ERCOT Response to Comments on AGS-ESR Test Requirements

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Frequently Asked Questions:

- ERCOT has posted the FAQ document on the February 2025 IBRWG website

Frequently Asked Questions:

Q1. Does ERCOT require ESRs to maintain headroom for AGS during real-time operations?

- The test requirements are designed to confirm whether an ESR possesses AGS capability through model quality tests.
- ERCOT does not mandate that ESRs maintain headroom for AGS during real-time operations as proposed in NOGRR272 and PGRR121

Q2. Is it clear whether plant controls should be considered in the testing process? Should all plant controls be included in the site-specific test?

- All plant controls that are needed to represent the ESR's performance at Point of Interconnection must be included in the site-specific test

Frequently Asked Questions:

Q3. Why are there no tests conducted at full charge power or with reactive power?

- ERCOT evaluated various dispatched scenarios when developing the proposed test requirements
- ERCOT believes that the selected dispatch scenarios in the test requirements are sufficient to verify ESR with AGS characteristics
- Additionally, all generation projects must undergo further evaluation during the full interconnection study including dynamic stability study conducted based on ERCOT Protocol, Planning Guide and NERC Reliability Standards. Various scenarios are evaluated during the system impact analysis.

Frequently Asked Questions:

Q4. Why are reactive step tests, such as the series compensation step test, not included in the ERCOT test requirements?

- ERCOT AGS ESR Test requirement document. It was discussed at IBRWG in September 2024. See the following document.

ERCOT Advanced Grid Support ESR Test Requirement_.pdf

Q5. How does ERCOT ensure that AGS-ESR models account for converter limitations on the DC side, including active power limits?

- The dynamic model of an AGS-ESR should account for converter controls, including current or voltage limits on the DC side if necessary to represent appropriate dynamic behavior, as well as interactions with the AC system

Frequently Asked Questions:

Q6. Why does Small Voltage Disturbance Test indicate very tight V(Q) droop and/or closed-loop plant controls?

- For the model quality test, we do not prescribe specific control requirements. Instead, we evaluate the response of the resource at the Point of Interconnection (POI)
- The 3% voltage step test is an existing requirement that all IBRs must pass. This step change is intentionally set outside the tolerance bands specified in Section 2.7.3 of the ERCOT Nodal Operating Guide

Frequently Asked Questions:

Q7. Why is the frequency change and inertia response test only conducted at zero active and reactive power? Does ERCOT require a specific response beyond a 1Hz/s rate of change of frequency (ROCOF)? Why are there no tests for conditions exceeding 60Hz? Was this omission intentional? How realistic is an instantaneous 0.3Hz frequency step? Doesn't this represent an effectively infinite rate of change?

- This is NOT a ROCOF ride-through test. The primary purpose of the inertia response test is to assess whether the ESR provides the required energy response during the frequency decay (1Hz/s) within the first 0.5 seconds.
- The initial dispatch of ESR must be set to zero active power with approximately zero reactive power such that performance related to ESR's energy response (i.e., active power response) can be observed without complicating the response with other factors.
- ERCOT believes that the selected dispatch scenario is sufficient to verify ESR with AGS characteristics.
- Frequency step is an existing requirement that all IBRs must pass.

Frequently Asked Questions:

Q8. For Frequency Change and Inertia Response Test, what are the performance criteria for the instantaneous provision of active current? The passing criteria could potentially be met by a fast Grid-Following (GFL) inverter, which inherently introduces dead time due to metering, control delays, and communication latency. Furthermore, the statement “Voltage should not deviate from steady state for any significant amount of time” lacks specificity. Since inertial power is delivered through plant impedance, some voltage deviation is expected. How is the allowable duration of voltage deviation defined? Additionally, plant controls can impact ΔE. Should the Power Plant Controller (PPC) be activated or deactivated during this test? Does this imply GFM-Droop is required on convertor or Plant level frequency controls??

