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Relying on Automatic Throwover Circuit Breakers

A consideration of the pros and cons of automatic throwover circuit breakers to transfer between utility power and a standby source.

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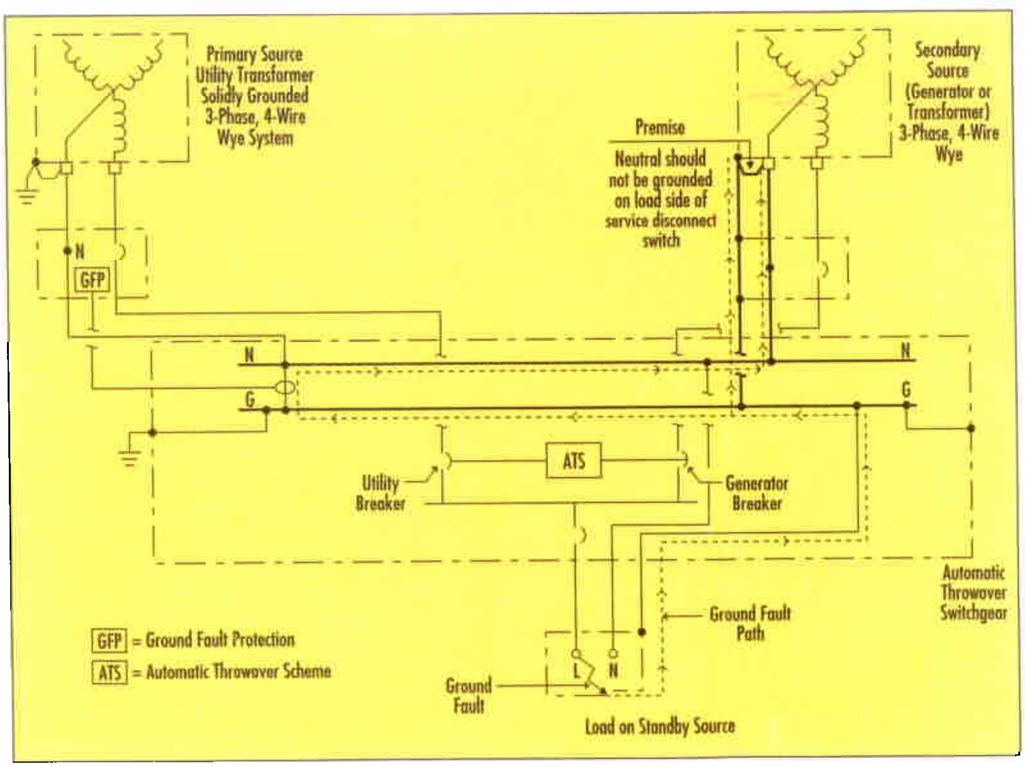
Typically, power is brought into a facility at medium voltage, transformed to 480/277 volts and distributed to three-phase and single-phase loads such as lighting or distribution dry-type transformers. Power is transformed to low voltage power at 208/120 volts for receptacles and low voltage distribution.

Since most facilities have some 277-volt power requirements—such as lighting or three-phase, four-wire mechanical equipment—system designers must give consideration to power feeders from separately derived sources when installing automatic throwover circuit breakers to transfer power between the primary and secondary source.

The primary source is typically a utility- or facility-owned transformer to provide 480/277 volts. The secondary source might be a standby generator or a redundant transformer, and these secondary sources might be either local or, more likely, remote to the switchgear. Generally, for increased reliability and flexibility in the electrical distribution system, a main-tie-main switchgear with primary and secondary sources being transformers—or with primary source a transformer and secondary source generator—are installed.

