GE VERNOVA

VRT / PFR CONTROLS COORDINATION - GE VERNOVA PERSPECTIVE

Presenter: Dustin Howard
Other Contributors: Ignacio Vieto, Patrick Djan-Sampson
GE Vernova Consulting Services
8/15/2025

Outline

- Plant Control Functions
- Frequency Measurement Methods and Common Issues
- Common Mitigations for Frequency Measurement Issues
- Detecting Fault Ride Thru
- Typical Fault Ride Thru Behavior
- Transitioning between FRT and normal Operation

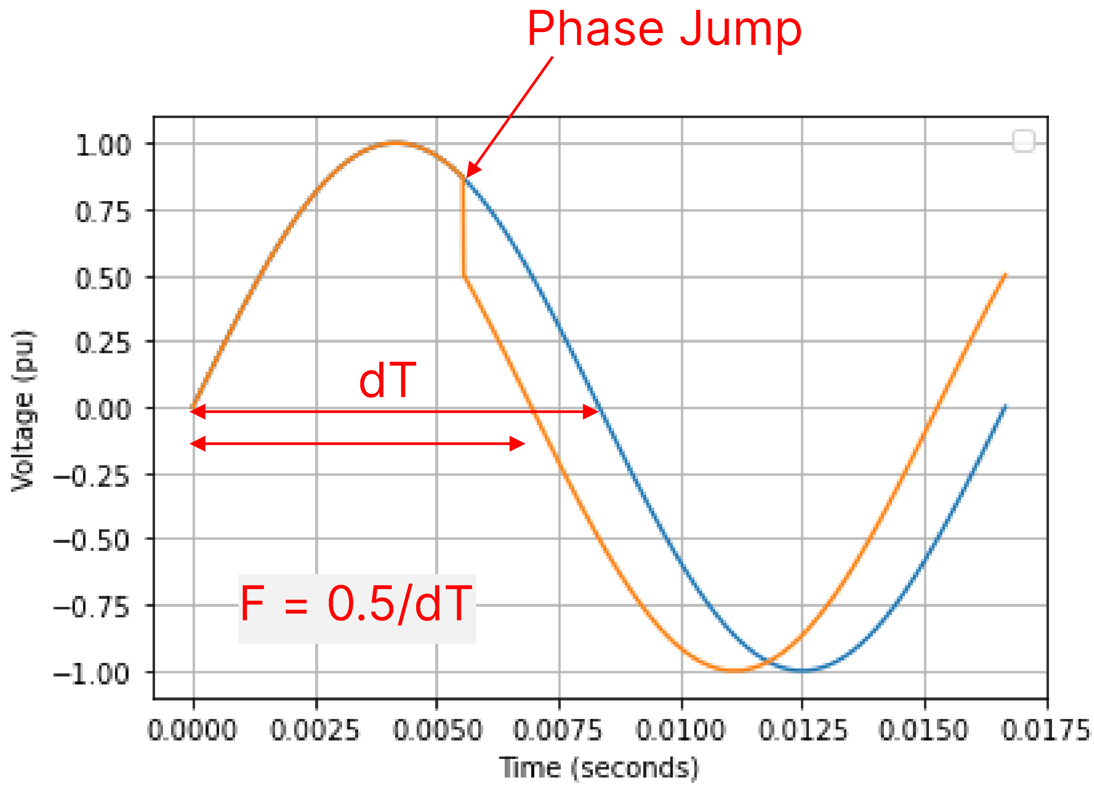
Plant Control Functions

- Plant Control Primarily for Steady-State Regulation at POI
  – Active Power Control
  – Voltage Control (or Q or PF)
  – Primary Frequency Response (PFR)
- Dispatches downstream IBRs to meet POI setpoints
  – For variable resources (wind/solar), power only regulated when curtailed or to regulate dP/dt
- Generally slow control (e.g. few seconds to minutes) response times
- Generally not intended to
  – impact plant in-fault behavior in a significant way
  – Impact behavior immediately after fault (e.g. until IBR has fully recovered from FRT)

Frequency Measurement Methods and Common Issues

GE VERNOVA

- Controls estimate frequency based on voltage measurements
  - Zero Crossings in Voltage
  - PLLs
- Voltages provides good indication of frequency in steady-state conditions
- Frequency measurement “spikes” or other inaccuracies may occur due to
  - Noise related to non-fundamental frequency distortion
  - Phase jumps (e.g. line opening)
  - Faults



Common Mitigations for Frequency Measurement Issues

- Filtering
  - Heavy filtering reduces risk of “mis-detection” of voltage events as frequency events
  - Light filtering speeds up response to real frequency events, increases risk of mis-detection
- Temporary Control Freezing
  - Algorithms distinguish “real” frequency events from voltage transients/noise
  - Temporarily freeze output to avoid undesired response in power
- Deadbands
  - Wider reduces risk of mis-detection
  - Narrower reduces plant response time for grid support

Detecting Fault Ride Thru

GE VERNOVA

- IBR Decides how to React to Grid Event Using Local Feedbacks – Not necessarily dictated by Plant Controller
- Explicit vs Non-Explicit Mode Switch Using Local Signals
    - Explicit Switch: Different controls/regulators, gains or commands once a VRT mode is initialized
    - Non-Explicit: Continuous limits that constrain commands based on feedback strategy
- Sequence Voltages at the Inverter Terminal are a Good Option for Feedback:
    - Fault Severity can be Inferred from Positive Sequence Voltage
    - Fault Type Inferred From Negative Sequence Voltage
    - Filtering Exists in the Sequence Calculation

Typical Fault Ride Thru Behavior

- Typical In-fault behavior of IBR
  - Reduce active power
  - Increase reactive current
  - Temporarily override/ignore plant-control dispatch
- Typical Post-Fault behavior of IBR
  - Rapidly attempt to return to pre-disturbance voltage or reactive power
  - Ramp back to pre-disturbance power
  - Resume following plant-control dispatch after recovery of power and V/Q
- Voltage un-steady during and immediately after faults
  - Phase jumps due to rapidly changing power, line openings, etc.
  - Non-fundamental components in voltage due to xfmr saturation, resonances, etc.

Transition from Fault Ride Thru to Normal Operation

GE VERNOVA

- Smooth transition achieved by
  - Adjusting reactive current based on local voltage conditions
  - Ramping power slow enough to avoid subsequent voltage collapse
  - slowly transitioning back from IBR-dominated response to resumption of plant control
  - Avoiding aggressive control response to perceived frequency events that also coincide with large voltage events
- “Bumps” in transition are unlikely
  - If observed, are likely resolved by configuration/parameter changes
  - May require verification that changes don’t adversely impact other performance aspects

GE VERNOVA