Selecting Between a
THREE- OR FOUR-POLE ATS

INTRODUCTION

The choice between a three- or four-pole automatic transfer switch (ATS) depends on the grounding scheme for the system. To ensure you are specifying the correct type, it is important to understand how it affects the grounding of the system and the ground-fault protection for the emergency system. This white paper covers the criteria to be considered when selecting an ATS.

DESIGN CHOICES TO MAKE: REGULATION CONSIDERATIONS

Before considering the reasons for using a three- or four-pole ATS, we must consider regulations of NFPA 70-2017 (also known as the National Electric Code or NEC) that lay out procedures for ground fault protection (GFP).

The NEC stipulates that ground fault protection must be provided for solidly grounded wye electrical systems when the potential volts to ground is more than 150 V but not exceeding 1000 V when the service disconnect is rated for 1000 amps or more.

Entities such as the NFPA that specify safety standards are concerned that grounding the neutral alone does not provide full protection from stray electrical currents and other faults occurring in conductors.

The NEC makes the following distinctions between system and equipment grounding:

**System Ground:** A connection to ground from the conductors of a circuit or interior wiring system.

**Equipment Ground:** Where the equipment body not carrying current has metal parts, such as the generator or metal conduit, is grounded.

**System Neutral Ground:** A system neutral ground is a point in the system wiring where an equipment neutral and the ground connections are bonded together so the voltage potential at the neutral and ground are made equal.
UNDERSTANDING GROUND FAULTS: ASSUMING VARIOUS CONDITIONS

The grounding for the emergency system and the ground fault protection scheme is what determines if a three- or four-pole transfer switch should be selected. There are many design choices to make when designing a backup power system. One is whether to specify a three-pole or four-pole ATS. This choice depends whether your emergency power system will be a separately derived system or not. This paper will explain when to design a separately derived system using a four-pole transfer switch.

USING A THREE-POLE TRANSFER SWITCH: SOLID NEUTRAL SYSTEM

On systems using a three-pole ATS, the neutral is continuous through the whole system. This is known as a solid neutral, and it’s bonded to ground at only one location. The neutral to ground bonding point is shown in Figure 1 at the utility service. There is no connection (link) between the neutral and equipment ground at the generator. The only ground connection at the generator will be the equipment ground for the generator.

NO FAULT CONDITION

The example in Figure 1 depicts a power system with a three-pole ATS (a solid neutral connection). The circuit breaker (ground fault protection) at the utility service entrance is based on the current and voltage ratings required. The NEC requires this service entrance have a ground fault sensing device (indicated as GFS) which compares the current flow between each phase and the neutral working in conjunction with the ground fault trip (indicated as GFT) at the circuit breaker. The current flow is only shown for phase “A” to simplify the diagram. Note that the standby generator will have ground fault sensing and ground fault trip as well.

Here the current produced by the utility leaves along the phase line “A,” does its work at the load and then returns to the utility through the neutral. Since the outgoing utility “A” phase current flowing through the ground fault sensor is equal in magnitude to the current returning through the neutral (opposite direction in flow), the resultant sum of the current flows through the ground fault sensor equal zero. With zero difference in the resultant sum of currents, the circuit breaker will not trip.

Figure 1 depicts a power system where the normal source (utility) is powering loads through a three-pole ATS (solid neutral) without a ground fault. Current flow is shown through the A-phase only to simplify the diagram.
GROUND FAULT INDUCED

In Figure 2 we will introduce a fault to ground at the load at phase “A.” The current will leave phase “A” and return to the utility service entrance source along the equipment ground. Figure 2 shows that the current will find its way back to the neutral of the utility service entrance at the neutral-to-ground bond. Compare how the current flow is different between Figures 1 and 2.

As the neutral-to-ground link is on the utility side of the ground fault sensor, the ground fault sensor is only registering the outgoing phase “A” current and cannot detect any current returning through the ATS neutral.

Therefore, the resultant sum of the current flow through the ground-fault sensor equals the outgoing phase current only. And if the resultant sum of the current flow through the ground fault sensor is greater than the ground fault trip setting, the ground-fault sensor will trip its associated circuit breaker at the utility.

THREE-POLE TRANSFER SWITCH GROUND FAULT CONSIDERATIONS

When a fault occurs at the load with a three-pole ATS (solid neutral connection) where the source is the utility as shown in Figure 2, the current through the neutral is not being sensed causing the utility service entrance (normal source) circuit breaker to trip open. Because there is a solid neutral through the entire power system, the sensing on the standby generator (emergency source) side may trip the generator breaker at the same time since there is current flow through the neutral back to the generator when the ATS is connected to the normal source. This can be a problem if the circuit breakers are not reset on the generator after the fault is cleared. The generator will not be able to supply power to the load with the circuit breaker tripped open the next time the standby generator is needed. Therefore a four-pole transfer switch may be considered in the power system design to avoid multiple source breakers tripping.

Figure 2 depicts a power system with the normal source (utility) powering loads through a three-pole ATS (solid neutral) with no ground fault present. Current flow is shown through the A-phase only to simplify the diagram.
USING A FOUR-POLE TRANSFER SWITCH:
NEC DEFINITION OF SEPARATELY DERIVED

According to the NEC, a separately derived power system is “a premises wiring system whose power is derived from a source of electric energy or equipment other than a service. Such systems have no direct connection from circuit conductors of one system to circuit conductors of another system, other than connection through the earth, metal enclosures, metallic raceways or equipment grounding conductors.”

SEPARATELY DERIVED SYSTEM

On systems using a four-pole ATS, each source’s neutral is bonded to ground at its source, so each source is considered “separately derived.” Regardless of which source the customer load is switched to, if a ground fault occurs, the fault current will travel through ground directly back to the source that is presently supplying the loads. This is known as a switched neutral system.

SWITCHING THE NEUTRAL

In this case, because the ATS neutral is switched versus solid, the standby generator is a separately derived source and must have its own neutral-to-ground connection (link). With this in place, it will be able to detect the ground fault explained in the previous example.

Compare Figure 3 below to Figure 2. Figure 3 shows a power system with a ground fault at phase “A” configured with a four-pole ATS having a switched neutral. Note that on the standby generator a link between the neutral and ground has been added to make it a separately derived source.

Note that the fault current path is the same, however, using a four-pole ATS with switched neutral does not allow a current path back to the generator through the neutral and avoids the generator circuit breaker tripping. When the ground fault is cleared, and the utility circuit breaker is reset closed, the power system is ready for an emergency transfer without having to reset the generator circuit breaker.

Figure 3 depicts a power system with the normal source (utility) powering the loads through a four-pole ATS (switched neutral) with a ground fault present. Current flow is, again, shown through the A-phase only to simplify the diagram.
NEC ARTICLE 700 EMERGENCY SYSTEMS

One additional note: NEC article 700 states that fault protection is not required for the alternative source of an emergency power system. Since it may not be appropriate to disconnect the emergency source during certain conditions, for example powering a fire pump, the emergency source provides an alarm versus ground fault trip during a ground fault condition.

This alarm can be generated from a separate relay versus disconnecting the emergency source. The ground fault alarm relay monitors ground fault current without the use of current transformers so it can be used with either a three- or four-pole ATS.

FINAL THOUGHTS

While there are many factors that determine whether to use a three- or four-pole transfer switch, it should be emphasized that in systems with more than one ATS, it is important to use the same ATS configuration (three- or four-pole) throughout the system. This is essential to maintain the integrity of the ground fault scheme.
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