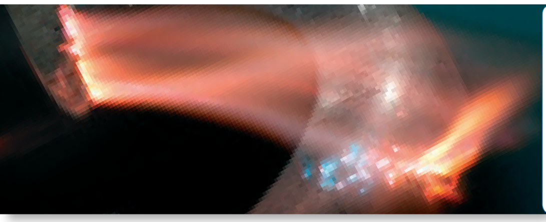
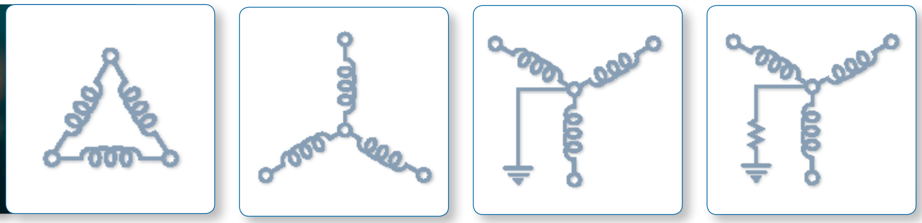
iGARD

Unparalleled Protection

GROUNDING OF STANDBY AND EMERGENCY POWER SYSTEMS

POWER SYSTEMS





ASK THE EXPERTS, September 2018

ADDRESSING GROUND FAULTS ON MV GENERATORS

A hybrid grounding system design allows flexibility

Medium voltage generators are not designed to withstand full fault current during a single phase-to-ground fault. This is the main reason that medium voltage generators are connected to a system with either low or high impedances. There are many methods to ground generators.

Low Impedance Grounded. A low impedance grounded system comprises of a connection of the generators neutral terminal to ground through an impedance as shown in Fig, 1. The resistor typically limits ground fault currents from 200 to 800 Amperes for a short duration. The fault current is selected in order to minimize damage at the point of fault as well as providing selective coordination of the protection system. As well as minimizing the damage at the point of fault, low impedance grounded systems also minimize shock hazards caused by stray currents, minimize thermal and mechanical stresses on equipment, and control transient overvoltage's.

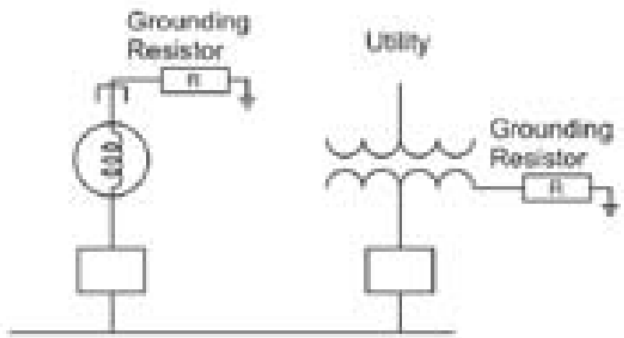


Fig. 1 Low Impedance Grounded System

As the generation capability within facility increase, as shown in fig. 2, the value of ground fault current also increases. As an example, if four generators are connected to a common bus the maximum ground fault current may be anywhere between 200 A., if only one generator is on line, to 3200 A. if all four generators are online with a 800 A low resistance grounded system. As more and more generators are connected, the advantages previously listed quickly diminish. The greatest drawback of this type of system is witnessed when a ground fault occurs within the stator winding of a generator. Experience has shown that the ground fault will not be removed from the generator even though the generator breaker has opened. The generator will continue to supply the current through the ground fault until the field excitation decays. The physical damage caused to the generator is caused by the duration of the fault and not the magnitude of the fault.

Single Point Ground System. Single point grounding ensures that only one source is grounded at any given time. There are three ways in which this can occur. Fig. 3 shows a multiple generated connected system where neutral isolators ensure that only one resistor is connected to the electrical system at one time.

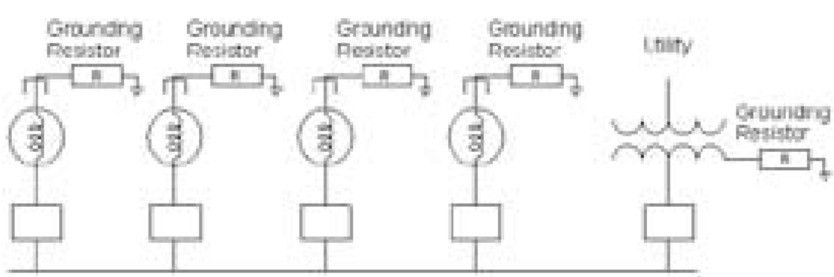


Fig. 2 Variation of Single Point Grounded System

This system is complex as the isolator switches are necessary. It is also necessary to implement an operation procedure for any kind of transfers. The other disadvantage of this type of system is that the system will become ungrounded should the connected grounded source become isolated. This would put the entire system at risk. As generators ramp up and placed into service they as well would be ungrounded until they are connected to the power system.

