

Transfer switch set up for reliability and efficiency, part 1

Transfer switch operation sequences

> White paper

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Many facilities that have generator sets (gensets) also have automatic transfer switch equipment (ATS) to automatically start the generator set on a power failure and automatically switch the load from the utility to the generator set and back again. To obtain the most reliable and efficient system operation, it's important to have the ATS properly set up so that it can sense power failure and operate in the best sequence for the system that is installed and the equipment it supports. PT-7016 part 1 explains how transfer switches operate and the time sequence of power failure and return. PT-7016 part 2 covers characteristics of utility power failures and the sensing of power failure sequences. PT-7016 part 3 looks at ATS setting best practices and features available on the equipment.

A typical standby power system includes a generator set operating on diesel fuel or natural gas, and one or more automatic transfer switches. The system will also have a number of accessory components such as battery charging equipment, fuel pumps, ventilation fans, and other equipment. The transfer switch directs power to critical loads from either a utility service or your generator set. If it's an automatic switching device, it needs to:

- Monitor power availability on each source
- Send a start command to the genset when it needs to run

- Provide timer functions for power failure sequence, power return sequence, and exercise sequence
- Physically switch load from one power source to another

If the transfer switch is improperly set up, the system may fail to detect and respond to a power failure, or it may start the generator set and transfer unnecessarily. In order to set it up correctly, you first need to understand what a transfer switch is, and how it operates to provide power transfer functions. From there, you will need to have a clear understanding of what loads are served with genset power in your facility and what their requirements are, and how the utility power distribution to your facility is configured. With that understanding in, decisions on proper settings can be made.

Transfer switch operation

There are a wide variety of transfer switches available through many different manufacturers. Variations that are available include manual operation, automatic open

TRANSFER SWITCH SYMBOLIC ILLUSTRATION

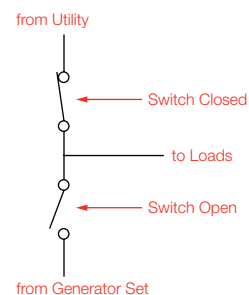


FIGURE 1

transition and closed transition operation sequences (some with mechanical bypass capability), closed transition load ramping devices, and solid-state types. The most common type of ATS, and the one we will look at in detail is an automatic electro-mechanical device that operates in an open transition sequence. “Open transition” means that the switch disconnects load from one source before it connects to another source. So, whenever the transfer switch operates from source to source there is a short (fraction of a second) power failure. The timing functions and setting practice discussed in this document will be applicable for most types of transfer switches.

Sequence of operation on a power failure

A typical ATS sequence of operation on a power failure can be described by the illustration in FIGURE 2. We see the position of the transfer switch power carrying mechanism across the bottom of the illustration. The wide red line indicate an energized source (first picture on left indicates utility power is available and load is connected to utility), and the black dots indicate a not energized source. Again, you can see in the first illustrations in the power transfer process and the equipment operation functions throughout the process. Note that the scale of the control sequence in time is in seconds. Local codes and standards require

that emergency loads (loads required to be served to maintain facility safety) be served with power within 10 seconds after a power failure, so we have shown a typical emergency sequence. Standby loads (loads not required for safety) can take longer to be energized without violation of code.

At time “0” the power suddenly fails. The ATS senses the failure, and starts a short time delay called “time delay start”. The duration of this time delay is typically short (about 1 second), but can vary between 0 and approximately 15 seconds, depending on ATS manufacturer. Time delay start is usually adjustable in the ATS control. The intent of the time delay on start is to make sure that the power really has failed before starting the generator set. Short voltage deviations that might cause the ATS to sense a power failure are relatively common, and we don’t want to start the genset if power is returning in a matter of a few seconds. However, if the ATS is serving emergency loads, we need to set the time delay on start short enough so that the generator set has time to start and pick up loads in 10 seconds. In most transfer switches a return of power to the switch will cause the switch to reset its timers, so multiple short duration failures will cause the sequence we show here to start at the time that the power fails long enough to exceed the time delay start.

