Selecting Between a

THREE- OR FOUR-POLE ATS

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INTRODUCTION

The choice between a three-pole 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 (also known as the National Electric Code or NEC) and other local codes that lay out requirements for ground-fault protection (GFP).

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

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. 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.

This choice depends whether your emergency power system will be a separately derived system or not.

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. When the NEC requires this service entrance have a ground-fault sensing device (indicated as GFS) it 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.

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 equals zero. With zero difference in the resultant sum of currents, the circuit breaker will not trip.

Figure 1

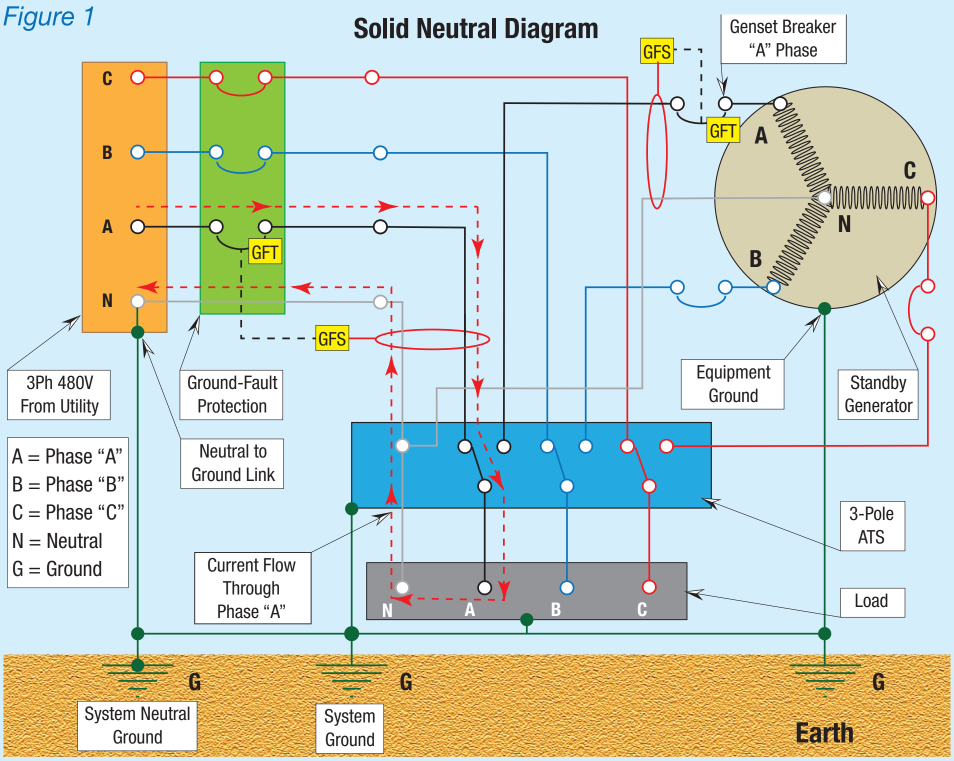

Figure 1 depicts a power system where the normal source (utility) is powering loads through a three-pole ATS (solid neutral) with no ground fault. Typical systems have sensing around all three phases and the neutral. This diagram shows only the "A" phase current and sensing to simplify the diagram.

GROUND-FAULT INDUCED

In *figure 2* the generator is now the power source. We will introduce a fault to ground at the load from phase "A." The current will leave phase "A" and return to 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 and continue through the neutral wire to the generator neutral connection. Note that the generator does not have a connection between the neutral and ground, and therefore is not a separately derived source. As the neutral-to-ground link is on the utility side of the ground-fault sensor, the generator ground-fault sensor is registering the outgoing phase "A" current and also the current returning through the ATS neutral.

Therefore, the resultant sum of the current flow through the ground-fault sensor equals zero. The ground-fault sensor at the generator will not trip its associated circuit breaker with a fault present in the system.

THREE-POLE TRANSFER SWITCH GROUND-FAULT CONSIDERATIONS

When a ground fault occurs at the load with a three-pole ATS (solid neutral connection) where the source is the generator as shown in *Figure 2*, the current through the neutral is being sensed by the GFS on the utility side and may cause the utility service entrance circuit breaker to trip open.