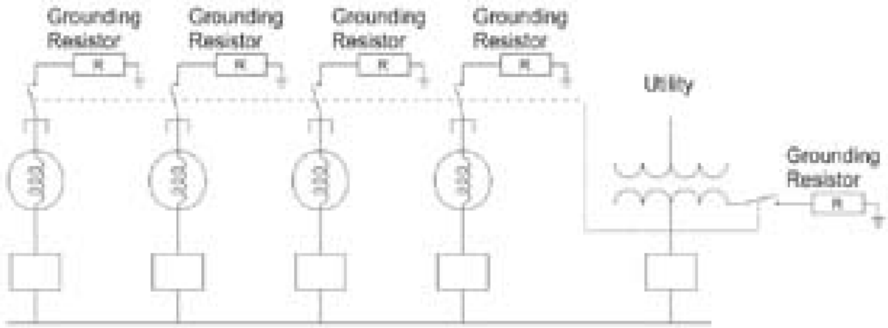


Fig. 3 Variation of Single Point Grounded System

The disadvantages of the ungrounded system described in Fig. 3 are addressed with the system in Fig. 4. In this scenario the neutrals are all connected together and there would exist only one return path for any ground faults. The concern of generators going off line is also addressed.

There are 2 major disadvantages of this kind of system, one being the circulating third harmonic currents through the connected neutrals, and the other being the complex serviceability of a generator. With the neutrals all connected together, a ground fault anywhere in the system will elevate the potential of the neutral whether the generator is connected to the system or not. This posses a safety hazard for any personnel working on the generators. The following schematic addresses the single point ground with an artificial neutral. This method is much simpler than the one in Fig. 3, however the disadvantage is the ungrounded state of the generators when not connected to the electrical system.

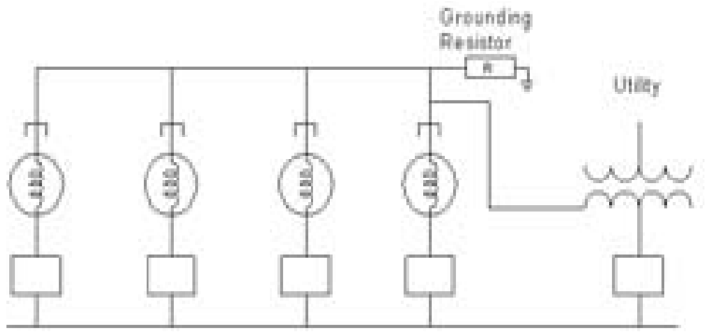


Fig. 4 Common Neutral Single Point Grounded System

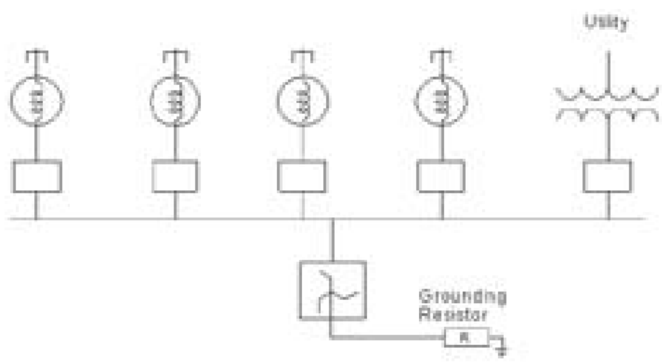


Fig. 5 ZigZag Single Point Grounded System

Multiple Point Grounded. The schematic shown in Fig. 2 is an example of a multiple point grounded system. Each generating source is grounded through its own grounding resistor. There is no risk of leaving a source generator ungrounded. There is also no safety hazard when servicing a generator.

With many generators connected, the amount of ground fault current can exceed levels that will limit the damage at the point of fault. This is extremely evident should the point of fault occur in the stator winding of the generator. With the fault in the stator winding, fault current would not be interrupted, even with the occurrence of an interruption of the circuit breaker connecting the generator to the electrical distribution system. This type of fault in a multiple point grounded system will have severe damage in the stator windings.