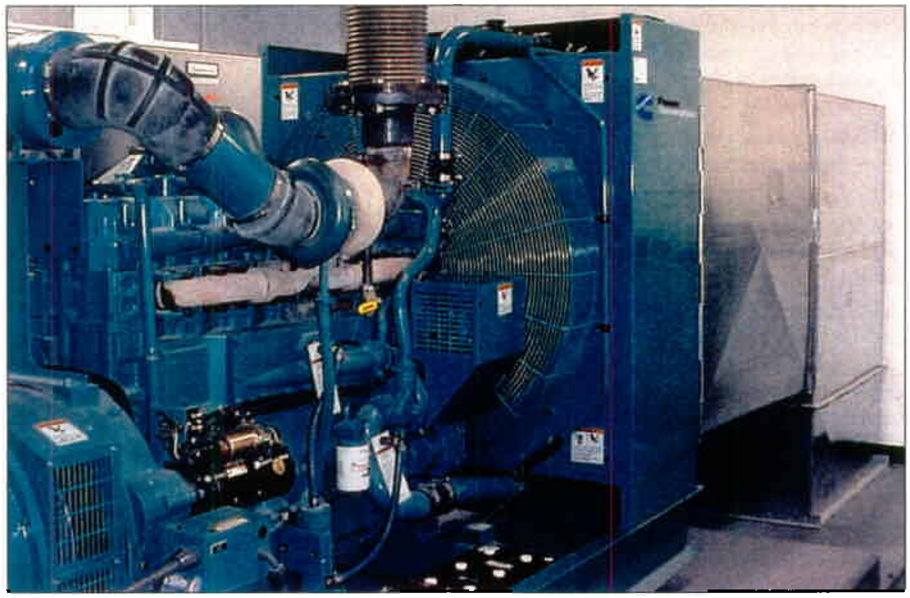


With a standby generator, the

breaker throwover transfer scheme is installed to switch power between it and the utility source. If three-phase, four-wire (grounded neutral) distribution is run from both the generator and utility source, and if the neutral is not switched, then at least one source must not be separately derived.

For example, the utility feed may be grounded with the neutral and ground bond established at the source. However, the standby generator neutral-to-ground bond may not be established at the generator; instead, it must run to the utility neutral-to-ground reference point. In this scenario the utility source is treated as separately derived, while the standby generator is not.

If the utility-source transformer and the standby generator source are treated as separately derived sources—that is, neutral and ground are bonded together local to the the sources—then the neutral at the automatic transfer pair circuit breakers must be switched. Otherwise, when using normal power, a phase-to-ground fault at the load will travel to the utility source and also back to the standby generator, as shown in the figure below. If the fault is of significant magnitude, it is feasible to trip open the standby generator output breaker and normal utility breaker with ground fault, thus leaving the facility with no power.

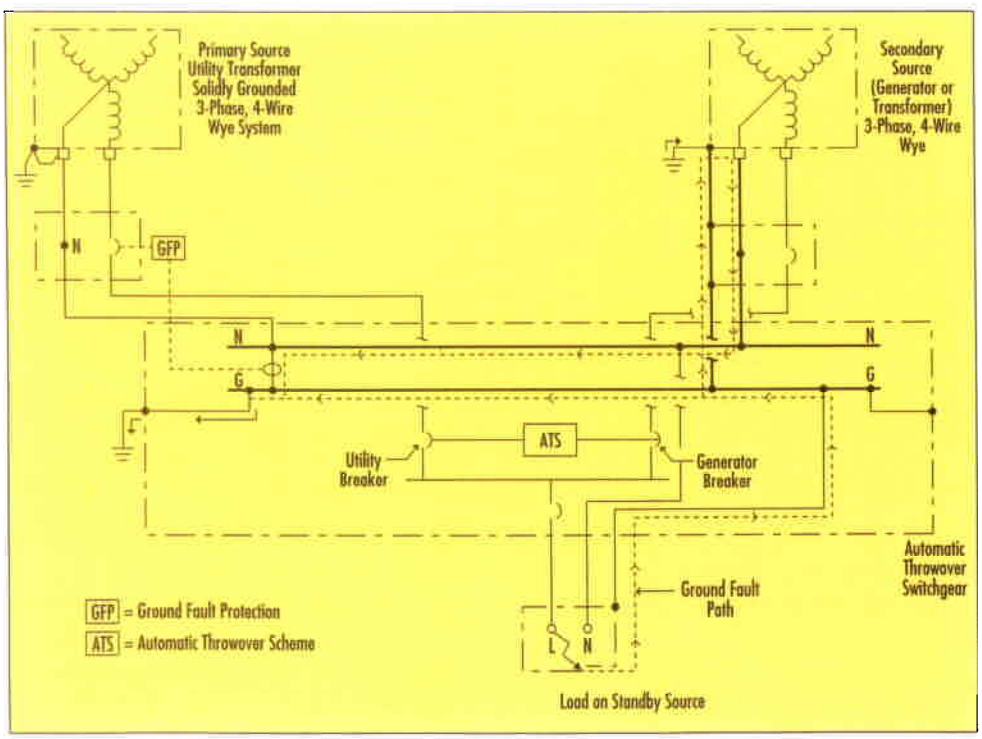


A common practice is to unground the standby generator and run the ungrounded neutral to the utility source, thereby establishing a neutral-to-ground bond at that location as shown in the figure below. This solution works in some applications, but special consideration must be given when the standby power source is remote from where the neutral-to-ground is established. If a ground fault occurs, then the path fault will travel to the secondary source, and there is a potential, given sufficient fault, that the generator output circuit breaker may trip on overcurrent and the utility breaker trip on ground fault protection.