Figure 2

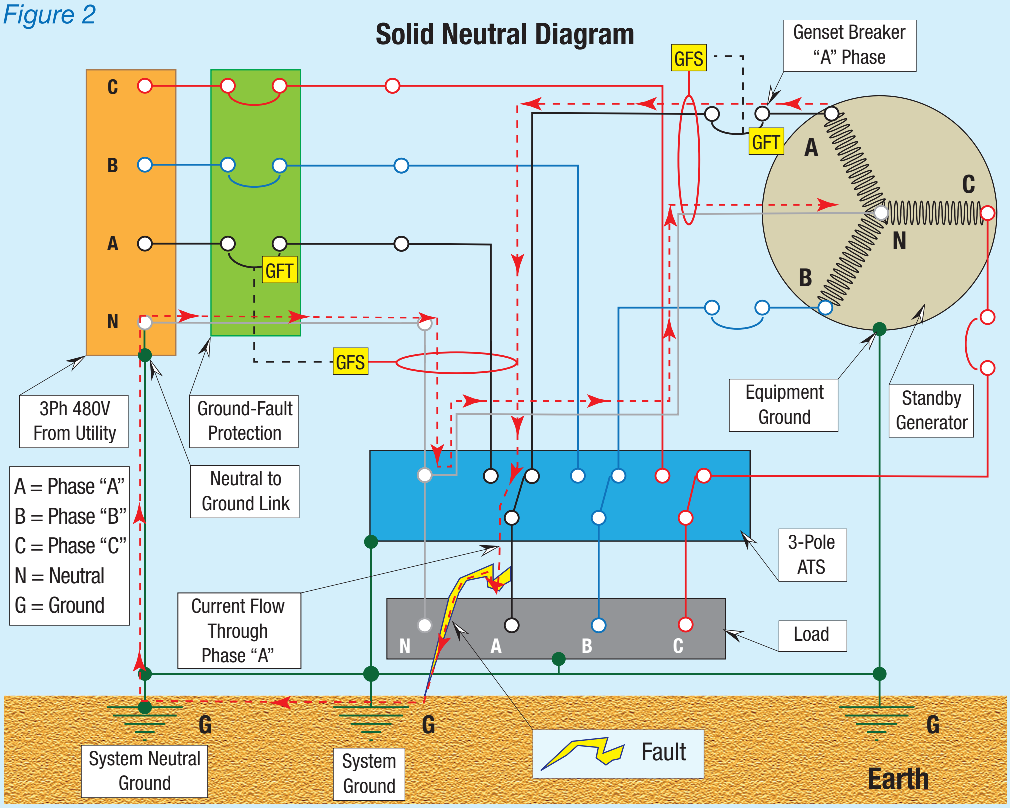

Figure 2 depicts a power system with the backup source (generator) powering loads through a three-pole ATS (solid neutral) with ground-fault present. Typical systems have sensing around all three phases and the neutral. This diagram shows only the "A" phase current and sensing to simplify the diagram.

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 (linked) 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.

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” but 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 ground fault current path is different. Since the current flow through the GFS at the generator has current flowing through the phase and not the neutral, the resultant sum will trip the generator breaker.

Figure 3

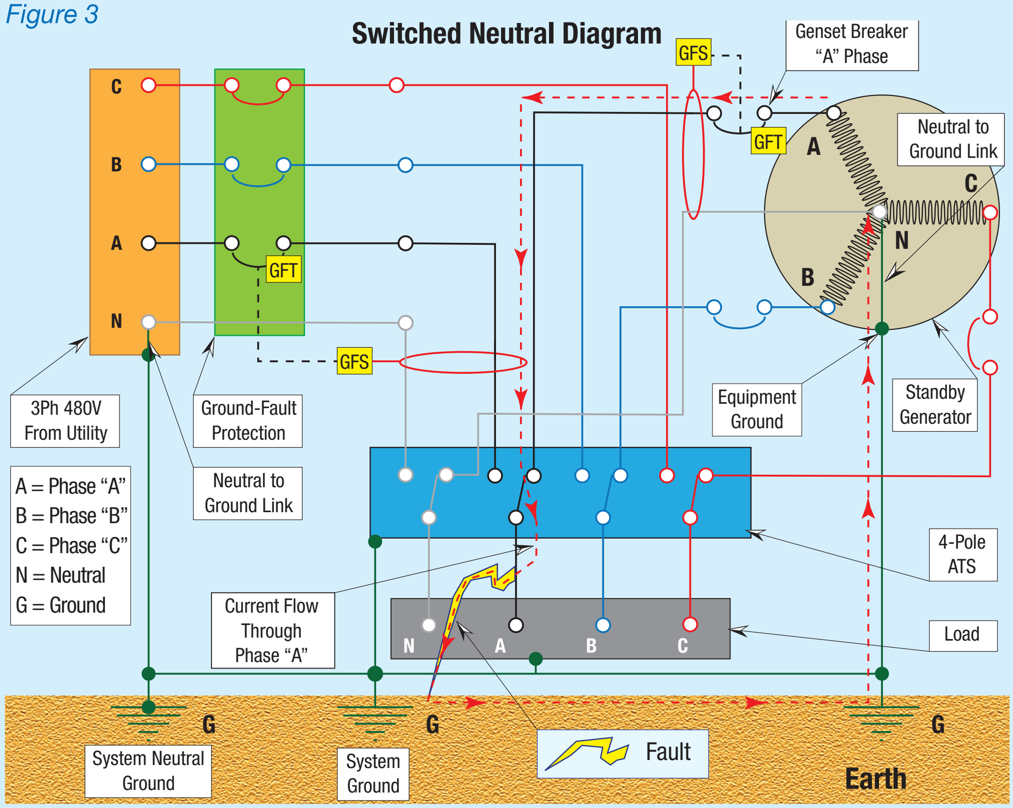

Figure 3 depicts a power system with the backup source (generator) powering the loads through a four-pole ATS (switched neutral) with a ground-fault present. Current flow is, again, shown through the A-phase only to simplify the diagram.

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.

When multiple generators and paralleling switchgear are used, the same grounding system rules apply. Above all, remember to consult with a Kohler-authorized representative. If you get your system design right at the planning stage, then you'll reduce the chance of problems during the operational phase.

ABOUT THE AUTHOR

Mike Pincus is currently the Director of Industrial Sales Operations for Kohler Power Systems. He leads a team responsible for product application engineering support, custom product quotations, and paralleling switchgear application engineering and sales support. He is also responsible for account management for both corporate accounts and distribution. Prior to his current role, he was the Manager of Switchgear Engineering where he was responsible for both development and application engineering for the paralleling switchgear product line. Pincus joined Kohler in 1995 and holds a bachelor of science degree in electrical engineering from the University of Wisconsin-Madison and an M.B.A. from the University of Wisconsin-Milwaukee. He is a member of Institute of the Electrical and Electronics Engineers (IEEE) and a registered professional engineer in the state of Wisconsin.

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