High Impedance Grounded. A high impedance grounded system comprises of a connection of the generators neutral terminal to ground through an impedance as shown in Fig. 1. The resistor typically limits ground fault currents to a low value for an extended duration. The fault current is selected in order to be equal to or greater than the system capacitive charging current.

The advantages of the high impedance grounded system are numerous, minimal fault current at the point of fault, continuity of operation, and a reduction of transient overvoltages as far as the ungrounded system is concerned. One disadvantage of a high impedance grounded system is the sensitivity required for the detection of a ground fault. The ground fault current in the order of magnitude of 10A, more sensitive ground fault protection is necessary.

As the charging current increases in large distribution networks or as more generators are placed on line, it may not be feasible to have a high impedance grounded system. The optimal solution is a combination of the low impedance grounded system and the high impedance grounded system. The system would effectively be low resistance for all ground faults. If, however the fault is a ground fault within the generator, the system would revert to a high impedance grounded system and minimize the damage. This schematic is seen in Fig. 6.

Hybrid Grounding. The generator shown in Fig. 6 is grounded through both a low impedance and a high impedance device. This scenario would allow all the benefits of the low impedance grounded systems in that all through ground faults will have the selective coordination, there is also minimal damage at the point of the fault. The ground fault current would be limited to the sum of the low impedance system and the high impedance system. In the case shown the ground fault current would be 410A. If the ground fault was downstream then the isolating device closest to the fault will isolate the ground fault.

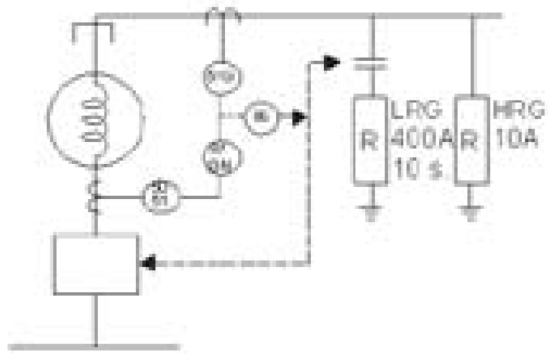


Fig. 6 Hybrid Grounded System

If the ground fault occurs within the stator winding, the ground fault current would be limited to 410A. until the differential protection isolates the generator from the supply and opens the contactor for the LRG device. Thus limiting the ground fault to 10A until the generator slows down to standstill.

When multiple units are placed on line and each unit is protected by the hybrid system, the tendency will be to have all hybrids identical. This would cause extremely high ground fault current when the system is in low impedance, and the benefits would be lost. To compensate for this, the schematic can be reconfigured to that of Fig. 7 and all the benefits would once again be experienced.

This schematic indicates that the maximum ground fault current is in the order of magnitude of 400A., regardless of how many sources are connected to the system. Ground faults downstream will be isolated by the breaker closest to the fault by selective coordination and ground faults within the stator will be isolated by the differential scheme shown in Fig. 6, but isolation will only occur in the supply breaker for that particular breaker. This will leave the generator in a high impedance grounded state and minimize the damage to the stator.

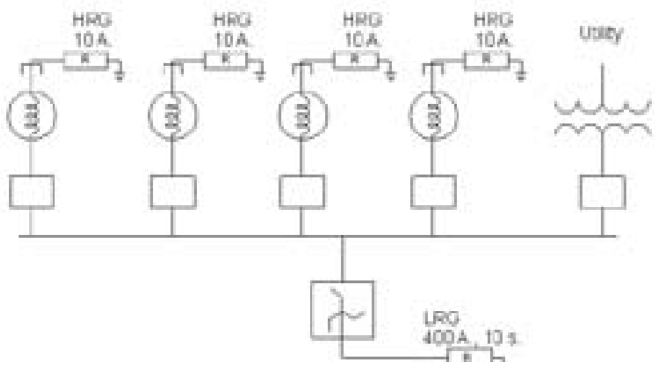


Fig. 7 ZigZag Single Point Grounded System

Q&A

QUESTION AND ANSWER

HT NEUTRAL GROUNDING VIA RESISTOR

Q. We have a 3.3kV system with only one generator grounded via a neutral earthing resistor and the other generators are running in parallel. All three generators are provided with a neutral isolator, and at any time only one of them is connected. If the generator is offline, then we select the other to be connected to the neutral earth. Why is only the generator grounded and not more? Are the other generators floating, and if not, why not?

A. There are at least two main reasons why I would not recommend connecting all three neutrals to common bus:

1) Circulating currents will flow within neutrals and generators. This will cause over-heating of generators (resulting in a de-rating factor) and other problems common to harmonic issues.
2) If the neutral isolator is left closed while the generator main circuit breaker is open, then a shock hazard exists due to neutral voltage rise during ground-faults.

