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Discussion on Site PFR and Inverter Ride Through Control

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1. Understanding of Observed PFR Issue after LVRT

Per IBRWG Meeting Minutes, July 2025,

- **Issue:**

  "IBR units that have been reducing output during voltage ride-through events due to high frequency calculations or PPC interactions during fault conditions… , it was found that some of the wind and solar sites are following the voltage ride-through standard. However, after the fault, they are reducing output due to a perceived frequency event or using a new setpoint based on reduced output during LVRT."

. Further observation and speculated root causes:

*"The site's calculation of the local frequency is **coinciding with the time of fault**, so it is producing **frequency spikes** that are **not seen** across ERCOT, nor is it indicative of system frequency.*

*Unexpected **interaction between turbine level voltage ride through and the park controller level frequency droop response functions**.*

*PPC assigned new setpoint to inverters by looking at current output, which was during the low active power output **during LVRT**."*

2. Sungrow Suggested Practice on PFR & FFR at a Site

- **Inverter unit level frequency-active power control function (F/W)**
  - The inverter's P is regulated according to a predefined frequency–watt (F/W) control curve, which includes customer-adjustable parameters such as deadband and slopes, etc.
  - F/W control at the inverter level can be configured for fast frequency response (FFR). However, for sites equipped with a power plant controller (PPC), inv unit F/W control is typically disabled.
  - When inv F/W control is enabled, the frequency is calculated from the voltage signal measured at the inverter's AC terminal. The filtered fundamental frequency element is then used.
- **Site-level PFR (Primary Frequency Response) is typically implemented in site PPC**
- **Site-level FFR (Fast Frequency Response): Sungrow suggests** control parameters and logic to reside in the PPC since the frequency at POM (point of measurement) is monitored by PPC.
- **Sungrow doesn't offer any PPC product in the NA market.** Site-level PFR and FFR performance depends on the PPC vendor's product.

3. Sungrow Inverter Ride Through Control Logic Outlined

- **Sungrow Inverter Ride-Through Modes Explained:**

  - **Momentary Cessation (MC)**
    - Without P/Q support

  - **Non-MC**
    - With P support, Q support, or both P & Q support.
    - Customer selectable VRT control modes. Configurable to meet specific grid or industrial standards (e.g., ERCOT, IEEE 2800, etc.) through adjustable VRT control parameters. Options include pre-fault I_q superposition and specific current injection logics, etc.

3. Sungrow Inverter Ride Through Control Logic Outlined, Cont.

- **VRT Triggering Control Logic:**

- VRT detection uses the **filtered fundamental-frequency RMS positive-sequence voltage** measured at the inverter LV AC terminal.

- VRT is triggered almost **instantly** once thresholds are met.

- During VRT:
  - The inverter **pauses response to PPC** dispatch commands.
  - The inverter continues receiving and logging PPC commands for internal use.

3. Sungrow Inverter Ride Through Control Logic Outlined, Cont.

- **General Current Injection Control Logic During Non-MC VRT (typically configured as Q-priority):**

- **Reactive Current Injection Control (Iq):**
  - Use LVRT as an example,

    Iq = Iq0 + (Vref - Ut) * Kf * In

    Iq: Reactive current generated during L/HVRT;
    Iq0: Reactive current before LVRT; (selectable)
    Vref: Reference voltage. (various among VRT control mode)
    Ut: AC terminal voltage during LVRT(in pu);
    In: inverter rated current;
    Kf: Reactive current injection ecoefficiency (Configurable).

- **Active Current Injection Control (Ip):**
  - Under Q-priority, inverter active current injection is determined by the remaining active current capability after VRT reactive injection, the pre-fault active current, and other specified control factors.

3. Sungrow Inverter Ride Through Control Logic Outlined, Cont.

- **VRT Exiting Control Logic:**
  - Hysteresis-based VRT exiting voltage thresholds and other control logics, which ensure inv move out of the VRT model smoothly.
  - Maximum VRT Duration, predefined or governed by OV/UV protection settings.

3. Sungrow Inverter Ride Through Control Logic Outlined, Cont.

- **Inverter Active and Reactive Power Recovery after VRT**
  - **Active current/power recovery**
    - The inverter follows the predefined P-recovery ramp logic, ramping output to the latest PPC active power command.
  - **Reactive current/power recovery**
    - If no new PPC Q command is received during VRT, Q recovers instantly to the pre-fault value.
    - If a new Q command is received, recovery follows a staged ramp-up to the latest PPC command.
    - Additional recovery control logics to allow a smooth operation transition.
- **Once the recovery process is complete, the inverter will return to normal PPC-controlled operation**

4. Discussion on Frequency Measurement at PPC

- **Quality and accuracy of frequency measurement at POM is subject to:**
  - Signal noise
  - Voltage disturbances (ground faults, phase jumps
  - Line/feeder switching
  - PLL parameter configurations,
  - etc.

- **Improvements can be achieved through:**
  - Robust, fine-tuned signal filtering and enhanced frequency calculation at the PPC
  - Refined triggering delays and stability checks for PFR activation
  - Refined PPC – inverter coordination to prevent false PFR/FFR activations

5. Summary

- Sungrow conducted preliminary LVRT testing using the ERCOT-suggested MQT setup and did not observe the reported frequency spike at the inverter AC terminal.
- Preliminary results indicate that the inverter is unlikely to be the source of the frequency spikes observed by the PPC.
- To optimize LVRT recovery performance, the inverter VRT recovery P ramp-up slope can be fine-tuned as needed.
- Sungrow is willing to collaborate closely with ERCOT and other stakeholders on further root cause analysis and solution validation.

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Thank You! Q/A?

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