When the time delay on start is completed, the ATS sends a signal to the genset to start. The generator

STARTING AND POWER TRANSFER SEQUENCE FOR GENERATOR SET AND TRANSFER SWITCH

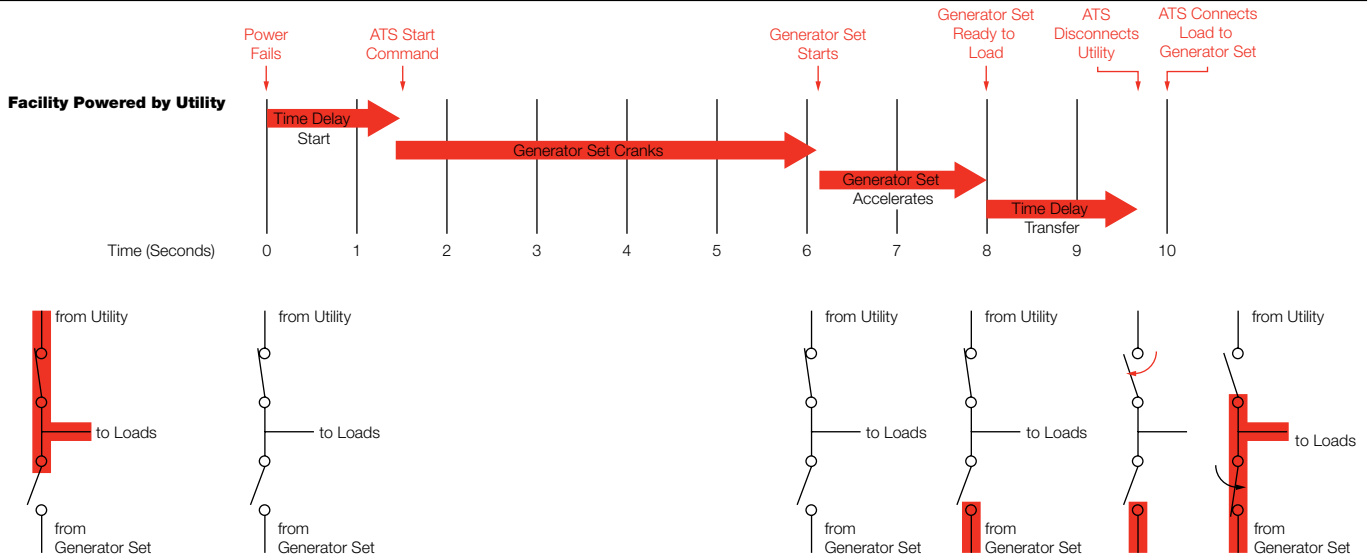


FIGURE 2

1. Sets indicates that there are actually two or more sets of switch contacts in every transfer switch, with the actual number dependant whether your facility uses single or three phase power, and whether or not the neutral is switched. Only one set of contacts for each source is shown for simplicity—but in general all the switches for each source operate at the same time.

set begins to crank, and when the engine starts, it accelerates to rated frequency² and voltage builds up on the generator set output. Note that by the time the generator set reaches rated speed and voltage, the transfer switch senses that the generator set is ready to accept the load. There is another time delay, which is called “time delay to transfer” which is provided to allow a short period of time for the generator set to stabilize before load is applied. If the normal power returns before the transfer switch goes to the next step, the genset will generally run for a short time to cool off, and then shut down. The transfer switch will not proceed to connect power to the genset when normal power is available.

Upon completion of the time delay on transfer, the transfer switch normal source contacts open. A very short period of time later (this time period is adjustable on some ATS equipment), the emergency source contacts close, connecting generator set power to system loads.

Note that the time required for the generator set to start and accelerate to rated speed and voltage varies considerably from unit to unit, especially with ambient temperature. Consequently, if you have emergency loads (life safety) that must be served by a generator set, you may need to shorten the time delay on start or time delay on transfer in order to meet the 10-second start requirement.

