Electrical System Grounding

The ground reference of an electrical system can affect the magnitude of voltage transients, especially the voltage from line to ground. This may cause electrical stress on wire insulation, motor windings, or electrical sensor circuits.

The term “grounding” has different meanings in electrical systems:

Equipment grounding ensures that the chassis is properly bonded to earth. This ensures that the voltage potential on the chassis is limited to safe values, even during fault conditions. The term “bonding” is also used to describe equipment grounding.

System grounding sets the line-to-ground voltage value during normal operation. The system ground is made on the secondary side of the feeder transformer.

Ground fault is an unwanted connection from any phase(s) to ground. The most common example is faulty insulation on wires or in a motor. Ground fault protection is often used to quickly remove power from a circuit when current flows to ground.

Note: Equipment chassis must be grounded to earth regardless of system grounding method. Failure to install equipment ground may result in electrical shock hazard.

IEEE Standard 142-2007 provides a detailed description of electrical system grounding methods. The most common methods include:

Center grounded wye limits the line-to-ground voltage to equipment. Ground current may be high during fault conditions, leading to large arc flash potential. Center grounding requires a feeder transformer with wye-connected secondary.

Impedance grounded limits ground current that may flow during fault conditions. This limits the potential for arc flash, as well as transient voltage spikes, during a fault. The voltage across the ground impedance also provides a simple method to measure ground current for ground fault trip capability. This category includes High Resistance Grounded (HRG) systems.

Ungrounded systems may continue to operate with a single line-to-ground fault (acts like a corner grounded system). This results in high transient voltage from line-to-ground during fault conditions.

Corner grounded allows a ground reference to be installed on a transformer with delta secondary.

The system ground reference is made at the feeder transformer. Isolation transformers allow the feeder to be locally ground referenced while the upstream electrical system is ground referenced at the upstream transformer, such as the electrical substation transformer.

These grounding methods differ by how the ground wire is connected to the transformer winding (or left disconnected). Wye connected transformer windings allow for connection at the center point, while delta connected transformer windings do not (Figure 3).

Center grounding is achieved by connecting the center point of a wye connected secondary winding to ground (Figure 4). This provides symmetrical ground reference, meaning that the line-to-ground voltage is the same for all lines.

High-impedance grounded systems include a resistive element between the transformer center point and ground (Figure 5). By measuring the voltage across the ground impedance, a value of ground current can be calculated. The ground current value is used for ground fault interrupt trips, as well as for system monitoring. The ground impedance also limits the peak value of ground current during fault events.

Delta-connected secondary windings do not allow for center grounding. Delta-connected secondary windings are often left ungrounded (Figure 6). The most common method of grounding a delta-connected secondary winding is by connecting one phase to ground, referred to as corner grounding. Some delta-connected windings include a center tap on one winding, which can be connected to ground, referred to as high-leg grounding (not pictured).

Figure 3. Examples of delta-delta and delta-wye transformers