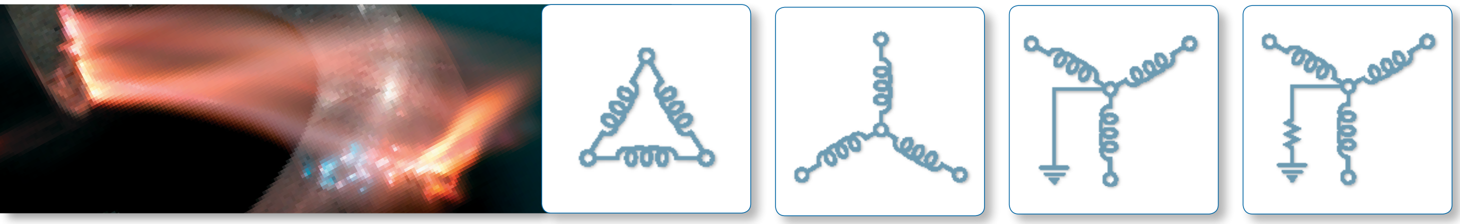
Unparalleled Protection

NEUTRAL GROUNDING RESISTORS: HOW TO SIZE AND SPECIFY

Q&A



Webinar Q&A, April 2020

NEUTRAL GROUNDING RESISTORS

Thank you for attending our webinar focused on Neutral Grounding Resistors: How to Size and Specify; it was a pleasure sharing decades of experience with you. For those of you who missed it, or would like to watch it again, both the PDF and webinar recording is available on our website. Please find the link below or visit www.i-gard.com. As always, if you have any further questions, please email support@i-gard.com and one of our support team members will gladly assist.

Click here

CODE CHANGES

During our presentation we discussed the recent code changes that you may not have been aware of;

1) CSA C22.2 Part 1. (2018) Section 10-300 through 10-308
   a. 2018 moved the relevant codes from 10-1100 to 10-300
   b. More emphasis on resistor monitoring; when and where and what to monitor
   c. Allowance of HRG on Distributed neutral systems, This is not a new rule, in fact it has been in the code for some time. More rules were placed on what is allowed and what is not.

   For example , the system must trip if a ground fault is in;
      i. The neutral or a current carrying conductor, or
      ii. In the connection between the Neutral and the resistor, or
      iii. The connection between the neutral and the ground becomes open circuited
      iv. When you can leave a ground fault on the system.

2) CSA 295-15 Neutral Grounding Devices. This is a relatively new standard. An important feature to take away from this standard is the Rated Voltage Test

   6.2.1 :The assembly shall be operated at the maximum line to neutral rated voltage. The current shall be measured immediately for a short-time rated device, or after 60 min for a continuously rated assembly. The current shall not vary from the rated current by more than 20%.

   This in effect means that the Resistance shall not increase by more than 25%.

3) C57.32 (2015) "IEEE Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices"

   a. This is where we see the significance of the temperature coefficient of resistance and how it affects the final resistance of the NGR And more importantly how it affects the current.

$$\alpha = \frac{R_2 - R_1}{R_1(\theta_2 - \theta_1)} \qquad R_2 = R_1\left[1 + \alpha(\theta_2 - \theta_1)\right]$$

Where;

- R1 is the initial resistance(Ω)
- R2 is the final resistance(Ω)
- T1 is the Initial Temperature (°C)
- T2 is the final Temperature(°C)
- α is the Temperature coefficient of resistance(1/ °C)
- Example 400 A 2400 V 10 s.

Example 400 A 2400 V 10s.

6 Ω 760°C

$$R_2 = R_1\left[1 + \alpha(\theta_2 - \theta_1)\right]$$

Alloy	Temperature Coefficient of Resistance (1/°C) α	Percent change in Resistance	Current decrease as a percentage
AISI 304	0.00092	70% Increase to 10.2 Ω	41.1% to 235 A
AISI 430	0.00146	110 % Increase to 12.65 Ω	52.5% to 189 A
18SR	0.000358	27 % Increase to 7.63 Ω	21% to 314 A
1JR	0.000241	18 % Increase to 7.1 Ω	15.4 % to 338 A

First 3 rows violate CSA Standard as the current decreases by more than 20%
First 2 rows violate IEEE C57.32 as resistance increases by more than 67%