The main reason why this grounding scheme is selected is to reduce costs. However, after factoring in the de-rating for each generator and the safety factor of losing a ground and going to an ungrounded system, your current system significantly costs more than an NGR, which is typically 3%-5% the price of a new generator.

4160V GENERATOR GROUNDING

Q. What is the grounding practice (solid or low resistance) for three 4160V, 1000kW generators operating in parallel? This is a Level I (Life Safety) generator installation and requires high availability. The load is a 4160-480V, 3000kVA step-down transformer located 600 feet from the generators. I assume charging currents must be considered.

A. Regarding solidly grounding the generator, there are hazards that must be considered due to the high ground-fault currents. IEEE Std. 141-1993 (Red Book - Recommended Practice for Electric Power Distribution for Industrial Plants) Section 7.2.4 states, “A safety hazard exists for solidly grounded systems from the severe flash, arc burning, and blast hazard from any phase-to-ground fault.” By placing a resistor between the neutral and ground, the ground fault current is typically reduced to 5A only if the capacitive charging currents are < 5A.

Since the transformers are ~600ft from generators, the capacitive charging currents are probably < 5A (please check for surge capacitors on generator terminals; if so, then charging current may be > 5A). Also, since your application is high availability, I would recommend HRG (5A) on the generators to allow for operation during ground-faults.

IEEE Std. 141-1993 (Red Book - Recommended Practice for Electric Power Distribution for Industrial Plants) Section 7.2.2 states, “There is no arc flash hazard, as there is with solidly grounded systems, since the fault current is limited to approximately 5A.” So by limiting the ground fault to 5A, you have avoided the hazards with solidly grounded systems.

In addition, several generator manufacturers require resistance grounding as the generators are not rated for ground faults as they are often times higher than three-phase faults. IEEE Std. 142-1991 (Green Book - Recommended Practice for Grounding of Industrial and Commercial Power Systems) Section 1.8.1 states, “Unlike a transformer ... a generator will usually have higher initial ground-fault current than threephase fault current if the generator has a solidly grounded neutral. According to NEMA, the generator is required to withstand only the three-phase current level unless it is otherwise specified ...” This is due to low zero-sequence impedance within the generator causing very high earth-fault currents. The resistor also significantly reduces any circulating currents, which are typically triplen harmonics leading to over-heating in the generator windings.

I typically recommend either resistance grounding each source or derive a neutral on the paralleling bus via zigzag transformer and resistance grounding the derived neutral (which is not to be used for any loads or connected to anything except the resistor).

In addition, I would use HRG (5A) on the 480V systems as well. Our Application Guides on our website (www.i-gard.com) discusses this in detail.

CIRCUIT BREAKER TRIPPING DURING PARALLELING OF GENERATORS

Q. We have three 1000kw generators in parallel operation. When each generator runs in single operation, it operates normally. When we start to parallel the units, the generator circuit breaker trips off and indicates a ground-fault. But when we disable the ground-fault protection of the circuit breakers, the generators runs in parallel, taking load. Is it not advisable to use these circuit breakers with ground fault protection for generator paralleling?

A. All generators create a third harmonic (and triplens) due to fractional pitch windings. Generator windings are fractional pitched to reduce the number of end turns and to control harmonics. Each fractional pitch cancels that harmonic (i.e. a 2/3 pitch generator has very little third harmonic, a 4/5 pitch has very little fifth harmonic, and so on). Unfortunately, coil pitch cannot eliminate all harmonics simultaneously. As one is eliminated, others increase. These harmonics circulate between system's neutrals and associated grounding system.

Relays are detecting this circulating current and providing a trip signal. However, it is not a fundamental current. Hence, one resolution is to use a relay that only monitors fundamental current, which all ground-faults are only fundamental. Although you have fixed the nuisance tripping problem, you still have circulating harmonic currents that cause over-heating, thus, a de-rating factor must be applied. Generator manufacturers suggest matching all third harmonic voltages produced by each machine by installed same-pitch machines. Even with matched pitches, you will still have a circulating current.

So if your system is solidly-grounded, then the impedance is low and these harmonics cause significant damage within the generator windings in the form of heat. If high-resistance grounding is used, then the extra resistance in the circulating path reduces the harmonics to negligible levels. Also, most generators are not rated for ground-faults (as they often exceed three-phase fault levels due to its internal low zero-sequence impedance). So they require impedance grounding to reduce the ground fault below three-phase fault levels.

