

TOP **10**
QUESTION
from the Tech Talk



TECHTALK

IMPORTANCE OF INDUSTRIAL GROUNDING

In this Tech Talk, **Importance of Industrial Grounding**, learn about the various grounding techniques, why industrial facilities need to have a well-designed grounding system, and the types of generator grounding.

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GE VERNOVA



Importance of Industrial Grounding



QUESTION



ANSWER

Why is grounding important, especially in industrial facilities?

- Keeps personal and equipment safer by detecting faulty equipment.
- Stabilizes transient voltage levels and prevents overvoltages (as ungrounded systems are notorious for transient overvoltages).
- Provides the ability to detect a single phase to ground fault before it evolves into a multiphase to ground fault.
- If impedance is introduced, ground fault current can be engineered or limited, limiting associated damages.
- Provides a ground source for other protection systems.

What are the various grounding systems?

Ungrounded Systems: With these, it is difficult to detect the first ground fault since there is no ground fault current generated. Phase-to-phase transient voltage develops across insulation, so systems must be designed to handle these transient voltages or damage will occur. If the first ground is undetected, a second ground makes a phase-to-phase fault.

Grounded Systems: By providing a ground path or source, ground fault currents are present for the first ground, making it easy to detect. If solidly grounded high fault current levels are present, it could lead to safety and damage concerns. By introducing an impedance in the ground path, the ground fault current can be engineered or limited to safe and detectable levels.

What types of generator grounding are there?

- Low impedance generator grounding provides a ground source, allowing ground fault currents to develop. The generator could be damaged due to an internal ground fault.
- High impedance generator grounding limits ground fault currents, minimizing or even preventing damage during ground faults. Very low levels of ground fault currents are generated.
- Hybrid generator grounding is a combination of low impedance and high impedance grounding. Normally the generator operates with a low impedance ground. When there is an internal generator fault detected, the low impedance ground is removed and a high impedance ground is introduced to limit or prevent equipment damage.

When is a ground CT required?

Ground CT is typically required for detecting faults in a solidly or low impedance grounded systems. The ground CT is connected to a ground fault detection relay. For generators and transformers, the ground CT is installed in the neutral leg. Ground CTs are sized differently than phase CTs because they typically—especially for impedance grounded systems—need to sense lower levels of fault currents.



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QUESTION



ANSWER

What type of ground CT connection is typically used?

There are two methods for ground CT connections: a residual connection and a zero sequence CT. For the residual connection the three phase CTs are connected together and then connected to the ground relay input, hence measuring the “residual” of the three phase CTs ($I_g = I_a + I_b + I_c$). In modern microprocessor relays it is not necessary to have this residual connected ground CT input as the relays can calculate the residual or ground current from the three phase currents they are already measuring ($I_g = I_a + I_b + I_c$). The disadvantage of the measured or calculated residual current is that it is only as sensitive as the phase CTs which might not be sensitive enough for ground current levels. To get more sensitivity for low levels of ground current, a zero sequence CT is used. This CT can be sized appropriately independent of the phase CTs and essentially wraps around all three phase conductors.

What ground fault methods are used to protect a low impedance grounded machine?

Typically, a ground CT is installed in the generator neutral and connected to a ground current relay. This relay can operate instantaneously or on an inverse time curve if needed to coordinate with other external protection systems. For better selectivity, a ground differential can be used where the CTs are installed at the generator terminals as well as the neutral. This method does not need to coordinate with other external protection systems. Instead of a ground differential, a directional ground fault relay can also be used for better fault selectivity. In addition to the operating ground current, these relays also need a polarizing source which is typically a voltage measurement/connection.

What ground fault methods are used to protect a high impedance grounded machine?

Since there are no ground fault currents on high impedance grounded systems, a non-current based protection scheme is needed. Voltage-based methods are used instead since transient voltages are present on high impedance grounded systems. A residual overvoltage (similar to the residual current method) relay or zero sequence relay can provide up to 95% coverage from the generator terminal to the neutral. Third harmonic voltages are present in running generators; their distribution is linear from the neutral to the terminal during conditions but change during a ground fault. Hence a third harmonic undervoltage relay on the generator neutral can provide 5%-15% fault coverage from the neutral. When combined with the overvoltage, 100% ground fault coverage is provided for the generator. A third harmonic differential can also be used instead of the third harmonic undervoltage, which provides more sensitivity and better coverage.

What is sub-harmonic stator ground fault protection (64S)?

This is another method that can be used to provide 100% coverage for ground faults in a generator. This method involves the injection of a sub-harmonic signals into the generator neutral and measuring the resulting sub-harmonic current and voltage. Either the resistive current or impedance can then be calculated to determine if there is a ground fault present on the machine. This method is superior to the third harmonic methods since it is not dependent on the machine generating these third harmonic voltages, which can be difficult to determine and predict. This method is more expensive since, in addition to the relay, an injection module with a coupling filter is needed. However, it is easier to determine the protection setpoints with this method rather than the third harmonic measurement method. This method can even detect ground faults when the generator is offline!



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QUESTION



ANSWER

What is the typical grounding method for bus-connected generators?

When two or more generators are connected/paralleled to the same bus, this is referred to as bus-connected generators. They can be connected directly to the power system bus with no transformer in between or can be paralleled to a common step-up transformer (GSU). Typically, these generators are low impedance grounded to provide selectivity for internal ground faults on the respective generators. The protection method for each generator is similar to a low impedance machine. Directional or differential protection is provided for selectivity of internal faults in each generator. In addition ground time overcurrent is provided for backup protection.

What GE Vernova relays can be used for generator protection?

For medium- to large-sized generators, the Multilin G60 and the MiCOM P34x Agile provide all-encompassing generator protection for any type of grounding method including generator differential. In addition, when paired with the GPM-S subharmonic injection set, the G60 and P345 relays can detect ground faults through 100% of the stator winding including the neutral point (64S). If a GSU is to be included in the generator differential zone, then the G30 and P343/4/5 are available.

For small- to medium-sized generators, the Multilin 889 and MiCOM P342/6 Agile provide full protection for all grounding methods. In addition, the 889 and P346 include generator and transformer differential protection.

Learn more here: <https://www.gevernova.com/grid-solutions/multilin/selector/generation.html>



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