Understand High-Resistance Ground Fault Protection

Industrial drive systems need ground fault protection systems.

By Rob Dannemiller, Post Glover Resistors

Neutral grounding resistors are used for resistance grounding of industrial power systems. They are designed to limit the maximum fault current to a value that will not damage generating, distribution or other associated equipment in the power system.

>> When most people think of resistors in industrial drive systems, they think of dynamic braking. However, resistors are also effective when designing ground fault protection systems.

Ungrounded distribution systems are frequently used in industrial installations containing variable-frequency drives because they can provide continuous service with a ground fault on one phase. With no conductive path other than the system capacitance, a single phase-to-ground fault cannot generate high and potentially damaging current.

However, the phase-to-ground voltage of the remaining two phases rises by 73 percent, stressing the cable insulation and other equipment connected to the system. Locating and repairing the first ground fault is imperative. However, this isn't easy in most factories because some portion of the operation must be shut down to focus on the problem area. Also, there is no easy way to identify which feeder, let alone which machine or bend in a cable tray, houses the fault.

An ungrounded system is defined as a system of conductors with no intentional connection to ground except through potential indicating and/or measuring equipment, or other high-impedance devices. This type of system is coupled to ground through the distributed capacitance of conductors and transformers, or motor phase windings. In the absence of a ground fault, the line-to-ground voltage of the three phases will be about equal because of the equally distributed capacitance of the system.

It's common practice to allow a faulted ungrounded system to operate until it's convenient to shut it down for repairs, or a until second fault forces an emergency shutdown. Unfortunately, it's not always a good idea to wait for the most convenient repair time. The ungrounded system is susceptible to a buildup of high voltage — up to six times the nominal system voltage — when the first system fault is the intermittent type (also identified as an "arcing fault").

This can initiate that second fault at the weakest point in the system's insulation, causing large, more damaging fault currents. The second phase-to-ground fault on the same feeder will usually cause high fault currents to flow between the two insulation failures. The over-current devices that protect the circuit involved should operate to clear the fault.

Should the phase-to-ground faults occur on separate feeders, or if the path to ground is not exceedingly conductive, the magnitude of the fault current will be considerably lower. It may be too low to trip over-current devices; this is the ideal situation to create an arc flash incident. This can cause extensive damage to the equipment, resulting in even more expensive repairs or a more extended shutdown than would have been necessary if repairs to the first ground fault would have been performed immediately instead of waiting for a convenient time. The potential harm to nearby workers is tremendous.

Over-voltages caused by intermittent ground faults can be held at phase-to-phase voltage by grounding the system neutral through a resistor that limits the ground current to a low value, typically 5 to 7A for a 480V system. This can be achieved on a wye-connected system by a high-resistance neutral-grounding resistor, connected between the wye point and ground.

The same can be achieved on a

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delta-connected system by creating an artificial neutral through the use of a zig-zag or wye-delta grounding transformer, and then applying a high-resistance grounding resistor. This allows the system to remain online with a single fault, yet dramatically reduces the potentially damaging over-voltages associated with ungrounded systems. System reliability and safety are greatly increased compared to ungrounded systems.

When you're converting an industrial distribution network from ungrounded to high-resistance grounded, pay attention to the system capacitance. The inherent line-to-ground capacitance associated with system components determines the magnitude of zero-sequence charging current. The value of this current is required for proper selec-

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tion of high-resistance grounding equipment.

You can calculate the charging current of a system by adding the zero-sequence capacitance or by determining capacitive reactance of all the cable and equipment connected to the system. If actual values aren't available, you can use graphs and approximation equations.

For correct application, the let-through current of the high-resistance grounding equipment should be higher than the capacitive charging current of

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the system. This ensures that fault current will flow through the resistor and not break down system insulation. The installation of a tapped ground resistor unit is recommended when you expect to expand the system in the future or the designer is unsure of the charging current value.

Unfortunately, the last step in the distribution system's design is usually the ground fault protection system. While existing systems can be retrofitted to include high-resistance grounding, it's easier when you consider it from the beginning and incorporate it into the total protection. In either case, all necessary information must be available before starting the design.

The ground fault protection system design should include information such as a complete single-line diagram containing the transformer data, type and size of the interrupters; the type and current rating of the overcurrent devices; the size, type and length of all feeders; and load types (both single- and three-phase) and sizes. Additional information, such as operating modes, interlocking systems and special switching arrangements, will influence the design.

The state of supervision also can be a major factor. Unattended systems may require fully automatic protection integrated via Ethernet or other protocol into a SCADA system, while selective indication may be sufficient for attended systems where preventive and corrective maintenance is scheduled in weekly or monthly intervals.

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