When synchronizing generators, there are several ways to ground the neutral. For example, each generator can have its own grounding system or one can be established on the synchronizing bus. If each generator has its own grounding system, then it can operate as a separately derived system. However, if all are synchronized, then each generator's available fault current is accumulative at the point of fault. For example, if each generator had a 5A NGR and there were two synchronized generators, then the total ground-fault at the point of fault would be 5A x 2 = 10A. The total ground fault current is dependent upon the number of synchronized generators at the time of fault. This may lead to coordination issues.

Another method of grounding is at the synchronizing bus via neutral deriving transformer (i.e. zigzag transformer) and DO NOT connect anything to the neutral of the generators. The advantage is that the total ground-fault current is independent upon the number of synchronized generators and will be fixed.

In addition, since the generators' neutrals are disconnected, there cannot be any circulating currents. (Remember, although the generator neutrals are disconnected, the system is grounded via zigzag transformer.) However, if the synchronized bus is out of service, then the generators can not supply a load as they will be ungrounded.

DISCONNECT SWITCH FOR NGR

Q. In our project, we have three generators (11kV).The neutral of these generator are grounded separately thru NGR. These generators can run in parallel. Our client requires a means of disconnecting be fitted in the neutral earthing connection at each generator, so that generators may be disconnected for maintenance. My question is do we really require these disconnect switches? If we do not install these switches, what problems can we face?

A. If the neutrals are connected together and then run through a common NGR, then yes. A disconnect switch is required as the common neutral bus voltage rise with respect to ground during a ground-fault. This voltage could and will back feed into the generator windings.
If each generator has its own NGR, then I would suggest that a disconnect switch is not needed. With the generator's MCB open, an open circuit is created. There is no potential rise. If your client still wants a disconnect switch, then I would install one on the ground side (save money by using a 600V disc SW) of the NGR and ONLY open when generator MCB is open.

SYNCHRONIZATION OF GENERATORS

Q. For synchronizing generators of different ratings, what are the criteria for neutral grounding? What is floating neutral?

A. When synchronizing generators, there are several ways to ground the neutral. For example, each generator can have its own grounding system or one can be established on the synchronizing bus.

If each generator has its own grounding system, then it can operate as a separately derived system. However, if all are synchronized, then each generator's available fault current is accumulative at the point-of-fault. For example, if each generator had a 400A NGR and there were five synchronized generators, then the total ground-fault at the point-of-fault would be 400A x 5 = 2000A. The total groundfault current is dependent upon the number of synchronized generators at the time of fault. This may lead to coordination issues.

Another method of grounding is at the synchronizing bus and DONOT connect anything to the neutral of the generators. The advantage is that the total ground-fault current is independent upon the number of synchronized generators and will be fixed. However, if the synchronized bus is out of service, then the generators can not supply a load as they will be ungrounded.

After determining the location of the grounding point(s), you must decide on the type of grounding. The most common is either a solidly grounded (SG) or resistance grounded, either HRG or LRG. If 600V or below (HRG), the ground-fault is typically left on the system until it is located, and then a decision is made to immediately shut-down the faulted circuit or prevent a future hazard or allow to remain on the system until a more convenient time arises to repair the fault. If 5kV and below, it is either HRG or LRG, dependent upon system capacitive charging current. Systems above 15kV are typically LRG and trip within 10 seconds.

The advantage of resistance grounding versus solid grounding is at least two-fold (please refer to our Application Guides on our website for further discussion on RG vs. SG www.i-gard.com). Regarding synchronization, all generators create a thirrd harmonic and triplens due to fractional pitch windings. These harmonics circulate between systems neutrals and associated grounding system. So, if SG is issued, the impedance is very low and these harmonics cause significant damage within the generator windings. If RG is used, then the extra resistance reduces the harmonics to negligible levels.

Also, most generators are not rated for ground-faults (as they often exceed three-phase fault levels due to its internal low zerosequence impedance). So, they require impedance grounding to at least reduce the ground fault below three-phase fault levels.

EARTH FAULT PROTECTION OF ALTERNATOR

Q. We are operating a 625kVA DG set with 500kW alternator, wherein the star point of the alternator is solidly earthed; we have placed CT for earth-fault protection on the neutral wire in the downstream of the alternator in the ACB panel. Is this acceptable? How is the fault before the ST going to be protected?

