Understanding Neutral versus Ground

Understanding Neutral versus Ground when applying RFI filters in electrical equipment installations

The grounding of electrical equipment is probably one of the least understood aspects of electricity. As the characteristics of electrical equipment changes from linear to non-linear, the nature of grounding expands from the task of insuring the safety of personnel to insuring that one type of electrical equipment does not interfere with other types of electrical equipment. One point for confusion rests with the often interchanged terms of *Neutral* and *Ground*. Many articles have been written concerning the problems with 3rd harmonics overloading the neutral conductor. Many articles have been written concerning the problem of electrical ground noise. Even with all these articles, there still exists confusion concerning whether equipment should be connected to the neutral or connected to a ground.

It may be possible that a simple rule would clarify the differences between *Neutral* and *Ground*.

It can be stated that ***Neutral*** can be grounded, but *Ground* is not neutral.

A *Neutral* represents a reference point within an electrical distribution system. Conductors connected to this reference point (*Neutral*) should, normally, be non current carrying conductors, sized to handle momentary faults (short circuits) occurring in electrical equipment. However, with the introduction of non linear loads, such as computers, electronic lighting, TVs, VCRs and other switchmode power conversion equipment, the requirements for the neutral conductor has changed (increased).

A *Ground* represents an electrical path, normally designed to carry fault current when a insulation breakdown occurs within electrical equipment. (Note: Breakdowns can be forced by connecting (dropping) a metal tool or conductive material from a voltage potential to the steel structure within a facility.) Connections to the electrical path (Ground) are made convenient for the installation of electrical equipment. Some current will always flow through the ground path. This current will come from a number of normal sources. Capacitive coupling and Inductive coupling between power conductors and the ground path (conductive conduit, conductive structure members, etc) are the greatest sources of ground path current.

Among the many types of distribution systems, the 3 phase, 4-wire, 480/277 V system used in commercial centers and large buildings is very common. It is used since it enables 3 phase ac motors to operate at the 480 V level while 120 V fluorescent lighting operates with the primary of a stepdown lighting transformer connected to the 277 V (line to neutral) potential. The secondary (120 V side) of the lighting transformer has one of its terminals connected to ground. This grounding procedure is done to reduce the possibilities of shocks due to an internal fault in the transformer. The grounded terminal of the 120 V lighting supply is often referred to as the lighting neutral. This IS NOT the true *Neutral* of the distribution system. Although this point within the lighting system is grounded, it is unlikely that a short in any lighting equipment on that branch will ever see current returned to the true neutral within the distribution system.

In a 3 phase low voltage distribution system, the preferred installation should consist of a five wire system. That 5 wire system would consist of, 3 phase conductors, a neutral conductor and a separate ground conductor. In normal practice, the ground conductor is often the building ground consisting of the metallic building structure. Although this type of ground is usually suitable for 60 cycle leakage and fault currents, it is not suitable for leakage currents that exist when non linear loads such as computers, electronic lighting, variable speed drives and other equipment using internal switch mode power supplies and other types of conversion rectifiers are used. The current caused by non linear electrical equipment consisting of low amperage high frequency currents. These currents are often measured incorrectly by 60 Hertz sensors and mistakenly interpreted as higher amperage 60 Hertz values. This occurs as a higher voltage develops across the sensor whose impedance increases as the frequency increases.

The previously mentioned equipment creates rapid changes in voltage and current while transferring energy from the distribution system to the equipment load. These changes cause currents to flow through capacitive paths that exist between phase conductors and between any phase conductor and ground conductors. These currents have high frequency characteristics which results in a phenomena not unlike the results from a small radio transmitter. Very little power is required to create magnetic field which can transmit a Radio Frequency Interference types of electrical noise to other equipment. Usually other equipment, in metallic enclosures is not affected by these small radio-type signals, however, some equipment circuitry may be affected. The typical solution is to add RFI filters in the incoming power lines to the equipment causing the condition. These RFI filters, like other electrical equipment, require grounding. The normal grounding practice is to connect the RFI filters to same ground point used by the equipment causing the condition. This practice is suitable when that ground point has a high frequency low impedance path to the equipment creating the condition. It would not be necessary to install a separate conductor back to the ***Neutral*** reference point in the electrical system as long as a high frequency, low impedance path exists from the grounding point to the equipment ground.

Unfortunately, too many variables exist within any grounding system. However, if standard grounding practices are replaced with high frequency grounding practices (shielding and low impedance ground paths), it is unlikely that electrical ground noise problems will occur. Radio Frequency Interference types of electrical noise will always create problems for AM radios, which are designed as very sensitive electrical noise detectors. Fortunately, most types of electrical equipment are designed, and tested, to be insensitive to RFI generated noise. The general practice should include discussions with equipment suppliers to determine if and what types of electrical interference affect their products. Suggestions regarding installation practices should exist and may be suitable in eliminating any potential problems.