QUESTIONS AND ANSWERS

Q. Is the test kV voltage AC or DC?

A. An AC high voltage test (Hi-Pot Test) is used on all our NGRs to determine the sufficiency of the insulation.

Q. What will happen in phase to ground fault to main breaker?

A. In a High Resistant Grounded system There is usually no need to place ground fault detection on the main breaker. As a matter of fact the DSP system we use does not detect a fault on the main breaker. The DSP system has the ability to monitor which feeder has the ground fault. If a fault is detected on the main or transformer that is not captured by the feeder, it is detected as a "Bus Fault"

Q. This is not a question but a comment. Please fix the typos on the slide with the IEEE and CSA test voltages. Most of the IEEE test voltages are missing a decimal point.

A. This was a mistake, thank you for pointing it out. Please find the correction below.

System Voltage	Neutral Voltage	IEEE C57.32 Test (kV)	CSA Test (kV)
480	277	1.554	1.554
600	347	1.694	1.694
1200	692	3.557	5
2400	1386	5.116	5
4160	2400	7.400	15
7200	4156	11.351	19
13800	7967	19.925	26
14400	8313	20.704	36
27600	15935	37.853	60

Q. The term neutral voltage should actually be referred to as "line to neutral voltage".

A. The terms are not the same, The line to neutral voltage is consistent, The neutral to ground voltage depends on the amount of ground fault.

Q. There is no CEC 2020, it is 2021

A.It was Canadian Electrical Code , Part 12018

Q. How do you determine the charging current?

A. We have an application guide on our website that assists one in calculating this value. It goes through calculating, Measuring, and using a “rule of thumb”. Click here visit the guide.

Q. For an output fault on a VFD, won't the internal VFD electronic detect and trip the output stage? That what we normally see on VFD, even on HRG networks.

A. This would depend on the size of the VFD and the amount of current the the resistor limits the fault current to.

Q. My question was regarding how to calculate the capacitive charging current for a system. Additionally, are surge arrestors treated the same as surge capacitors?

A. There is an excellent resource online that can calculate the amount of leakage current caused by different types of classes of arrestors and voltage applied across them. Secondly, yes, the contribution by surge arresters and surge suppressors is the same and they add a significant additional amount of current to the total system leakage. For additional information, see our Application Guides “Ground Fault Protection on Ungrounded and High-Resistance Grounded Systems” on our website www.i-gard.com.

Q. Per NEC Table 310.104(E) the insulation of any system between 2000-35000 shall be 133% if the fault clears in one hour and 173% if run indefinitely. So this rule applies to 5000V system too. Please clarify your comment on this topic.

A. The table does show levels between 2000-35000 V , however look under the heading for 2000-5000 V, only the 100% is indicated. For 5001-8000V , you will note the 100% 133%, and 173%

Table 310.104(E) Thickness of Insulation for Shielded Solid Dielectric Insulated Conductors Rated 2001 to 35,000 Volts

Conductor Size (AWG or kcmil)	2001–5000 Volts		5001–8000 Volts						8001–15,000 Volts						15,001–25,000 Volts					
	100 Percent Insulation Level [1]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]	
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
8	2.29	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6–4	2.29	90	2.92	115	3.56	140	4.45	175	—	—	—	—	—	—	—	—	—	—	—	—
2	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	—	—	—	—	—	—
1	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420
1/0–2000	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420

Q. Can the introduction of different frequencies from VFDs through ground faults to the NGR cause NGR monitoring systems to malfunction? Perhaps through ferroresoncance?

A.This may be the case. It is important to ensure that equipment such as VFDs, UPSs, and SPDs are compatible with HRG. Compatibility should be confirmed with the manufacturer, but generally concerns not having capacitors connected from phase to ground and ensuring that devices such as MOVs are rated for the L-L voltage. Incompatibility issues may result in interference with NGR monitoring.

Q. How about the impact on the sizing due to 80% or higher VFD loads?

A. The issue we have noticed with many VFDs is that there are higher capacitive loading current due to the EMI filters placed on the VFDs. This would have to be accounted for. When a fault occurs, one may see current is all feeders but it would be only the faulted feeder that indicates a pulsing current as this fault current is resistor dependent. All other current are voltage dependent.