A. The current transformer for earth-fault protection needs to be placed on the generator neutral to earth link, so that the any earthfault current will return to the generator from the earth carried by this neutral-to-earth link will be seen. This should be the only path available from earth. So a second neutral earthing at any other location is not allowed and it will disable the earth fault protection. Earth faults anywhere in the system on the load or line side (including the generator winding) will be sensed, and the load neutral current will not be sensed as it will directly go to the generator.

Q. A 480V, Wye connected generator, resistively grounded, feeds a 480V Wye - 4160V Wye transformer, both neutrals solidly grounded. I understand that the wye-wye transformer is not a ground source, yet zero sequence currents will pass through the windings. In the event of a ground fault on the 4160V system, the ground current will try to get back to the generator neutral, through the grounding resistor. The zero sequence currents in the 480V windings must therefore be equal to the zero-sequence currents in the 4160V winding. What is not clear to me, is the maximum voltage the grounding resistor will be subjected to; Is it 277V or 2402V?

A. By solidly grounding both sides of the step-up transformer, you allow zero-sequence currents to flow. The voltage across the resistor will be 277V.

SWITCHING TRANSIENTS CAUSING SUPPRESSOR FAILURE

Q. We have a 4160V 2.8MW generator installation into a 5kV paralleling transfer switch. The utility feeder is from a 2500kVA grounded WYE transformer with no neutral. The new transfer switch feeds existing customer 5kV switchgear. The new generator is connected as the utility transformer is with three-phase wires with a ground. The neutral and the ground at the generator are not bonded. Twice now when transferring from utility to generator in a closed transition mode we have blown the “A” Phase suppressor on the first load breaker within the customer’s switchgear. The PowerCon two-breaker transfer switch looks at voltage and frequency and brings them into specs and then looks at the phase angle difference between the two sources and will close in the generator breaker when the phase angle gets to five degrees or less. They use a Woodward LS4 relay for this function. Since there is no customer neutral, should the generator neutral be bonded to the ground at the generator? Could the current connection setup during the closed transition operation be causing the suppressor to fail?

A. It appears that the 4160V utility supply is solidly grounded and, from your description, that the generator is ungrounded. It is possible that the Phase A surge-suppression device, which must have been selected for a solidly grounded system, will see phase-to-ground voltage swings after the utility breaker opens. This could cause the Phase A suppressor to blow. With the generator alone supplying the load, the current through the suppressor when it fails should be quite small perhaps 5A-10A. So I am surprised that it has blown twice. Please verify the current and the voltage rating of the device.

When the generator is supplying the load, you would probably want to retain the solidly grounded characteristics of the system. So you have two choices:

1) Connect the generator neutral to ground. This will maintain the phase voltage to ground before and after the transition and keep the system stable. The negative aspect is that while utility and generators are running in parallel, there could be a small circulating current flow through the ground driven by the unbalance is phase-voltage and triplen harmonics. Another problem is that the zero-sequence impedance of the generator is smaller than the positive sequence, so the phase-to-ground current will be high and could cause high fault damage at the point of ground-fault.
2) You could have small resistance (NGR) between the generator neutral and ground which will overcome both difficulties with solid grounding. I would suggest a resistor with let-through current of 400A or more will keep the generator phase-to-ground voltages in balance. 10-second-rated resistor could be applied with suitable ground-fault relay.

GENERATOR GROUNDING

Q. There are three 1100kW/480V/60Hz used in a MOPU (mobile operating production unit). We are adopting the IT system of earthing. Is it required to go for high-resistance grounding of generators at the neutral point and leave the neutral floating? Please advice.

A. The requirement depends upon your application. If it is used in mining, then yes, HRG systems are not only required but also a resistance monitor (that continually monitors the resistor integrity) is also required by all mining codes and standards. If it is used in petroleum and/or chemical facilities, then yes, it is a requirement per good engineering practices as HRG systems have been adopted as standard practice within these facilities. If any other application, then I would say yes based on the following: In your question, “Is it required to go for high resistance grounding of generators at the neutral point and leave the neutral floating?” I assume that you meant “…OR leave the neutral floating” (as in ungrounded system) and that the generators will be paralleled.

In high-resistance grounding (HRG) systems, the neutral is not floating. During ground-faults, it is held to line-to-neutral voltage with respect to ground, hence, eliminating the damaging transient over-voltages associated with ungrounded systems.

