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Effective Grounding – Grounding Bank Options and Sizing

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Problem Statement

- Grounding transformer and equipment supply chain issues, coupled with the uncertainty surrounding study scope and durations, are leading to increased project risk (duration, cost, etc.)

Additional Background

- Supply chain issues of equipment is an ongoing problem in the industry, some items are having lead times double or triple what is typical.
- Uncertainty surrounding study completion has increased as well, driven by DG penetration levels leading to the need for group studies at the distribution level as well as the ASO process.
- These factors make project timelines highly variable, which can have a dramatic effect on meeting the expectations of customers and stakeholders.
- Developers need more flexibility in equipment ordering, with the focus specifically today on effective grounding requirements and grounding banks, and their alternatives.

Technical Background and Requirements

- The Massachusetts utilities are requiring effective grounding analysis to be performed as part of the SIS, and have the following technical references:
  - National Grid: ESB756 7.3.2.1 (Dec. 2021);
  - Eversource: "Information and Technical Requirements for the Interconnection of Distributed Energy Resources (DER)" 2.8 (Jan. 2020):

National Grid

- Reference ESB756 7.3.2.1:

“7.3.2.1 Effectively Grounded, Four-wire Multi-grounded 3-phase Wye EPS:

To avoid overvoltage on the distribution EPS and other customers, the Company’s policy requires any DER facility 500 kW and above connected to a four-wire multi-grounded distribution feeder to provide an effectively grounded system with respect to the Company’s EPS. Refer to Section 7.1.4 for specific grounding requirements.”

ESB756 7.3.2.1

- ESB756 7.3.2.1:

"Effective grounding may be accomplished………:

1. A wye-grounded to wye-grounded transformer with a grounded generator source (a generator which can demonstrate production of a sufficient amount of zero-sequence fault current). A <u>neutral grounding reactor or grounding resistor </u>between the generator neutral and ground may be required in event the generator's contribution to faults on the Company's EPS results in undesirable fault current values. See section 7.1.5."

Eversource (MA)

- Section 2.8 from Technical Requirements:

"Eversource reserves the right to specify any aspect of the DER's grounding scheme if deemed necessary by Eversource Engineering. This may include GSU winding configuration and neutral grounding method.

Effective grounding shall be required for all DER interconnections where any of the following is true:

• The fault current at the point of common coupling (PCC) is caused to increase by at least 10 percent of the existing value.
• Areas where fault current may already be deemed excessive.
• DER interconnections equal to or larger than 1MW.

• Anywhere there may exist a potential islanding concern regarding generation to load ratio."

Eversource (MA) Section 2.8 Continued

"To achieve effective grounding, the DER owner shall design and install an interconnection system where the ratio of the DER's reactance parameters meets the following criteria:

$2 < X0/X1 < 3$ — X0 = zero sequence reactance and X1 = positive sequence reactance

- A generator step-up transformer (GSU) with a reactively grounded neutral on the high (utility) wye-connected side and a delta configuration on the low (generator) side.
- A GSU with a grounded-wye / grounded-wye configuration and a grounding transformer on either side of the GSU (for DER that do not source ground fault current).
- A delta high (utility) side GSU configuration and a grounding transformer on the high (utility) side. "

Study Output

- One (1) Customer owned 112.5 kVA, 13.2 kV wye-ground primary, 480 V delta secondary grounding transformer with a %Z= 5 and X/R = 1.78.
  - When reaching out to a manufacturer they tend to follow IEEE C57.32, where it is recommended that the frame size is decided by a longer-term continuous rating (based on expected system imbalance between phases), and a short-term maximum expected unbalanced fault current (1 sec/10 second rating, etc.).
  - If we specify the frame size and the %Z, this leads to confusion, typically they want the %Z and expected values mentioned in the previous bullet.
  - Currently, there are no provisions for utilizing a zig-zag grounding bank in the allowed solutions for either utility; which all things equal are a factor $\sqrt{3}$ smaller than a Ygrounded/delta grounding bank.

Z0 Equivalence with a Neutral Impedance

- Grounding Transformer Calculator for Effective Grounding

Volt (kV)	Transformer (MVA)	Zbase	% Z	Zactual (ohms)	Neutral (ohms)	New 3Z0 (ohms)
12.5	0.3	520.8	5.00%	26.042	2.16	28.197
12.5	0.1125	1382	2.04%	28.197		28.197
0.48	0.3	0.768	4.50%	0.035	0.007	0.042
0.48	0.1125	2.048	2.04%	0.042		0.042
0.48	0.3	0.768	4.00%	0.031	0.011	0.042
0.48	0.1125	2.048	2.04%	0.042		0.042

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Solution/Conclusion

- Uncertainty in transformer supply chain drives the need to start the process for grounding transformers earlier in a project life cycle.
- Flexibility to utilize zig-zag transformers, as well as larger frame size grounding banks to account for short term and long-term ratings.
- Flexibility to utilize neutral impedance with a larger frame size unit.
- Formal acceptance of these alternatives will help with flexibility given the current supply chain and utility study climate and assist with good equipment design practice.
- Would National Grid and Eversource support these options for current and future projects?

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