

Guidelines for ATS selection: How to choose the right transfer solution for your power application.

> White Paper

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Transfer switch equipment is available in a variety of types, with a wide array of features. Selecting the appropriate transfer switch for a specific application requires a clear understanding of site needs and application restraints. This paper discusses the various types of power transfer equipment that are available, along with their advantages and disadvantages, so that a more informed selection can be made.

Transfer switches are at the heart of an emergency power system, providing a dependable power transfer between the utility and emergency standby generator, or between other types of power sources and facility loads. When the normal power source fails (usually the utility), transfer switches detect the loss of power, send a start signal to the standby generator and then connect the generator to the facility's loads when the generator has achieved proper frequency and voltage. In cases of utility failure when the emergency power source is not operating, electrical service to a facility's loads will be lost for a period of approximately 10 seconds while the generator set starts — unless there is an uninterruptible power supply (UPS) serving loads in the system to bridge the power gap while the generator set starts, reaches the proper parameters, and the automatic transfer switch transfers.

When transferring between two live sources, such as when normal power has returned or during generator set test/exercise periods, a system designer can select different types of transfer switches to minimize or even eliminate the electrical disturbance to critical loads.

One might expect that the type of transfer switch selected is primarily a function of reliability, but in some cases selection is simply based on convenience. In general, minimizing the disturbance that can occur when switching between sources will increase the cost of a transfer switch. It costs more to completely eliminate the switching disturbance, and the added complexity can have negative impacts on the reliability of the transfer device and even the generator equipment. So, whether the application is a simple standby power system in a home, a large emergency system in a hospital protecting the lives of patients, or standby service to a data center handling millions of dollars in transactions, a careful consideration of the balance between cost, reliability and the quality of power provided to critical loads is necessary to select the most appropriate transfer switch equipment.

Types of transfer equipment

Transfer switch equipment can be categorized into four general groups:

- **Open-transition transfer devices:** Open the connected source before closing the new source, causing a total power interruption for a short period of time;
- **Fast closed-transition transfer devices:** Operate like an open-transition transfer switch when a source has failed, but will parallel the two sources for 100 milliseconds or less and then disconnect when both sources are available, so a total interruption of power is avoided;
- **Soft closed-transition devices:** Operate like an open transition transfer switch when a source has failed, but when transferring between live sources

will actively synchronize the sources, then connect them together and ramp load to the new source. This results in a transfer that provides the minimum disturbance to the loads; and

- **Sub-cycle transfer devices:** Open and then re-close on the new source in less than one-quarter of an electrical cycle. The resultant interruption is so short that most load devices aren't affected by it. They are used primarily in UPS systems and only occasionally with a generator set. These devices are very expensive in relation to mechanical switches and are typically protected with fuses. They are also more complex than mechanical switches and are considered by some to be less reliable. This type of transfer device will not be further discussed in this paper.

Open-transition transfer switches

Open-transition transfer switches provide a “break-before-make” switching action. They are specifically designed to transfer power between utility and onsite power systems. The connection to one source is opened before the connection to the second source is closed. (See Figure 1) Mechanical interlocks that positively prevent interconnection of sources in automatic and manual modes are commonly used. Open-transition transfer switches are the most commonly used type of transfer switch and are used in all types of applications. By design, they neither require nor allow generator set paralleling with the utility service. (See Figure 2) Typical customer applications include basic standby power systems for small businesses, hotels, small manufacturing and commercial buildings that can tolerate brief interruptions during monthly power system testing and retransfer to the utility after an outage.