- See the response to Question #7 for the purpose of this specific test. Even if a GFL-ESR passes the inertia response criteria, it must pass all other remaining tests to be considered as AGS-ESR.
- Similar to current ERCOT requirements, the intent is to avoid overly prescriptive criteria, particularly for responses transitioning to the stabilization period. This approach allows engineering judgment to assess performance more effectively. For details on damping criteria, please refer to ERCOT Planning Guide Section 4.
- All plant controls must be modeled in the site-specific test. For the model quality test, we do not specify which controls are required. Instead, we evaluate the response at the POI

Frequently Asked Questions:

Q9. For System Strength Test, why is the test only conducted during discharge mode? Why is there no reactive power response, despite GFM inherently providing reactive power support? Experience indicates that GFM controls most frequently fail under asymmetrical fault conditions, particularly during phase C-to-ground (C-GND) faults. Should all fault types be considered in the test?

- This test is the same as the existing system strength test required for all IBRs. The primary goal is to assess the performance of the AGS-ESR at different system strength levels.
- Various scenarios are possible. However, the goal of these test requirements is to define a minimum set of tests. to determine whether the ESR demonstrates AGS capability.
- Additionally, all generation projects must undergo further evaluation during the full interconnection study including dynamic stability study conducted based on ERCOT Protocol, Planning Guide and NERC Reliability Standards (e.g., TPL-001-5.1 and FAC-002-4).

Frequently Asked Questions:

Q10. Regarding the Loss of Synchronous Machine Test,

- If there is concern about plant-to-plant oscillation, should this first be tested within a single plant (block-block), or should more onerous tests be applied?
- No specific performance criteria are mentioned for Scenario 3. What is the justification for the 5- and 10-seconds?
- Can a check be added to ensure that there is no opposing active (P) or reactive (Q) power exchange between the two plants?
- The current setup suggests that f(P) and V(Q) droop controls are required at the converter level—was this intentional?

– Having the two machines is primarily to examine appropriate real and reactive power response from the ESRs and to ensure any control issue between the two machines, especially when one of them is at its limit.

– The duplicate ESR is the copy of the project ESR. The only difference is the initial dispatch. Therefore, there should not be any circulating active or reactive power.

– Performance criteria is clearly defined in Table 6. Also refer to the response to Question #13

– The performance expectation related to the 5 and 10-sec durations is based on testing various OEM models and past experience.

– For the model quality test, we do not specify which controls are required. Instead, we evaluate the response at the POI. Please ensure compliance with the rules outlined in the Nodal Operating Guide.

Frequently Asked Questions:

Q11. For the phase angle jump test, is an increase of 0.2 pu required for a 10-degree angle drop?

Performance Criteria
A. Instantaneous active power output of the plant should quickly respond to oppose the angle change. The peak active power change should be at least 0.2 pu (based on rated active power) for each 10-degree voltage phase angle change, in opposing direction. (e.g., A 100 MW rated plant should temporarily decrease active power output from 100 MW to 80 MW, or below, when source voltage angle is increasing 10 degrees; and it should temporarily increase active power from 100 to at least 120 MW, if the current limit allows, when voltage source angle is decreased by 10 degrees.)

– Yes, it is required. However, if the current limit in the inverter is reached when the angle jump is applied, the performance criteria may not apply.

Frequently Asked Questions:

Q12. Tesla's analysis and simulations results reveal site-specific dependencies for phase angle test outcomes

- Recommends adding flexibility to the requirement based on site-specific impedance
- Power change is a function of total impedance and the requirement is not always achievable

Assumptions:

- Initial P = 1 PU
- V_2 and V_1 equal 1 PU and stay constant

$$\Delta P = \left(\frac{\sin(\Delta\ \delta + \delta_0)}{\sin\ \delta_0} - 1\right), \quad \sin\ \delta_0 = X$$

Requirement boundary :

- ΔP at least 0.2 PU for 10-degree angle change

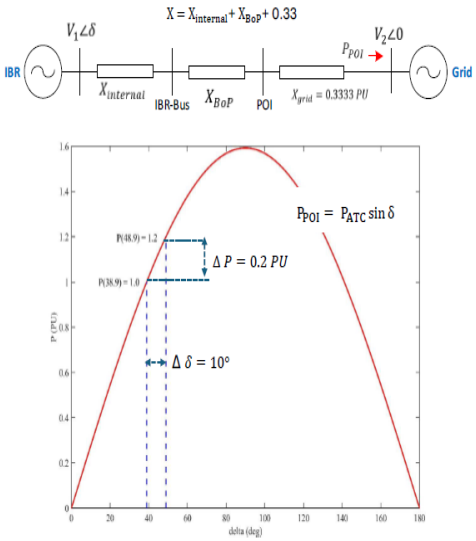
$$\delta_0 \leq 38.9,\ or\ \ X \leq 0.63\ PU$$

