



## **GMD Introduction & Preliminary Benchmark GMDVA Voltage Findings**

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# Agenda

- Geomagnetic Disturbance (GMD) Primer
  - Significant Historical GMD Events
  - What are GMDs and Geomagnetically Induced Currents (GIC)?
  - Characteristics of GMD and Effects on the Grid
  - The NERC Benchmark and Supplemental GMD Events
- NERC TPL-007
- Benchmark GMD Vulnerability Assessment (GMDVA): Initial steps and process
- Benchmark GMDVA preliminary voltage findings and recommendation
- Questions

# Significant Historical GMD Events

- 1859 Carrington Event
  - Largest solar storm on record
  - Disruptions in telegraph networks worldwide
- 1921 Solar Storm
  - Disruptions in telegraph networks across portions of western U.S.
- 1989 Quebec Blackout
  - Smaller than the 1859 and 1921 storms
  - 9 to 12 hour blackout in Quebec
  - TPL-007 benchmark GMD event is based off this storm
- 2003 Solar Storm
  - 20 to 50 minute blackout in Malmö, Sweden

## What are GMDs and GICs?

- GMDs are caused by coronal mass ejections from the sun interacting with the earth's magnetic field
- These disturbances can potentially cause variations in the geomagnetic field that lead to quasi-dc GICs in the grid

# Characteristics of a GMD Event

- Geomagnetic Latitude
- Earth Conductivity
- Geoelectric Field Waveshape
- Wide Area Geomagnetic Phenomena

## Effects of a GMD Event on the Grid

- GICs can cause transformers to experience half-cycle saturation which results in increased transformer hot-spot heating, harmonic current generation, and reactive power losses

# Factors that Impact GIC Flows

- Magnitude and orientation of GMD
- Geomagnetic Latitude
- Earth conductivity model
- Transmission line length and orientation
- DC Resistances
  - Substation grounding
  - Transformer windings
  - Transmission lines
- Transformer winding configuration

## The NERC GMD Events

- The benchmark GMD event uses a geoelectric field amplitude of 8 V/km while the supplemental GMD event uses 12 V/km



## NERC TPL-007

- Maximum effective GIC values for the worst case geoelectric field orientation for the benchmark and supplemental GMD events provided to REs or TSPs
- Thermal impact assessments are required from respective REs or TSPs for transformers with maximum effective GIC of over 75 A/ph for the benchmark GMD event and over 85 A/ph for the supplemental GMD event

## NERC TPL-007

- TPL-007 also requires determination of criteria for acceptable steady state voltage performance during the benchmark and supplemental GMD events
- GMDVA will be performed for both events
  - Corrective Action Plans (CAPs) will be developed for the benchmark GMD event
- TPL-007-4, effective October 1, 2020, will require CAPs for the supplemental GMD event as well

# Benchmark GMDVA: Initial Steps and Process

- Obtain outages that may be caused by the benchmark GMD event due to harmonics
- Obtain transformer thermal assessment results
  - No transformer exceeded the 75 A/ph threshold
- Evaluate steady state voltage performance criteria for the benchmark GMDVA

## Benchmark GMDVA: Outages due to Harmonics

- A Market Notice request was sent on March 20, 2019 for REs and TSPs to provide a list of potential equipment that may be removed from service as a result of Protection System operation or misoperation due to harmonics that could result from the benchmark GMD event

# Benchmark GMDVA: Steady State Voltage Performance Criteria

- The submitted potential GMD event outages were categorized as either:
  - Category A: High probability GMD event caused outage
  - Category B: Lower probability GMD event caused outage
- Category A outages were simultaneously applied to the GIC model then reactive losses were calculated and applied
- Category B outages were applied individually on top of that model

# Preliminary Voltage Performance Findings for the Benchmark GMDVA

- With Category A outages and reactive losses: no voltage violations, one low voltage deviation
- With Category A outages, reactive losses, and individual Category B outages: one low voltage violation (the same bus that experienced the low voltage deviation)

# Preliminary Recommendation for the Voltage Criteria and Next Steps

- No proposed changes to the steady state voltage performance criteria for the benchmark GMDVA
- ERCOT is continuing to work with some REs for clarification on their responses to the Market Notice

Questions?





Please send any questions or comments to  
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