Q. Is resistor monitoring going to be required for all HRG systems or just those feeding mobile/moveable systems?

A. In Canada under the new CEC, yes.

Q. What sort of allowances is i-Gard making for the effect of PWM drives on HRG systems, both in their GF detection but NGR monitoring and resistor ratings.

A. I-Gard has implemented standard controls for detecting NGR faults and ground faults with PWM drives. A great majority of issues come into play when we discuss the carrier frequency of the drive itself.

Q. Recent studies indicate you need 2xIco to dampen transient overvoltages, is that in your documents?

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A. All literature I have read only indicate IR ≥3ICO , If you can share the literature you have with us, we would greatly appreciate it.

Q. Will the slides be available after the presentation?

A. Yes, they are available on www.i-gard.com. Click here to visit slides.

Q. How do you handle residual harmonic currents. We used a filter.

A. Low pass filters are used in our ground fault devices to eliminate residual harmonics.

Q. We found that the 3rd and 5th H were causing a small voltage deflection on the volt meter.

A. Yes they would if you do not use a low pass filter on the Voltmeter.

Q. Effect of Harmonics on High Resistance Grounding. Any factors to consider?

A. A system with a lot of harmonics on it is generally not desirable as this may interfere with some features of an HRG system. Harmonics may indicate issues in how the system is grounded or compatibility issues or issues with other equipment installed on the system.

Q. The model for NGRs fault goes back to neutral; Why does the fault current not go to ground, underground copper wired.

A. The ground fault current will only go back to the source it originated from. It will use all paths , but to complete the circuit it must return back to its own source. Otherwise you would have current flowing in an open loop.

Q. When you inject current to NGR, what mili ampere do you inject?

A. If you are referring to commissioning/system verification using primary current injection, then the current level selected should correspond to the NGR rating and pickup level of the NGR. Pickup level depends on the ground fault relay being employed. For instance, if the NGR has a let-through rating of 200A and the pickup level is 5%, then 10A should be primary injected through the ZSCS to test the ground fault pickup of the ground fault relay. On the other hand, if the question is concerning i-Gard's ground fault relays and the question is: what is the signal that is injected during injection mode for NGR fault monitoring; then it depends on the relay being inquired about. In general, it is a voltage signal and not a current signal.

Q. How do you do maintenance on the Zig Zag transformer , and keep the grounding system active?

A. This question may need some clarification. If the question is about keeping the system grounded, then it should be understood that you cannot keep the system grounded while the zig-zag transformer is disconnected from the system. On the other hand, if the question is can you keep ground fault monitoring active while the zig-zag transformer is taken offline, then this depends on the type of ground fault monitoring system being employed. Some ground fault monitoring systems monitor the system-to-ground voltage to determine if the voltage shift that occurs on a ground fault has occurred and may also monitor zero-sequence current on feeders using ZSC sensors placed on the feeders. Such systems may not have equipment connected to the NGR and thus, can remain active while the zig-zag and hence NGR are taken offline. In addition, if there are any equipment connected to the NGR in such a system (such as NGR health monitoring) then such features would be offline for the duration that the NGR is offline.

Q. Does the material of the conduit matter? i.e. steel vs PVC

A. If you are referring to the ability to trace the pulsing affect on the system, no the material does not matter.

Q. Is there a problem detecting fault current when the harmonic current at the transformer is high?

A. High harmonic currents at the transformer may cause harmonic distortion, which affects the ideal sinusoidal wave of the system. The belief that three identical sine waves, 120 degrees apart, will cancel out at the neutral no longer holds true in this scenario. High frequency distorted waves will often add up at the neutral instead of cancel out, resulting in a nonzero neutral current. This increases the likelihood of nuisance tripping while decreasing the accuracy of hand-held meters. Several steps to eliminate large neutral currents include removing all shared neutrals and/or reducing distortion with the use of filters.