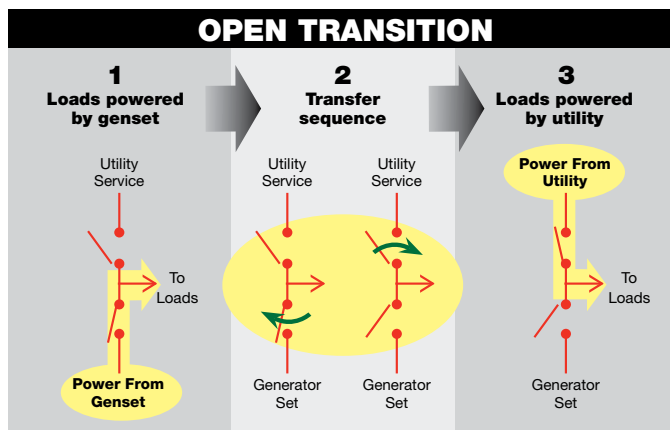


Figure 1

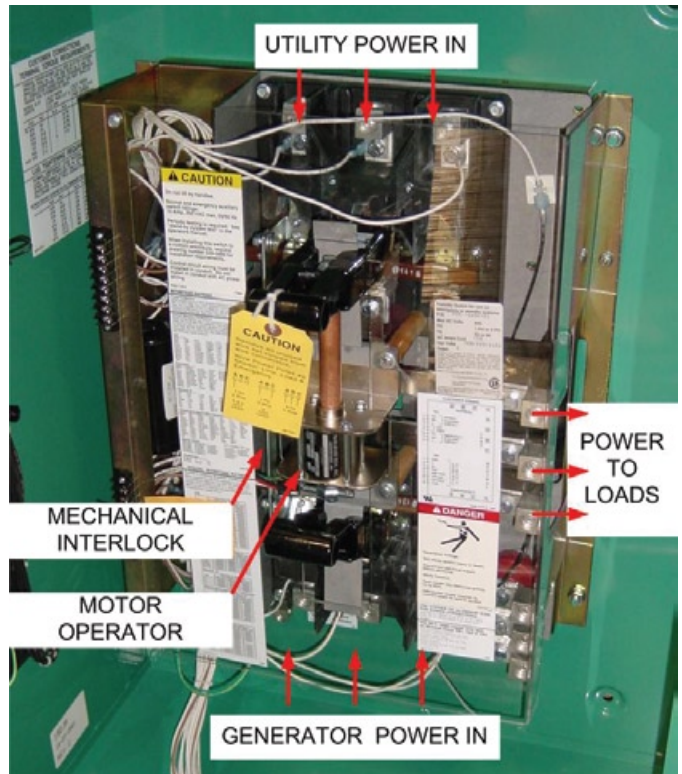


Figure 2 - Open-transition transfer switch

Advantages of using conventional open-transition transfer switches are:

- Lowest-cost automatic power transfer option available due to the simplicity of the controls and mechanism needed and the simplicity of the interface to the generator set.
- Most reliable option available, again due to simplicity, and the fact that there is no external utility protection or generator equipment needed.
- Most designs incorporate a mechanical interlock that positively prevents inadvertent utility paralleling.

The **disadvantage** of open-transition transfer systems is that during retransfer from the emergency generator to the utility following restoration of normal power — or during system testing — a fixed open time is needed to allow the arc developed on opening the contacts to decay. Typically this time requirement is approximately five electrical cycles. In applications with a high percentage of inductive loads (motors, transformers, etc.), open-transition transfer switches need added functionality to control the speed of operation of the mechanical switch and keep the contacts open for

one-half to three seconds to allow time for the residual voltage in inductive load devices to decay. This feature is called “programmed transition” or “delayed transfer.”

Some other open-transition transfer switch designs utilize phase angle monitoring between sources to initiate switching between sources when they are synchronized to minimize the transfer time between live sources. These are suitable for small motor applications where the largest motors served by the transfer switch are not more than 20 horsepower.

Fast closed-transition transfer switches

Fast closed-transition transfer switches provide a “make-before-break” switching action and utilize a momentary paralleling of both sources (<100 milliseconds) during the transfer period. Closed-transition transfer switches utilize a control system similar to that of open-transition transfer switches and are connected to the generator set in a similar way. Closed-transition transfer switches require a mechanism that is capable of being operated in open-transition sequence when switching from a failed source to a live source, and a closed-transition sequence when transferring between two live sources. Many closed-transition transfer switches do not include mechanical interlocking of sources, making it possible, especially in manual operation modes, to manually parallel the sources. This can be very damaging to the power sources or the transfer equipment. Closed-transition switching mechanisms are more complex and expensive than open-transition transfer switches.

While fast closed-transition transfer devices switch from sources without a total interruption, there is generally a disturbance in power supplied to the loads due to the sudden load change on the source. This is particularly true when transferring a load from the utility to the generator set. In general, in order to prevent disruptive transients, fast closed-transition transfer switches must be transferred sequentially, and each switch load should be limited to less than 25 percent of the standby rating of the generator set.

