Grid Modernization and System Upgrade Impacts on a Three-wire Distribution System Serving Critical Military Load

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Presented by: Mike Matre, P.E.

POWER ENGINEERS

Project Background

- Project Location – Sierra Vista, AZ
- Military Base Served off a delta tertiary
- Four zig-zag grounding transformers
- 13.8 kV effectively grounded wye distribution system
  - No Neutral

Project Goals

- Replace main transformer with new delta – wye transformer
- Determine if grounding transformers are still required
- Analyze grounding system performance
- Verify new fault current and equipment ratings
- Adjust relaying coordination
- Evaluate future projects

Effectively Grounded and Coefficient of Grounding (COG)

- IEEE Std 242 Recommended Practice for Protection Coordination of Industry and Commercial Power Systems:
  - X0/X1 ≤ 3.0
  - R0/X1 ≤ 1.0
- IEEE Std C62.92.4 Application of Neutral Grounding in Electrical Utility Systems
  - COG = VLN'/VLL
    - VLN' – Maximum line-to-ground voltage on unfaulted phases
    - VLL – System nominal line-to-line voltage
    - COG < 80% - Effectively grounded

COG Results

		SINGLE LINE-TO-GROUND FAULT		DOUBLE LINE-TO-GROUND FAULT		MODERATE IMPEDANCE (25 OHM) DOUBLE LINE-TO-GROUND FAULT	
ZIG-ZAG GROUNDING TRANSFORMER STATUS	SOLAR GENERATION STATUS	UNFAULTED PHASE VOLTAGE (KV)	COEFFICIENT OF GROUNDING	UNFAULTED PHASE VOLTAGE (KV)	COEFFICIENT OF GROUNDING	UNFAULTED PHASE VOLTAGE (KV)	COEFFICIENT OF GROUNDING
Only North B Bus Grounding Transformer Kept Online	Online	9.14 kV	66%	7.22 kV	52%	9.89 kV	72%
	Offline	7.97 kV	58%	6.29 kV	46%	8.61 kV	62%
All Offline	Online	9.43 kV	68%	8.51 kV	62%	9.89 kV	72%
	Offline	8.23 kV	60%	7.42 kV	54%	8.61 kV	62%

COG must be less than 80% for the system to be considered effectively grounded

Additional Considerations

- Surge arrestors and equipment ratings
  - Three-wire systems have higher MCOV than solidly grounded systems
- Fault current increase (~+1,000 A 3PH and ~+2,000 SLG)
  - IEEE Std 242 Table 15.3 – Coordination Time Intervals
- Future Projects
  - Distributed generation and islanding

Thank you!

What Questions Do You Have?