Selecting Between a 3-POLE AND 4-POLE ATS

AUTHOR
MIKE PINCUS
Director of Industrial Sales Operations

KOHLER Power Systems

INTRODUCTION

The choice between a 3-pole or 4-pole 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. Mike Pincus, Director of Industrial Sales Operations at Kohler Power Systems, explains more.

There are many design choices to make when planning a backup power system. One is whether to specify a 3-pole or 4-pole ATS. This choice depends largely on whether your emergency power system will be a separately derived system or not.

On systems using a 3-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 facility's utility service entrance. When the customer load is switched to the emergency source, a ground fault will result in fault current traveling through ground to the bonding point at the service entrance, then back to the emergency source on the neutral.

On systems using a 4-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, and the neutral switching can be open or overlapping (closed).

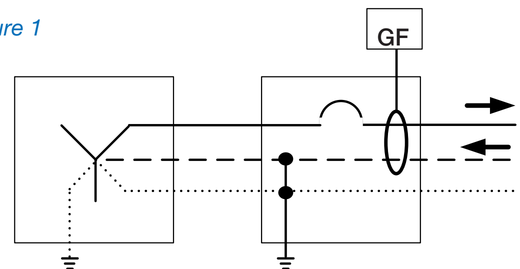
According to the 2011 National Electrical Code, a separately derived power system is "a premises wiring system whose power is derived from a source of electric energy or equipment other than a service. Such systems have no direct connection from circuit conductors of one system to circuit conductors of another system, other than connection through the earth, metal enclosures, metallic raceways or equipment grounding conductors."

The National Electrical Code (and many other local codes and standards) provides the system designer with guidance to determine whether the emergency system needs to be a separately derived source or not.

UNDERSTANDING GROUND FAULTS

The grounding for the emergency system and the ground-fault protection scheme is what determines if a 3-pole or 4-pole transfer switch should be selected. Ground-fault protection is a complex topic. One simple way to see how it affects a system is to model the three phases as one phase and assume that all the current produced by a source, a transformer or a generator returns to its point of production along the neutral line. So let's look at the example in *Figure 1*. Here the current produced by the transformer leaves along the phase line, does its work at the load and then returns to the transformer along the neutral. The switchgear shown in *Figure 1* is the service entrance for the facility and is based on its current and voltage ratings; the National Electric Code requires that this service entrance have ground-fault trip (indicated as GF). In our example, since all phase current flowing through the ground-fault sensor equals the current returning on the neutral, the algebraic sum of the current flow through the ground-fault sensor equals zero, and there is no ground fault for the sensor to detect.

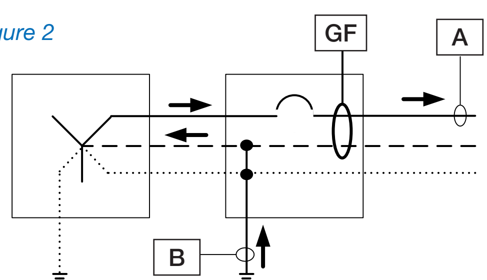
Figure 1



Transformer *Switchgear*

Now let's look at the example in *Figure 2*. Here we will introduce a ground fault at point A. So the current will leave the phase at point A and return to its source along the ground. It will find its way back to the neutral at the neutral-to-ground bond at the service entrance (shown as point B in *Figure 2*).

Figure 2

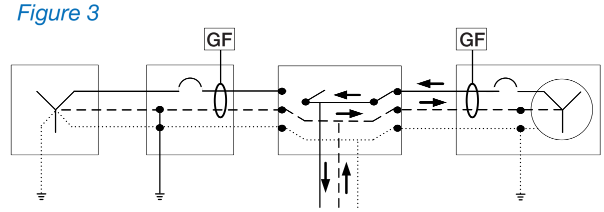


Since the neutral-to-ground link is on the source side of the ground-fault sensor, the ground-fault sensor is only registering the outgoing phase current and cannot detect any current returning on the neutral. Therefore, the algebraic sum of the current flow through the ground-fault sensor equals the outgoing phase current only. And if the algebraic 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 breaker.

USING A 3-POLE TRANSFER SWITCH

Now let's add a 3-pole ATS and a generator to our simple circuit see *Figure 3*. Because we have a 3-pole ATS in this system, the neutral is continuous, and the generator is not considered a separately derived source. There is no neutral-to-ground link at the generator. The only ground connection at the generator will be the equipment ground for the generator.