Many closed-transition transfer switches utilize passive synchronizing typically composed of a sync check device (also called a “permissive relay” or “phase band monitor”) to sense the phase relationship between the two live power sources and allow interconnection of the sources only when they are synchronized. The synchronizing is termed “passive” because there is no direct control over the generator set frequency. Instead,

it relies on changes in the loads or difference in the frequency of the sources to induce phase angle matching of the sources. As the loads on the system change, and the speed of the genset changes, the two power sources will eventually drift toward synchronism. The transfer is timed and signaled to occur so that when both sources are close together, they are synchronized at the instant when the generator set is interconnected with the utility. Paralleling of the sources occurs for a fixed time (not more than one-tenth of a second). The short duration of the paralleling makes it unnecessary to add more complex controls to control load on the generator set while paralleled with the utility grid. (See Figure 3)

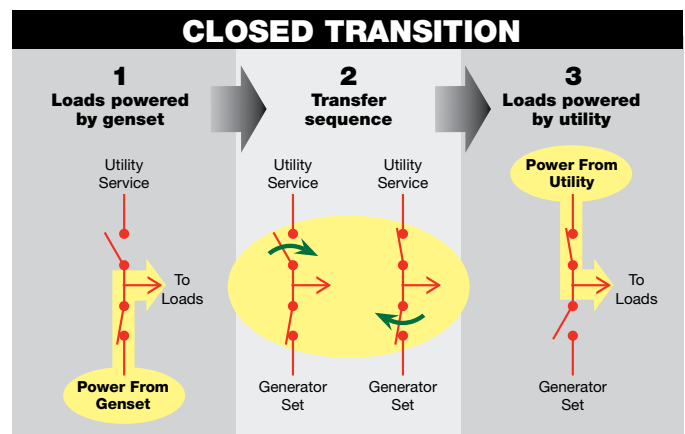


Figure 3

Advantages of closed-transition transfer switches with passive synchronizing are:

- Lowest-cost “non-load-break” system, due to simplicity of controls and lack of generator set governor synchronizing controls.
- They prevent momentary breaks in power during generator set testing and when closing back to a restored utility source. Splitting the loads into small portions and controlling the sequence of their transfer will minimize disruptive transients.

Disadvantages of this equipment are:

- The overlap time is very brief, so voltage and frequency transients will be imposed on the system which may be just as disruptive as a short total interruption, especially upon switching to the generator set.
- If facility loads are very stable, the two power systems may require an objectionably long time to synchronize. This “failure” mode may be intermittent,

since it depends on site loading variations to provide the frequency change necessary to induce changes in the phase relationship between the on-site power system and the utility.

- Generator sets used with this equipment may be subjected to abnormal stresses due to poor synchronizing accuracy. The premature damage to the excitation system due to imprecise paralleling with the utility does not necessarily occur at the instant of paralleling, and may cause failure of the generator set under emergency conditions.

Generator sets used with this equipment should be provided with protection against out-of-phase paralleling, as well as reverse power and reverse kVAR protection, so that failure to isolate the sources does not cause catastrophic damage to the generator set.

Since the closed-transition transfer switch is a utility paralleling device, and some failure modes of closed-transition transfer devices can result in sustained operation in parallel with the utility service, some utility service providers require protection of their systems from these effects. Common requirements include reverse power relays and/or fail-to-disconnect timers. No closed-transition transfer device should be operated in closed-transition mode without specific written permission from the local utility service provider.

Some authorities may interpret the National Electric Code as requiring the use of protective relaying and other devices when using closed-transition transfer switches. See NFPA 76 (National Electrical Code), article 705 for more details.

Closed-transition transfer switches with active synchronizing

Some fast closed-transition transfer switches incorporate an active synchronizing function in the control so that failures to synchronize can be avoided. One source of fast closed-transition devices with active slip frequency synchronizing is Cummins Power Generation. A PowerCommand® closed-transition transfer switch can incorporate active synchronizing and also contains an algorithm for adjusting the timing of the closing of the mechanical contacts in order to compensate for wear.

Advantages of closed-transition transfer switches with active synchronizing include:

- Synchronizing is more accurate and power transfers occur more rapidly.
- They prevent synchronizing delays in facilities with very stable loads.
- They prevent momentary breaks in power during generator set testing and when closing back to a restored utility source.

Disadvantages include:

- Similar to other fast closed-transition transfer devices, except that failure to synchronize is avoided.

Soft closed-transition transfer switches

Soft closed-transition transfer systems use an automatic synchronizer that forces the generator set to synchronize with the utility service, closes the generator to the utility and then gradually transfers the facility loads to the generator. Transfer time is adjustable and can vary from a few seconds to several minutes, depending on facility needs and utility requirements. On retransfer, a similar process occurs, allowing the genset load to be gradually reduced before dropping off the bus. As a result, the typical disturbances in voltage and frequency are eliminated for all practical purposes. Because this type of system is often used in situations where the generator set(s) are connected at the “top” of a distribution system — for example, powering the entire building — the switching mechanisms can be low- or medium-voltage power circuit breakers.

Typical applications include standby power systems for large businesses, resort complexes, data centers, government centers or facilities participating in interruptible or load-shedding programs in conjunction with their utilities.

