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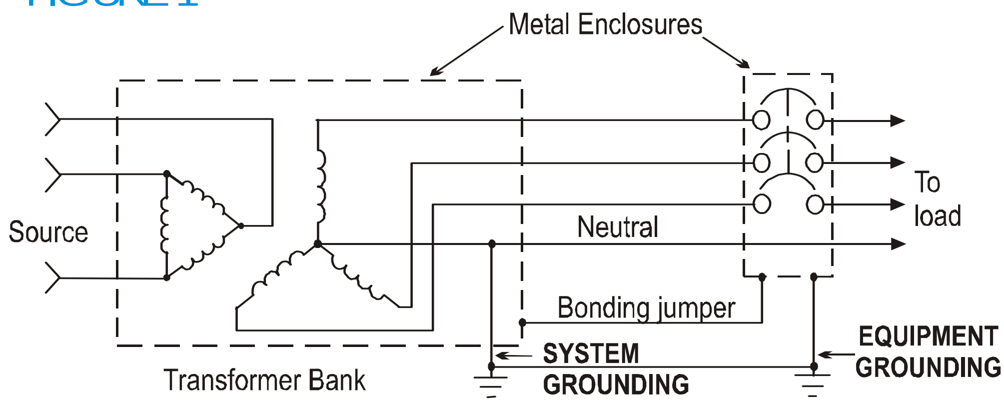
Upgrading Your Electrical Distribution System To Resistance Grounding

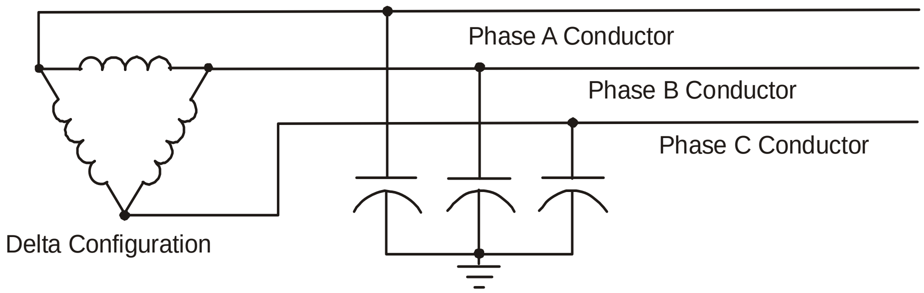
The term grounding is commonly used in the electrical industry to mean both "equipment grounding" and "system grounding". "Equipment grounding" means the connection of a non-current carrying conductive materials such as conduit, cable trays, junction boxes, enclosures and motor frames to earth ground. "System grounding" means the connection of the neutral points of current carrying conductors such as the neutral point of a circuit, a transformer, rotating machinery, or a system, either solidly or with a current limiting device to earth ground. Figure 1 illustrates the two types of grounding.

FIGURE 1



Many industrial facilities operate an ungrounded electrical system. An ungrounded system is one in which there is no intentional connection between the conductors and earth ground. However, in any system, a capacitive coupling exists between the system conductors and the adjacent grounded surfaces. Consequently, the "ungrounded system" is, in reality, a "capacitive grounded system" by virtue of the distributed capacitance. This is shown in Figure 2.

FIGURE 2



According to the Canadian Electrical Code 10-106 (2) “Wiring systems supplied by an ungrounded supply shall be equipped with a suitable ground detection device to indicate the presence of a ground fault”

In a high number of installations this requirement is met through the use of a three light system that indicates the presence and phase of any ground fault. To be truly effective this system requires constant vigilance and inspection a task made ever more difficult with switchgear being located in locked electrical rooms or electrical service being provided by a sub-contract firm. There is an interesting perspective provided with regard to this practice in the IEEE Standard 242-1986 Recommended Practice for the Protection and Coordination of Industrial and Commercial Power Systems 242-1986 section 7.2.5.