Other advantages with HRG are:

1) NO arc flash hazard – Resistor limits ground faults to 5A, thus, no arc flash hazards associated with solidly grounded systems. ~95% of all electrical faults are ground-faults, so a simple resistor lowers your risk of personal injury or death (and equipment damage) by 95%!
2) NO damaging transient over-voltages – Ungrounded systems are subjected to severe transient over-voltages caused by intermittent ground-faults and system capacitance.
3) Reduced third harmonics - When paralleling generators, a third harmonic current circulates between generators and ground. So, adding a neutral resistor for each will significantly reduce this current to negligible levels.
4) Continuous operation – No shut-down required during ground-faults, allowing production to continue.
5) Fault-locating feature – Pulsing system allows electrician to quickly locate ground fault.
6) Reduce ground-fault currents – Most generators have ground-fault currents above three-phase fault currents and are not rated for this higher fault current. So, most manufacturers require impedance grounding to reduce the ground-fault current below three-phase fault current level.

HRG systems are the safest and least expensive system available today. IEEE supports this by saying, “A safety hazard exists for solidly grounded systems from the severe flash, arc burning, and blast hazard from any phase-to-ground fault.” (IEEE Std. 141-1993, The Red Book).

Ungrounded systems may experience damaging transient over-voltages and lack the ability to locate ground-faults, presenting another danger to personnel.

Please remember that in HRG systems, the neutral cannot be distributed. So, if you have loads requiring 277V, a small isolation transformer can be added to serve the 277V panel. The cost savings in not distributing the neutral, smaller ground wires, and no GF feature in the MCB will more than pay for the isolation transformer.

In summary, HRG saves money by using less copper (very expensive now-a-days) and makes systems safer by eliminating hazards mentioned above.

Q. I want to ask about the generator grounding point and why we use it?

A. IEEE Std. 142-1991 (Green Book- Recommended Practice for Grounding of Industrial and Commercial Power Systems) Section 1.4.2 states, “Numerous advantages are attributed to grounded systems, including greater safety, freedom from excessive system overvoltages that can occur on ungrounded systems during arcing, resonant or near-resonant ground-faults, and easier detection and location of ground faults when they do occur.”

OK, now that we have established why you need to ground the neutral, let’s discuss how to ground the neutral. If you effectively ground the neutral, you have just replaced the hazards with ungrounded systems with new hazards in the form of arc flash / blast hazards associated with solidly grounded systems.

IEEE Std. 141-1993 (Red Book- Recommended Practice for Grounding Industrial and Commercial Power Systems) Section 7.2.4 states, “A safety hazard exists for solidly grounded systems from the severe flash, arc burning, and blast hazard from any phase-to-ground fault.” For this reason, IEEE recommends resistance grounding.

IEEE Std. 142-1991 (Green Book) Section 1.4.3 states, “The reasons for limiting the current by resistance grounding may be one or more of the following:

1) To reduce burning and melting effects in faulted electric equipment, such as switchgear, transformers, cables, and rotating machines.
2) To reduce mechanical stresses in circuits and apparatus carrying fault currents.
3) To reduce electric-shock hazards to personnel caused by stray ground-fault currents in the ground return path.
4) To reduce the arc blast or flash hazard to personnel who may have accidentally caused or who happen to be in close proximity to the ground-fault.
5) To reduce the momentary line-voltage dip occasioned by the clearing of a ground-fault.
6) To secure control of transient over-voltages while at the same time avoiding the shutdown of a faulty circuit on the occurrence of the first ground-fault (high-resistance grounding).”

IEEE Std 141-1993 (Red Book) Section 7.2.2 states, “There is no arc flash hazard, as there is with solidly grounded systems, since the fault current is limited to approximately 5A.” As you can see, it is best to not only ground the neutral, but ground through high-resistance (typically 5A) for all systems < 600V and most systems > 600V to 5kV. For systems > 5kV, low-resistance grounding (typically 200A or 400A) is used.

Just a quick note about resonance grounding: resistance grounding is preferred in the US mostly due to economics and complexity. Resistance grounding is a passive device that performs independent of system topology and frequency, whereas resonance grounding must adapt to system capacitance. Resonance grounding uses an inductor to create an impedance to match the system capacitance impedance. In doing so, both components cancel and the result is a small resistive ground-fault current.
Disadvantages of resonance grounding: 1) Typically the inductance is slightly larger to avoid a true resonance condition (if not, an overvoltage condition will occur) 2) System capacitance continually changes as feeders are brought on- and off-line (so monitoring system must be installed and inductor must be variable) 3) Cost for monitoring and inductor variability are high 4) Physical size of inductor is significantly larger than resistor. Resistance grounding offers a fixed ground-fault current independent of system topology. However, the fixed current must be larger than the system capacitive charging current. So, a value of 200-400 is usually selected.

