFM Project References**

Clean power for all

Typical GFM References

Project information

- Project capacity: 15MW/5.5MWh BESS
- Project location: Indiana, US
- Project time: 2019
- Product models: SC2500U+ Air Cooled Batteries
- Technology application: **Black start** application using VSG technology.

Values

- Using grid-forming ESS to replace diesel generators to complete the black start of two 110MW gas turbines

Project information

- Project capacity: 536MW/600MWh BESS, 2GW PV
- Project time: Q1 2025
- Project location: Saudi Arabia
- Product models: PowerTitan G1, 1+X modular inverters
- Technology application: **Coordinated grid-forming of PV & storage, seamless on-grid/off-grid switching**.

Values

- This project provides stable and reliable power supply for a new city in the Middle East.
- Grid-forming helps to build the world's largest new energy hydrogen production base.
- Seamless on-grid/off-grid switching.

Typical GFM References

Project information

- Project capacity: 200MW/800MWh BESS
- Project location: South Australia, Australia
- Project time: 2025 Q4
- Product models: SC6900UD-MV + PowerTitan G2 Batteries
- Technology application: **On-grid VSG technology**.

Values

- Applying grid-forming technologies to remediate system strength charges, and provide extra system strength.
- Provide extra grid forming values for potential future ancillary services.

Project information

- Project capacity: 30MW/60MWh BESS
- Project location: Finland
- Project time: 2025 Q3
- Product models: SC5000UD-MV + PowerTitan G2 Batteries
- Technology application: **On-grid VSG technology**.

Values

- Applying grid forming technologies to comply with Finland grid code, helping to enhance regional grid.

Questions?
Thank You!