“Ungrounded systems employ ground detector to indicate a ground fault. These detectors show the existence of a ground on the system and identify the faulted phase, but do not locate the ground, which could be anywhere on the entire system. If this ground fault is intermittent or allowed to continue, the system could be subjected to possible severe overvoltages to ground, which can be as high as six or eight times phase voltage. This can puncture insulation and result in additional ground faults. A second ground fault occurring before the first fault is cleared will result in a phase-to-ground-to-phase fault, usually arcing, with current magnitude large enough to do damage, but sometimes too small to activate overcurrent devices in time to prevent or minimize damage. Ungrounded systems offer no advantage over high-resistance grounded systems in terms of continuity of service and have the disadvantages of transient overvoltages, locating the first fault and burndowns from a second ground fault. For the reasons, they are being used less frequently today than high-resistance grounded systems, and existing ungrounded systems are often converted to high-resistance grounded systems by resistance grounding the neutral.”

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Grounding the system through the intentional connection of the neutral points of transformers, generators and rotating machinery to the earth ground network provides a reference point of zero volts. This protective measure offers many advantages over an ungrounded system, including:

- Reduced magnitude of transient over-voltages
- Simplified ground fault location
- Improved system and equipment fault protection
- Reduced maintenance time and expense
- Greater safety for personnel
- Improved lightning protection
- Reduction in frequency of faults

The reason for limiting the current by resistance grounding may be one or more of the following, as indicated in IEEE Std. 142-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems 1.4.3.

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

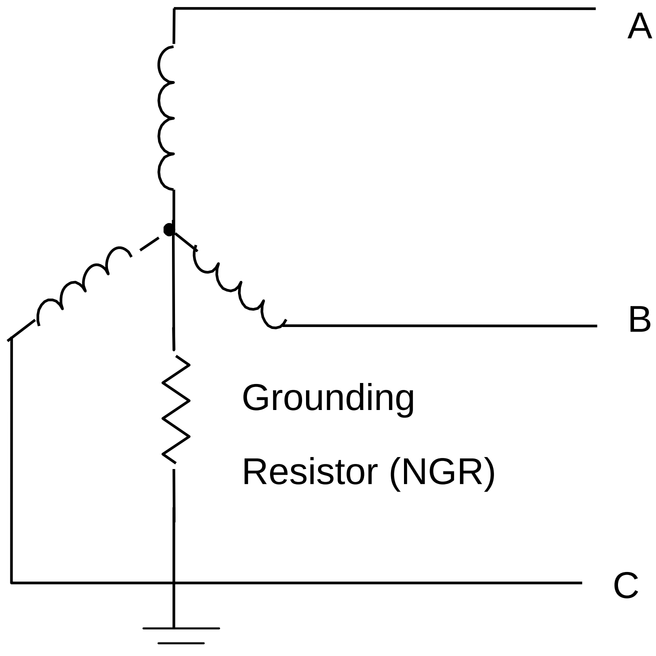
The two major questions facing the contractor when a customer wishes to upgrade and receive the benefits of resistance grounding are how do I size the grounding resistor and where do I make the connection?
The resistor must be sized to ensure that the ground fault current limit is greater than the system's total capacitance-to-ground charging current. If not, then transient over-voltages can occur. The charging current of a system can be calculated by summing the zero-sequence capacitance or determining capacitive reactance of all the cable and equipment connected to the system.
When it is impractical to measure the system charging current, the "Rule of Thumb" method may be used

SYSTEM PHASE-TO-PHASE VOLTAGE	ESTIMATED LET-THROUGH CURRENT VS. SYSTEM KVA CAPACITY WITHOUT SUPPRESSORS	ADDITIONAL CURRENT FOR EACH SET OF SUPPRESSORS
600	1A/2000 KVA	0.5A
2400	1A/1500 KVA	1.0A
4160	1A/1000 KVA	1.5A

There is no performance downside to having ground let through current of 5 amps, even on smaller 480 V system with only 0.5 amps charging current. It is critical to have the charging current more than 0.5 amps and it can be up to 5 amps. It is unlikely that a 480 V system would have a charging current larger than 5 amps. This would only occur if a customer has added line to ground capacitance for surge suppression etc. So if there is doubt then just verify that the charging current is less than 5 amps and simply install a 5 amp Resistor on any 480 V system using wire no larger than 8 awg.

Once we have determined the size requirement for the resistor the next step typically would be to connect the current limiting resistor into the system. It should be noted that converting the system will not affect the metering or relaying already in place.

On a wye-connected system the neutral grounding resistor is connected between the wye-point of the transformer and ground as shown below.



On a delta-connected system, an artificial neutral is required since no star point exists this can be achieved by use of a zig-zag transformer as shown.