NEUTRAL GROUND RESISTOR VALUE FOR A POWER STATION

Q. We are in the process of installing a 3x5.5MW,11KV, 50hz gas turbine generator. The star point of the alternator is to be grounded via a neutral ground resistor (NGR). Can you determine the value of the resistor and the ratio of the neutral current transformer?

A. I recommend using low-resistance grounding (LRG) due to the voltage and capacity. At 11kV and 3 x 5.5MVA, the capacity (MVA) indicates the system is large (in terms of total length of all of the feeder cables, which are typically the greatest contributor to system capacitive charging current) and the voltage induces higher amounts of system capacitive charging current. The next largest contributor to system capacitive charging current is surge arrestors.

If this is a unit-connected generator, then I would recommend high-resistance grounded (10A-15A) to minimize fault damage only if there is very limited number of small feeders (resulting in a low system capacitive charging current).

I would recommend 200A as this is becoming the industry standard. The NGR is determined by taking the line-to-neutral voltage (11kV/ 1.73 = 6.36kV) divided by desired current (200A) to get ohms (31.8ohms). Most people only allow the fault to be on the system for 10 seconds or less. So, the NGR would be rated for 200A /10 seconds. Just make sure that the protective relaying scheme clears the fault within 10 seconds. You can either use a 200:5 or a 100:5 ratio CT.

In general, the lower the fault current, the lower is the damage at the fault. Therefore, it is desirable to keep the fault current as low as possible. If MV motors are being protected then keeping the fault current low also helps in lowering the damage to the laminations at the fault point in the event of a fault in the stator winding. In wye connected motor windings, the driving voltage for the ground-fault reduces as the fault location moves closer to the star point, hence, ground-fault relay must be set sensitive enough to detect the fault and sufficient amount of current must flow. This will also dictate how low you can go with the resistor let-through current.

GENERATOR SYSTEM GROUND CONNECTION

Q. I have a 750kW generator set in an industrial plant. My question is should I ground the neutral conductor at the generator terminals? If so, how should I size the GEC? I've heard sometimes this case is not considered a separately derived system, and the neutral should not be grounded.

A. Low-voltage generators should only be solidly grounded if the loads they feed are four-wire loads and must have a neutral. Generators that feed three-wire loads do not need to be solidly grounded. Instead they should be high-resistance grounded to limit ground-fault current. Generators are not braced for the ground fault current that can occur when solidly grounded. Generators have a higher ground fault current than three-phase fault current. Transformers do not experience this phenomenon.

At any rate, assuming you must solidly ground the generator neutral for your application, here are your rules:

1. If the automatic transfer switch (ATS) is three-pole type with a sold neutral terminal, then you must not ground the generator neutral at the generator; instead you must connect the generator neutral to the neutral terminal of the ATS, which is in turn connected to the neutral of the normal power source transformer. The neutral of the transformer will be solidly grounded at the transformer, and this will also be the grounding point for the neutral of your generator. When you have a three-pole ATS with a solid neutral, your four-wire generator is not a separately-derived source.
2. If your ATS is either a three-pole with an overlapping neutral type, or a four-pole type, then your generator will be a separatelyderived source. In this case, the neutrals of the transformer and generator will not be connected together, and you must ground the generator neutral at the generator.
3. If your ATS is a three-pole only with no neutral terminal and your load is three-wire, then your generator is a separately-derived source and you can ground the neutral at the generator. However, as above, standards such as NEMA MG 1-2003 Motors and Generators (Section 32.34), and the IEEE Green Book on grounding IEEE Std. 142 (Section 1.8), recommend that generators not be solidly grounded unless they are rated for such duty (which they rarely are).

Gemini

- Dual path current limiting resistor
- Redundant fail-safe resistor circuit
- Integral ground fault relay
- Integral ground monitoring relay
- Fault location through pulsing
- Harmonic filter and time / current adjustments to reduce false trips

STANDARD

DSP-OHMNi

- Monitors and protects up to 50 feeders on one relay
- 1st Fault Alarm, 1st Fault Trip or 1st Fault Time Delay Trip
- Resistor Monitoring Module
- Selective Instantaneous Feeder Trip on 2nd ground fault

STANDARD

Sentinel

- Current limiting resistor
- Voltage and current sensing
- Integral ground fault relay
- Integral ground monitoring relay
- Fault location through pulsing
- Harmonic filter and time / current adjustments to reduce false trips
- Inrush detection restraint
- Multi-feeder protection
- Second fault protection
- MODBUS for remote monitoring

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