$$X_{internal} + X_{BoP} \leq\ 0.29\ PU^*$$

- ΔP at least 0.5 PU for 25-degree angle change

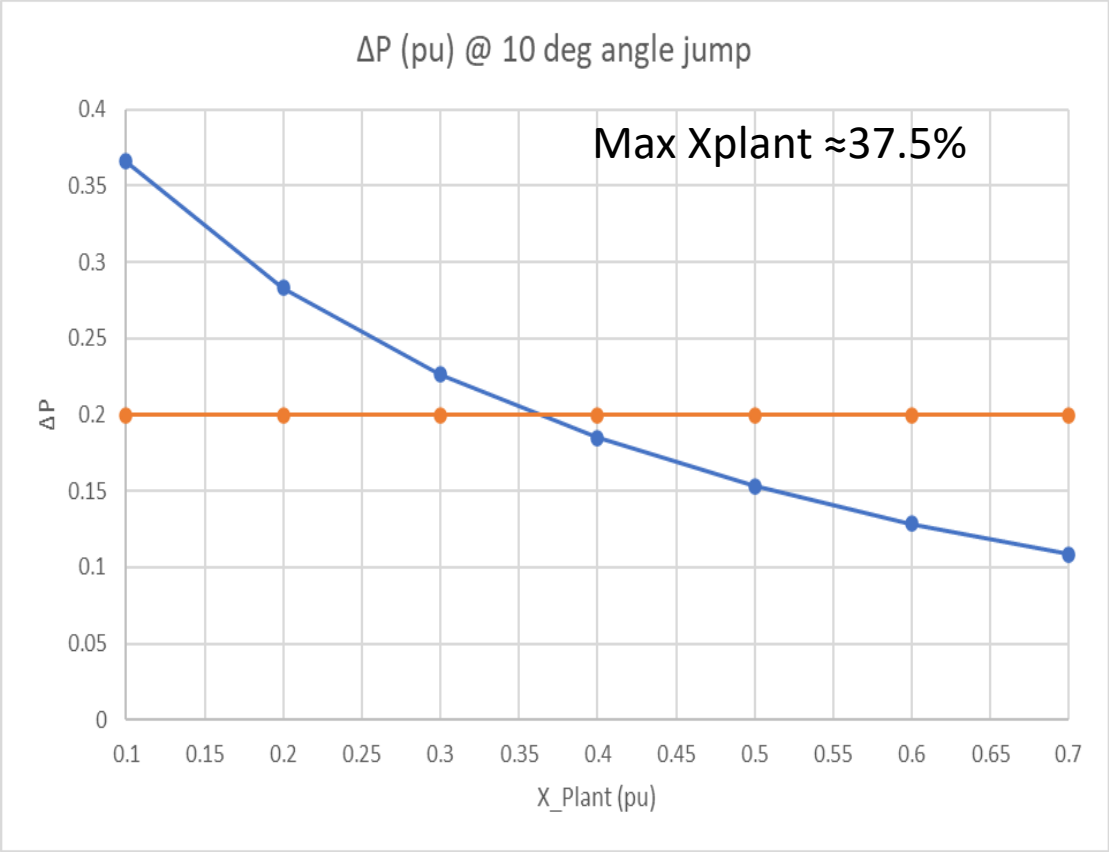
$$X_{internal} + X_{BoP} \leq\ 0.25\ PU^*$$

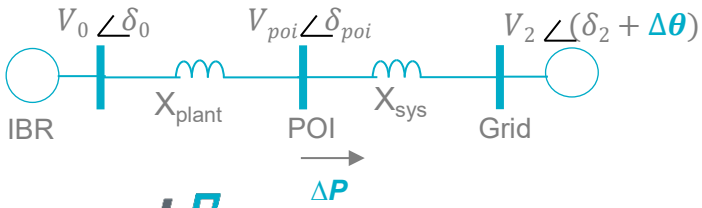
*On POI real power base



- Theoretically, voltages at terminal and voltage source must be higher than Tesla's analysis assumption (e.g., assumed constant at 1.0 pu)
- The success criteria is based on the worst-case total impedance approximately 70% (i.e. maximum plant impedance approximately 37% @ X/R ratio = 10). In addition, the criteria is based on testing various OEM models
- Refers to the knee curves in the next slide