Sequence of operation for normal power return

The sequence of operation of a typical transfer switch on return of normal power to the ATS is shown in FIGURE 3. At time “0”, the ATS senses that normal power has returned and starts a “time delay retransfer” sequence. This time period is in the control sequence to be sure that normal power is back and reliable before switching back to the utility. As with the time delay on transfer, if the power fails while in the time delay retransfer period, the ATS will restart the timing cycle. So, the time delay on retransfer represents the minimum time that the generator set will be connected to system loads if power transfers to it, but any disruption in power during the retransfer sequence will restart the process.

At the completion of the time delay retransfer process, the ATS will open the generator side switch contacts, and a short time later will close the utility side switch contacts. Operation of this part of the sequence too quickly can cause tripping of circuit breakers and damage to inductive loads, but the time period is short enough (usually less than ½ second) that it is not disruptive to many loads. For loads that are sensitive to short time interruptions, some suppliers provide controls that allow the user to delay retransfer until the load can be switched off, transfer, then turn the load back on.

SEQUENCE OF OPERATION ON RETURN OF NORMAL POWER

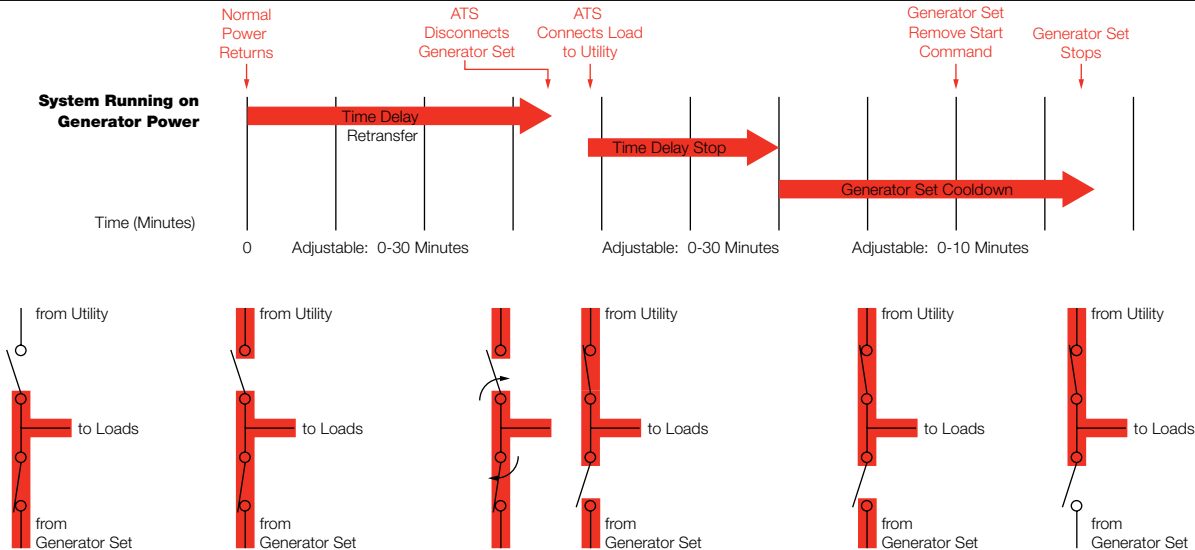


FIGURE 3

2. The generator set may have a time delay on start also, but we have ignored that here, since you only need one “time delay on start” sequence. If you have both in your system, you can set one of them to “0”.

About the author



Gary Olson graduated from Iowa State University with a BS in Mechanical Engineering in 1977, and graduated from the College of St. Thomas with an MBA in 1982.

He has been employed by Cummins Power Generation for more than 25 years in various engineering and management roles. His current responsibilities include research relating to on-site power applications, technical product support for on-site power system equipment, and contributing to codes and standards groups. He also manages an engineering group dedicated to development of next generation power system designs.

Once the loads are connected to the utility, the generator set will go through a time delay stop, or cooldown period. This allows the engine and alternator to cool off prior to shutdown to optimize their life. If the power fails during a cooldown period, the transfer switch will typically switch to generator set power utilizing only the time delays incumbent in the switching action (time delay start is not used, but the others are still in place). A typical generator set cool down time is approximately 10 minutes, but can vary by engine type and manufacturer.

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