

## NEUTRAL GROUNDING



For many industrial and commercial installations power continuity is essential. Loss of production due to ground faults can have serious economic or operational consequences. An arcing phase to ground fault can pose flash hazards to maintenance workers close to the fault and can completely destroy equipment. Consequently, down time adds to economic loss. There are three typical grounding methods which can offer relief to these potentially disastrous problems.

### **Benefits of System Grounding**

System grounding is the intentional connection of the neutral points of transformers, generators and rotating machinery to earth ground to provide a reference point of zero volts, which 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*
- *Note that solidly grounded systems offer only partial protection*

In a solidly grounded system, the neutral points have been intentionally connected to ground with a conductor having no intentional impedance. This reduces the problem of transient over-voltages found on the ungrounded system and aids in the location of faults.

However, solidly grounded systems lack the current limiting ability of resistance grounding and the extra protection this provides against equipment damage and arcing ground faults.

The well-documented destructive nature of arcing ground faults in solidly grounded systems is caused by the energy dissipated in the fault. The faulted circuits need to be tripped. Conventional time-current coordination makes it difficult to selectively trip the circuit with minimum time delay. As a result extensive equipment damage is emanate.

## Resistance Grounded Neutral Systems

Resistance grounding provides protection of a transformer/generator by solving the problem of transient over-voltages thereby reducing equipment damage. It accomplishes this by allowing the magnitude of fault current to be predetermined/limited by a simple Ohms law calculation  $I=E/R$  where  $I$ =fault current,  $E$ =Line to neutral voltage and  $R$ =Ohmic value of resistor. In addition, limiting fault current to predetermined maximum values permits the designer to selectively co-ordinate the operation of protective devices, which minimizes system disruption and allows quick location of the fault.

Neutral grounding resistors will save money by reducing magnitude of transient over-voltages, thereby reducing equipment damage, simplifying ground fault location, improving system and equipment fault protection, reducing maintenance time and expense, creating improved safety for personnel, improving lightning protection and reducing fault frequency.

There are two broad categories of resistance grounding: low-resistance and high-resistance. In both types of grounding, the resistor is connected between the generator/transformer neutral and earth ground. Low-resistance grounding of the neutral limits the ground fault current to a relatively high level (typically 50 amps or more), in order to operate protective fault-clearing relays and current transformers. These devices are then able to quickly clear the fault, usually within a few seconds. This fast response time is important, since it limits damage to equipment, prevents additional faults from occurring, provides safety for personnel and localizes the fault. The limited fault current and fast response time also prevent overheating and mechanical stress on conductors. It must be noted that the circuit must be shut down after the first ground fault occurs. Low-resistance grounding, typically 400 Amps for 10 seconds are commonly found on medium and high voltage systems.

High-resistance grounding of the neutral limits the ground fault current to a very low level (typically under 25 Amps with a continuous duty). It is typically used on low voltage systems of 600 volts or less. By limiting the ground fault current to a very low level, the fault can be tolerated on the system until it can be located and then isolated or removed at a convenient time. This permits continued production, provided a second ground fault does not occur. A single phase distribution transformer can be used in conjunction with a loading resistor to provide high resistance grounding. This is particularly well-suited for grounding of generators, in that it allows the system to operate as an ungrounded system under normal conditions, while still retaining the ability to limit fault currents during a fault condition. The primary of the grounding transformer is connected from the generator neutral to ground. The loading resistor is connected across the grounding transformer secondary. The resistor should be sized the same way as a neutral grounding resistor, except it will be reduced in value by the square of the turns ratio of the grounding transformer. When a ground fault occurs, downstream of the grounding transformer, ground fault current flows through the fault, back through ground to the grounding transformer. The loading resistor then limits the current flow in the secondary windings, which in turn limits the flow of the ground fault back into the system through the primary of the grounding transformer. The resistor is normally sized to allow a primary ground fault current in the range of 2 to 12 amps, and is rated for one minute duty. The grounding transformer should be sized accordingly. The transformer primary voltage rating should be the same as the system line-to-line voltage. The

secondary voltage is normally 120 or 240 volts. An overcurrent relay should be used to protect the grounding transformer in case of an internal fault.

## **Summing It All Up**

An ungrounded system has many operating disadvantages such as high transient over-voltages and difficulty of fault location. A system with a solidly grounded neutral provides greater safety for personnel and aids in fault location. However, the fault current is not limited and the system must be shut down after the first fault. Low resistance grounded neutrals limit the magnitude of transient over-voltages thereby reducing equipment damage. In addition, the fault current is limited to a predetermined value established by a simple ohms law calculation. This type of grounding is generally used on medium and high voltage systems. High resistance grounded neutral systems limit fault current to a predetermined level, permit continued operation after the first ground fault and simplify ground fault location. High resistance grounding is typically utilized on low voltage systems (600 volts and below).