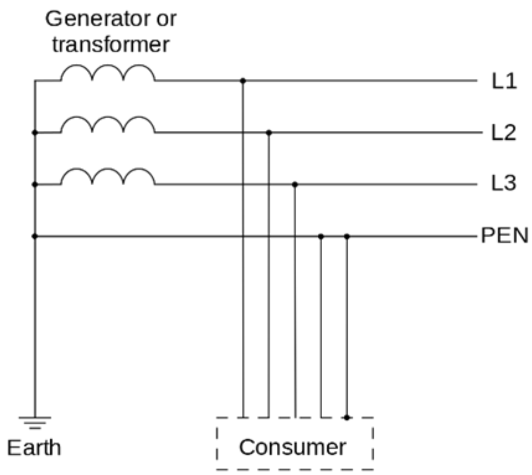
Q. On the advanced HRG scenario with Feeder Modules, what precautions need to be taken on main-tie-main switchgear, especially with closing or tripping the tiebreaker?

A. For multi-source substations such as double-ended main-tie-main board arrangements I-Gard offers Sentinel or DSP-OHMNI HRG system. In the case of a utility outage on one of the sources of such a system, the main breaker on one side will open and the tie breaker will close (through key interlock or other controls) so that power on the 'dead' side is supplied from the 'live' side to maintain service to both sides of the board. There should be two HRG systems – one on each side of the board, the let-through current of each high resistance grounding equipment should be equal to the total capacitive charging current of both systems under all conditions of operation.

I-Gard HRG system includes priority allocation to each feeder breaker depending on its importance. Normally they will operate independently of each other. However, when the tie breaker is closed the two HRG systems will not prioritize breakers on the other side of the board and in the event of a fault involving both sides of the board, the two breakers would trip. To prioritize the combined system it is possible to join the two priority buses together when the tie breaker is closed using an 8-conductor shielded cable. The cable can connected at either end through I-Gard cable adapter modules types DSP-CA or DSP-CAS. When the CA an s CAS are used the system will prioritize the breaker tripping so that only one breaker, the lowest priority breaker , will trip.

Q. Will your system work on a European TN-C system? TN-S is not much different than US systems but TN-C can cause problems.

A. Equipment grounding and System grounding sytsems must be independent. In TN-C any connection between the combined neutral -and-earth core and the body of the earth could end up carrying significant current under normal conditions. If there is a contact problem in the PEN conductor, then all parts of the earthing system beyond the break will rise to the potential of the L conductor. High resistance grounding should not be used in these types of systems.

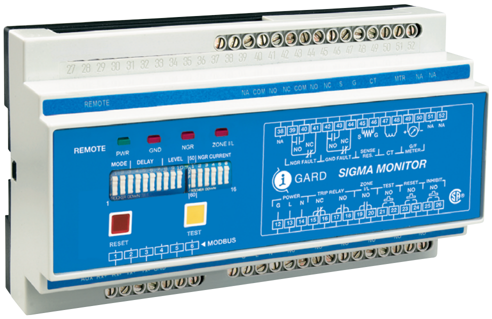


Q. How to choose CT with NGR properly? CT around neutral, CT primary and secondary?

A. The first thing to consider is the relay that is to be used with the NGR + CT/Sensors. The current required by this relay needs to be confirmed, as well as the initial current rating of the resistor. A CT that is adequately rated for the primary and secondary based on these factors, can then be chosen. It is also important to ensure the CT does not saturate.

Q. Can you spend a moment talking about neutral resistor monitoring?

A. The SIGMA 3 relay measures the impedance value of the ground path from the source neutral to ground using a Zero sequence current sensor and sensing resistor. During a short condition, the equivalent impedance of the parallel circuit formed by the NGR and the short will be very low; the relay will detect this abnormal condition and alarm. During and open circuit, the SIGMA 3 will automatically switch to injection mode, injecting a signal to the sensing resistor circuit. There will be no return of the signal to the relay due to the open circuit, and this condition will be alarmed.



SIGMA 3

I-Gard's SIGMA 3 relay is a combination ground fault and monitoring relay with pulsing capability. Unlike other products on the market, the SIGMA 3 has been specially designed to ensure effective monitoring of the NGR circuit, even when de-energized.

Click here to learn more.

SENTINEL

The Sentinel is designed to detect the event of a single ground fault, signal an alarm, and point to the affected branch or feeder. The Sentinel system can assist in locating the fault with a pulsing fault location circuit. In the event of a second ground fault, the Sentinel acts quickly to prevent loss of two feeders by selectively tripping the lower priority feeder only.

Click here to learn more.

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Phone: 905-673-1553
Toll Free: 1-888-737-4787
Fax: 905-673-8472
support@i-gard.com

www.i-gard.com