One major benefit of solidly grounding a separately derived source—such as a generator—is power stability and more accurately responsive ground-fault system. Furthermore, if the standby power source is grounded remote, the impedance due to remote neutral-to-ground bond can create overvoltage and introduce transients to the system. In addition, care should be paid to the safety of personnel working on the switchgear with this type of bond. Workers may believe that it is safe to perform maintenance on the section of the switchgear. In reality, it might not be safe. When the system is using standby power, a ground fault may flow through the switchgear—and to the earth in order to find the standby power source.

When using automatic throwover circuit breakers with transformers remotely installed, situations can arise that are similar to when a standby generator source is remotely located. When four-wire distribution is used from the switchgear, the neutral-to-ground bond should be established at the switchgear, which minimizes the ground impedance between the remote transformers and switchgear. The impedance differential between the sources may cause difficulty in providing coordinated ground fault protection.

If the transformers are separately derived sources, and there will be solid neutral and ground between the two sources via the switchgear, then unintended circulating ground



currents can develop between the two sources. If the power sources are not properly coordinated, and there is a ground fault on one feeder, it is possible that both services' circuit protections can trip.

Consequently, a ground fault coordination that incorporates time delay is required—in addition to the magnitude coordination between the primary and secondary sources. For larger system, coordination with distribution feeders is also required to ensure that the mains do not trip because of a fault on a feeder circuit. If the mains and tie are of similar capacity, coordination of breakers can be difficult, especially for the larger frame breakers greater than 2,000 amps.

When circuit breakers are used to transfer power between primary and secondary sources, the sources may be solidly grounded or ungrounded. If the sources are solidly grounded, then the transfer pair circuit breakers should be four-pole, or a neutral switch must be added to the system. If secondary source is ungrounded, system designers should consider locating the secondary source close to the transfer pair circuit breakers and the primary source. Remotely locating the ungrounded source can create unwanted circulating currents between the neutral and ground source where a neutral-to-ground bond is established.

If secondary source neutral-to-ground bond is remote and the load is unbalanced, there can be overvoltages reflected on the system. In addition, the power distribution can become unstable and prone to transients. A ground fault occurrence, when on standby power source, will be reflected onto the primary utility source. This can trip the utility breaker on ground fault and trip the generator on overcurrent under a phase-to-ground fault at the load.

To protect the reliability of the load while on generator or secondary source in a circuit breaker throwover scheme, the design professional should take a careful look at utiltizing breakers to transfer power between two source with three-phase four-wire distribution. Available options would include the following:

- **Automatic transfer switches in lieu of transfer pair circuit breakers** for applications where four-wire or single-phase grounded conductor distribution is required. The ATS should be provided with four poles or switched neutral. This will allow for the primary and secondary sources to be separately derived with wye configuration and consequently be a stable source. By establishing a neutral-to-ground bond local to the separately derived source, the distribution system should be less prone to overvoltage and transients. A more accurate ground-fault scheme can also be provided when the sources are grounded locally. The four-pole transfer scheme has some drawbacks. For large projects, the ATS may occupy more space. Also, to allow for the tie between two sources so as to provide redundancy of the transfer switches may be cost prohibitive compared to breaker throwover schemes in main-tie-main switchgears.
- **Main-tie-main circuit breaker throwover scheme.** This solution is common. Three-pole circuit breakers transfer power between two sources without switching the neutral. If three-phase four-wire distribution is used without downstream delta-wye transformers, then a detailed ground-fault scheme with time coordination is required. But there are inherent problems with this system. It forces the circuit breaker protection for primary and secondary standby sources to have a coordinated relay protection. In a main-tie-main configuration, a coordinated, timed ground-fault protection is required for all three breakers and large distribution feeder breakers of the switchgear. For applications where the separately derived sources are remote from the main-tie-main switchgear—which is where the neutral-to-ground bond is established—coordinated ground-fault protection schemes might be difficult to achieve. This is because the current transformers will be located in the switchgear, and the sources will be operating remotely ungrounded. Also, the ungrounded sources may be prone to overvoltages. False readings may be possible if there is impedance variation between the two systems.

- **Distribution isolation transformers for all single-phase loads with grounded neutral.** For this option, the primary utility and secondary standby sources should have only three-phase and ground run from them—even though they are four-wire wye systems. The secondary and primary sources should be grounded so as to be separately derived but with only three-phase and ground run to the switchgears for distribution. All downstream distribution loads from the switchgear shall be three-phase, three-wire and ground. Where three-phase four-wire is required, a delta-wye isolation transformers should be provided. With this configuration, the neutral is not required to be switched, because the neutral is not run from the sources. The system will be stable because the sources are wye and locally grounded with the exception that the neutral is run. The distribution transformers will provide isolation between the loads and the breaker throw-over scheme and thus producing a more reliable distribution system.

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