Frequently Asked Questions:





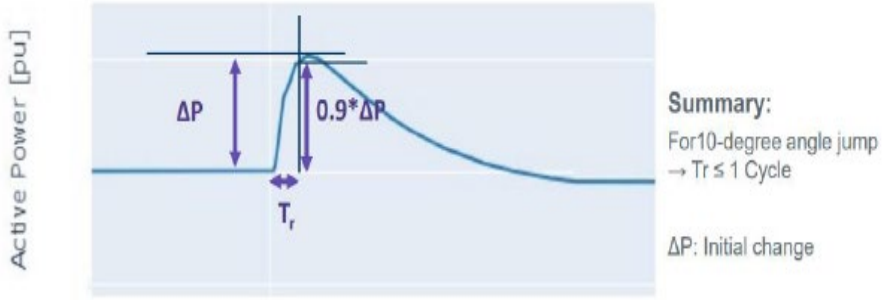
$$\Delta P = \frac{V_0 V_2 [\sin(\delta_0 - \delta_2 - \Delta\theta) - \sin(\delta_0 - \delta_2)]}{X_{plant} + X_{sys}}$$

* Assumed that R is negligible

Frequently Asked Questions:

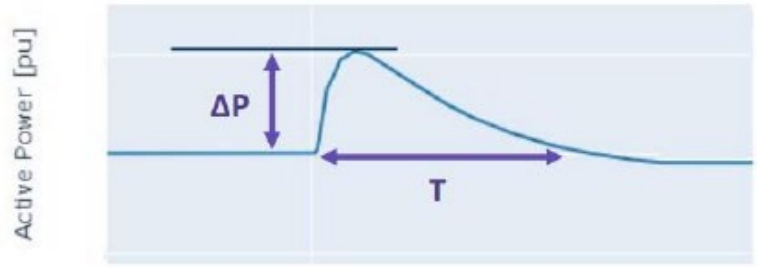
Q13. Does the one-cycle condition for rise time apply to the case with a 25-degree jump, or is it only relevant to the 10-degree case?

- The response time to 90% of the initial change in instantaneous active power should occur within one cycle. The criteria is applicable to both 10-degree and 25-degree angle jump tests
- The time to reach the power peak (1 cycle) is not a function of input (i.e. angle step size), it is based on the plant inductance between two sources. Therefore, it should satisfy the 1 cycle requirement.
- If the current limit in the inverter is reached when the angle jump is applied, the performance criteria may not apply.
- The criteria is also based on tests of various OEM models and a review of practices in other regions



Frequently Asked Questions:

Q14. Does the 3-cycle criteria in the Phase Angle Jump Test apply only when the plant reaches the current limit?



Summary:
For 10-degree angle jump → ΔP ≥ 0.2 pu
For 25-degree angle jump → ΔP ≥ 0.5 pu

T ≥ 3 Cycles

Note: If the pre-event dispatch causes the plant to reach the current limit in the inverter when the angle jump is applied, the performance criteria described above (criterion A) may not apply. However, the active power must return to the pre-disturbance level in a stable manner without causing undue degradation of system performance. The active power must be more than or equal to pre disturbance level for at least 3 cycles.

- The original criteria highlighted above has been updated to state: "*the active power must not return to the pre-disturbance level for at least 3 cycles*"
- If the current limit in the inverter is reached when the angle jump is applied, the performance criteria described above may not apply. However, the active power must return to the pre-disturbance level in a stable manner.

Frequently Asked Questions:

Q15. Commenter recommended to use quantitative requirements instead of qualitative ones, as the latter can be subject to interpretation.

- ERCOT's proposed test framework includes specific criteria when applicable and also qualitative expectation to avoid overly prescriptive criteria that could negatively impact the grid. This approach provides flexibility to accommodate various system conditions

Questions?

Comments to
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