Figure 3

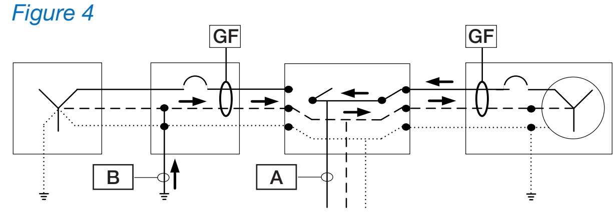


In *Figure 3* we see how normal current flows while the system is operating on generator power.

Since the generator is producing the power, the current flows out of the generator phase, does its work at the load and returns to the generator along the neutral. Once again, the algebraic sum of the current flowing through the generator's ground-fault sensor equals zero, and there is no ground fault.

Now let's see what happens if there is a ground fault at point A in *Figure 4*. The current will leave at point A, it needs to find a way back to the generator (along the neutral). Its only option is to

Figure 4



flow along the ground and to get back into the system at the neutral-to-ground bond at the service entrance (shown at point B).

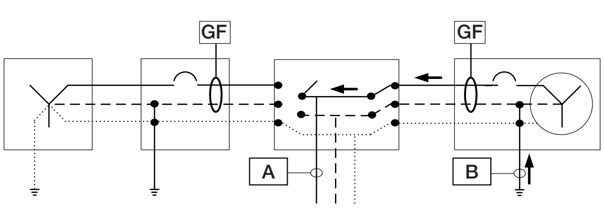
Once back in the system, the ground-fault current will flow along the neutral, through the solid neutral in the ATS, back to the generator. Just like during normal current flow, the algebraic sum of the current through the generator's ground-fault sensor equals zero. This means that the ground fault is not being picked up by the ground-fault sensor on the generator. The ground-fault sensor in a generator is often integrated into the circuit breaker, so in this case the breaker will not open during a ground fault. In fact, the ground fault may not be correctly sensed by the system until the ATS returns to utility power. (It might be seen at the normal-source breaker, causing the breaker to trip, even though the fault is not fed from the normal source.) As previously mentioned, since the neutral is continuous in a 3-pole setup, the generator is not a separately derived source and, therefore, there is no neutral-to-ground link at the generator.

USING A 4-POLE TRANSFER SWITCH

In order for the generator's current-based ground-fault sensor to detect the ground fault (and trip the associated generator-mounted circuit breaker), a system using a 4-pole transfer switch is needed. In this case, because the neutral is switched with the phases, the generator is a separately derived source and must have its own neutral-to-ground link. With this in place, it will be able to detect the ground fault from the previous example.

So let's take a look at what happens during a ground fault when a system is operating on generator power and a 4-pole transfer switch is installed. This scenario is set out in *Figure 5*. As with previous examples, let's see what happens if there is a ground fault at point A. As before, the current must return to the generator along the neutral.

Figure 5



Unlike in *Figure 4*, the neutral in the ATS is open between the utility service entrance and the generator. This means the ground-fault current cannot return using the utility service entrance neutral-to-ground link (as it did when we had the system with the 3-pole ATS). Instead, the current returns back to the generator through its neutral-to-ground link (at point B in *Figure 5*). Because the generator's neutral-to-ground link is between the source (the generator) and the ground-fault sensor, the algebraic sum of the current flow through the ground-fault sensor equals the phase current only. And since the algebraic 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 breaker.

FINAL THOUGHTS

While there are many factors that determine whether to use a 3-pole or 4-pole transfer switch, it should be emphasized that in systems with multiple ATSs, it is important to stick with one or the other neutral switching schemes. In other words, all the transfer switches serving 3-phase, 4-wire load should be of the same type, either all 3-pole or all 4-pole. This is essential to maintain the integrity of the ground-fault scheme.

When multiple generators and paralleling switchgear are used, the same rules used to determine the use of 3-pole versus 4-pole transfer switches should be applied. If the emergency power system is a separately derived source, then a neutral-to-ground link may be in place at each generator, or there may be a single neutral-to-ground link in the paralleling switchgear.

Above all, remember to consult with a proven supplier. There's a famous expression among carpenters that says you should "measure twice and cut once." The same applies here. If you get your system design right at the planning stage, then you'll encounter fewer problems in the operational stage.

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 the Institute of Electrical and Electronics Engineers (IEEE) and a registered professional engineer in the state of Wisconsin.

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