GF-03 : GROUND-FAULT MISCONCEPTIONS

Ground-fault protection is an important consideration in the design of industrial distribution and utilization systems. Many of the problems associated with ungrounded and solidly grounded systems are overcome with resistance grounding. Resistance grounding limits point-of-fault damage, eliminates transient overvoltages, and provides adequate tripping levels for selective ground-fault detection and coordination. Fortunately, resistance grounding is beginning to get the attention it deserves. This is evidenced by the addition of requirements for neutral-grounding devices in the 1994 edition of the Canadian Electrical Code, Part I. Unfortunately, misconceptions regarding ground-fault protection continue to flourish. This is evidenced by requests for protection systems that are not practical with today’s technology, misapplications of state-of-the-art technology, and attempts to introduce products that are somewhat less than state-of-the-art.

There should be no misconception as to what ground-fault protection is. Ground-fault protection is low-level fault protection. The function of ground-fault protection is to minimize the damage to electrical equipment when low-level phase current returns to the supply transformer through a ground-return path. The hazard to personnel is minimized by a well-designed ground-fault protection system; however, this should not be confused with GFCI’s which are designed to prevent shock by tripping at the 5-mA level on single-phase systems. Ground-fault protection does not protect people from electrical shock, it does not prevent ground faults from happening, and it does not protect a system against high-level faults. High-level faults must be cleared by fuses or by circuit breakers which limit the energy let through to the fault.

Confusion between ground-fault protection and GFCI’s is evident by the number of requests for ground-fault protection with GFCI characteristics for submersible-pump applications. The section of code often quoted applies to small, single-phase pumps in cottage-type applications—not to industrial 3-phase units. Distributed capacitance is small in single-phase systems that use GFCI’s; however, capacitive current is significant with respect to the 5-mA trip level of a GFCI. To overcome the nuisance-trip problem, even on these small systems, a quadrature-rejection circuit is used to identify ground-fault current in the presence of capacitive current. This rejection technique does not work in a 3-phase system because the resultant capacitive current can be at any angle and it will vary as phase voltages and loading fluctuate.

A common misconception is that a GFCI limits ground-fault current to 5 mA. This is not true! Ground-fault current is limited only by impedance. Timing to initiate the trip begins when the current to ground exceeds 5 mA, but the current can be very high until the trip occurs. Protection is achieved because human contact is usually slow with respect to the time to trip.

Misconceptions abound when the terms “ground fault” and “zero sequence” are used interchangeably. Any problem of unbalanced voltages or currents in a linear three-phase network can be analyzed by superposition of balanced systems of positive-, negative-, and zero-sequence voltages or currents. Since symmetrical components are not widely understood, it is not surprising when a ground-fault relay connected to a zero-sequence CT is mistakenly relied upon to provide phase-unbalance or phase-loss protection. The zero-sequence component of current is equal to one-third of the sum of the three line currents and this sum must be zero if there is no neutral or ground-fault current. A current transformer with all three phase conductors passing through its window (zero-sequence CT) measures the sum of the three line currents and this sum is equal to the sum of the three zero-sequence components of current returning to the supply transformer through a ground-return path. The zero-sequence component can be used to analyze an unbalanced system, but a zero-sequence CT will not measure unbalance—an unbalance does not involve zero-sequence components unless a ground fault is involved.

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Misconceptions are also prevalent with respect to the belief that magnitude coordination works, the relationship between tripping ratio and part-winding protection, the limits for sympathetic tripping, the limits for tripping and monitoring-only type systems, and the sizing of neutral-grounding devices. The consequence of these misconceptions is that many ground-fault-protection systems do not provide the desired protection and they suffer from nuisance and sympathetic tripping. Fortunately, the remedies are usually simple and inexpensive, and applications assistance is readily available at no charge.

Garry Paulson, Ph.D., P.Eng.