The advantage of this system is that voltage and frequency disruptions during the transfer process are kept to an absolute minimum. The process results in power transfer between sources that is imperceptible to nearly any load. Also, since the on-site power system is actively synchronized to the utility service, other weaknesses of other closed-transition systems, such as failure to synchronize and the potential for alternator damage, are also minimized.

Design challenges include incorporating code-compliant emergency power systems and providing effective ground fault detection and protection equipment. These challenges can be managed, but require consideration early in the system design to allow effective integration into a system.

Disadvantages are cost related, due to the additional equipment required in the system. These disadvantages include:

- Since interconnection time with the utility is usually longer than with some other systems, utility-required protective relaying equipment may be more extensive than with other systems, and the approval process will generally take longer.
- Active synchronizing functions and import/export controls for kW and kVAR are required in the system, which can add cost. These systems are considerably less expensive than they have been in the past due to advances in microprocessor-based controls for generator sets and integration of functions into simpler control systems.

Bypass/isolation transfer switches

Most of the transfer systems described in this paper can be provided with bypass/isolation capability. (See Figure 4)

A bypass/isolation provision allows the power-carrying mechanisms in a transfer switch to be bypassed and isolated without interrupting power to the facility. This allows the automatic transfer switch to be conveniently repaired or maintained.

As may be expected, these provisions are often specified in systems where the equipment is critical to operation of the facility or protecting life, and when the equipment loads are in active service 24 hours a day. The most common applications for bypass switches are serving UPS equipment in data centers and healthcare facilities.

While the bypass/isolation capability provides a valuable function, it does add significant cost to the transfer system, particularly in the larger sizes of the device (more than 1,000 amps). Transfer switches with bypass/isolation capability typically take up considerably more space in a facility, and often require both front and rear access for installation and maintenance. (See Figure 5)

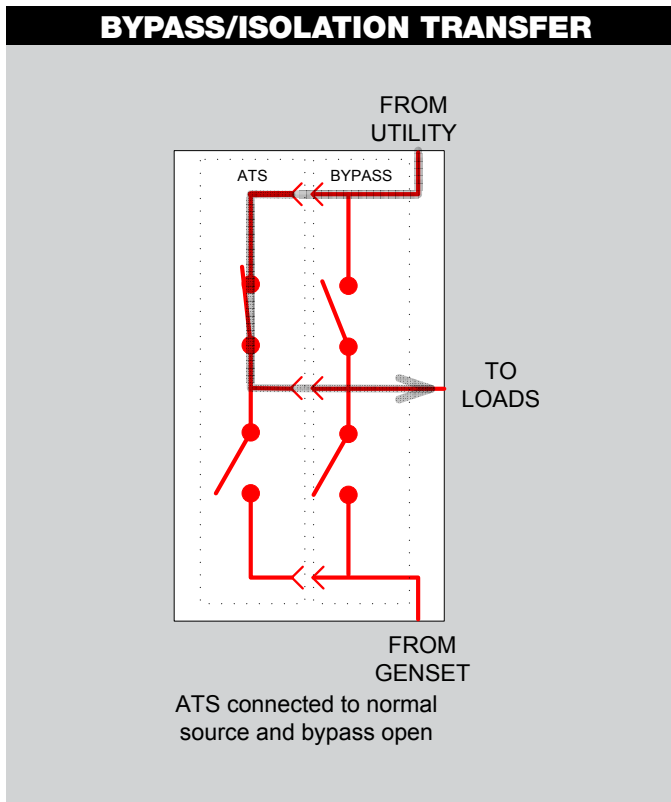


Figure 4



Figure 5 - Bypass/isolation transfer switch

About the author



Gary Olson has been an employee of Cummins Power Generation since 1977. He holds a B.S. in Mechanical Engineering from Iowa State University and an MBA from the University of St. Thomas. His current responsibilities

include research relating to on-site power applications, technical product support for on-site power system equipment, and contributing to organizations working on codes and standards. He also manages an engineering group dedicated to developing the next generation of power systems.

Conclusions and recommendations

The most desirable choice of equipment for a specific application will depend on two major factors: 1) equipment costs; and 2) the magnitude and duration of the voltage and frequency deviation the facility can tolerate. As a general trend, facilities of all sizes are identifying more and more critical loads that must have continuous power, and more facilities than ever are installing generator backup systems that will carry the entire facility. This trend leads to more closed-transition transfer systems, because the incremental cost of the closed-transition functions is a relatively small increase to the overall system cost.

Before choosing a system for a particular facility, work with a consulting engineer and power system supplier to consider all possible power transfer options to meet system performance and cost optimization requirements. When contemplating closed-transition systems, consultation with the utility will be required to meet the utility's interconnection regulations.

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