Transfer switch set up for reliability and efficiency, part 3: ATS settings for best operation

> **White paper**
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Power Generation

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.

ATS settings for best operation

First, recognize that it is normal for the voltage of the power service to your home or facility varies somewhat over time and is different in different locations. So, if you set up a transfer switch to start the generator set at 90% of normal voltage level, it might start a lot of times! Also, the typical voltage level at your home or facility varies over time depending on a number of other conditions. It's possible that it might normally be a little higher or a little lower than the nominal 120 volt level that is intended. That won't cause any problems, but it should be considered in the decision of how to set up your transfer switch.

Determine if the transfer switch serves emergency loads. If it does, you need to get a problem sensed quickly, and the ATS must connect to the genset in 10 seconds or less. A key factor in the settings is how long it takes to get the generator set started and up to proper speed and voltage. This varies somewhat with the size of generator set and the type of fuel that it uses, as well as other factors, such as the ambient temperature. You need to set up the transfer switch so that emergency loads are served with power from the generator set within 10 seconds after the utility service fails.

So, for emergency systems, the sum of the time delay on start, the time delay on transfer, and the time to start the generator set cannot exceed 10 seconds.

For non-emergency systems, you should make a judgment as to how long you can tolerate a power failure. The longer you can get by without power, the less often the generator set will need to be started. For non-emergency applications you should try to completely eliminate the "nuisance" starts that are caused by momentary power failures or fluctuations. Your utility service provider can often provide you information on the number, duration, and magnitude of voltage variations in the service that feeds your site.

As you contemplate which type of ATS settings to utilize, also consider the type of loads in your facility, and how they respond to various power quality problems:

- Different equipment loads are more tolerant of power failure than others. For example, loads such as incandescent lighting are highly tolerant of low voltage conditions and lost phase conditions. On the other hand, if a motor is exposed to low voltage conditions or a lost phase, it can be overloaded and its life will be shortened, or it may even fail.

- Codes and standards impact on the maximum acceptable duration of outage for emergency loads. The National Electrical Code (NFPA 70) requires that an alternate on site power source serve emergency loads within 10 seconds.
- Critical loads may be protected with UPS equipment. Equipment that can be damaged by power failures, or loads and processes that can't tolerate even short duration failures should be protected by UPS (uninterruptible power systems). These systems use stored energy from batteries, rotating flywheels, and other devices to feed loads for short duration power outages. Keep in mind that use of UPS at a site may drive the need for special features in the ATS equipment serving the UPS.

You may also want to review the characteristics of the utility equipment that feeds your site with your utility representative. If the distribution serving your site is protected using reclosers, you may want to check the operating sequence of the reclosers and coordinate that with the time delays on starting your generator set.

If a site is protected by fuses in the distribution system that can fail individual phases and your site incorporates a large number of motors, it would be a good idea to pay attention to the ability of your transfer equipment to sense single phase failures. These loads may also need programmed transition capability in the ATS.

Monitor not only successful starts, but also the timing in the starting sequence for your system on next test date. For each type of application you will want to consider both time delay settings and voltage sensing settings. Also, have a look at the voltage of your generator set as it starts. Monitor how long it takes for the voltage and frequency to get to and stay in the 90-105% of nominal range. (Generator set voltage may briefly go a little high as the unit is starting, and then stabilize at the proper level.)

Emergency settings: Set the drop out voltage (the point that is considered to be the lowest acceptable voltage level), and the recovery voltage (typically 5% higher than drop out). To minimize generator set running, set the drop out voltage to the lowest acceptable level and the time delay on starting to the longest acceptable level. For most generator sets, the time delay on transfer can be set to one or two seconds.

Set the time delay on starting to maximum level that allows the genset to start and the transfer switch to connect emergency loads in 10 seconds. Time delay on retransfer and time delay stop can be set as they would in any application. If both emergency and standby loads are connected to the generator set, the time delay on transfer for the standby loads should be set for a longer period than the emergency loads. If there are multiple standby load ATS's, you can sequence their starting by adjusting the time delay transfer to different levels for each ATS.

A typical setting for program transition is 0.5 seconds, for motor loads up to 200 hp.

Standby settings: Set the time delay on starting so that the generator set will start in the time frame that you require for your facility. Typically, this might be 20–30 seconds. The time delay on transfer should be longer so that the generator set is a little warmer when the first loads are picked up. A typical time delay might be 5 seconds. The time delays on retransfer and shutdown would be the same as for an emergency genset.

Set the voltage sensors to signal generator set starting at the lowest acceptable level. This level depends on the type of loads in the system. If all the loads are resistive, such as would be the case with incandescent lighting, the starting signal might be based on a relatively low voltage, such as dropping to less than 70 percent of nominal conditions. On the other hand, if the loads include a large number of motors, it is probably important to not expose the motors to sustained voltages of less than 85 percent of nominal for any significant time period.

Generator set exercise settings: Many transfer switches include an exerciser clock that is used to signal a a generator set to start and run on a timed basis. Generator set exercise periods are necessary to maintain the generator set reliability. The generator set manufacturer will recommend the exercise duration and cycle time. A typical diesel generator set is exercised once per month for 30 minutes under load. Note that exercise under load will cause a brief (0.5 second) power failure to the load when switching from source to source. Exercising the generator set under load also exercises the ATS, which is desirable.

Common ATS equipment features

Transfer switches for emergency systems are provided with voltage sensing on all phases of the normal source. You can use single phase sensing of the normal source for transfer switches serving other loads to reduce the cost of the transfer switch. Loads that are required to be served by emergency power include egress lighting, fire pumps in some buildings, smoke ventilation fans, etc. Keep in mind that many loads are

National Electrical Manufacturers Association

NEMA is the leading trade association in the U.S. representing the interests of electroindustry manufacturers of products used in the generation, transmission and distribution, control, and end-use of electricity.

Please Note:

Generator sets should NEVER be connected to the utility service, even for very short periods of time, without proper equipment and the knowledge and approval of the utility service provider.

not categorized as emergency loads, but still should be served by transfer switches with 3-phase sensing. These include loads with 3-phase motors, and some rectifier based loads.

Voltage sensing on the generator set source is often only single phase. This is because it is very unlikely for a generator set to lose only one phase when it fails. Often the generator set source also has frequency sensing. The frequency sensing system on an ATS uses information from the voltage sensors to determine when the engine of the generator set is running at the correct speed. Some loads are sensitive to operating at incorrect speed, so this feature helps to be sure that the loads in your system operate on the generator set just as well as they do on utility power.

Usually indicator lamps are provided on the exterior of the transfer switch to indicate which sources are available and which source is connected to the ATS load.

ATS equipment often includes a test switch that can be used to initiate a test of the generator set. In a test of the generator set the transfer switch starts the generator set and switches its loads to the generator set. This will cause a short disruption in power to the loads served by the transfer switch. In spite of this inconvenience, it is best to test the generator set with the loads that it serves, so that everyone will know which loads are served, and that the generator set has no problem operating them.

Transfer switches have a feature called a mechanical interlock. The mechanical interlock prevents accidental connection of the generator set output to the utility service. When this is done without proper equipment and protective devices it can cause damage to the generator set, danger to operators and to utility personnel, and potentially facility damage. Generator sets should NEVER be connected to the utility service, even for very short periods of time, without proper equipment and the knowledge and approval of the utility service provider.

Transfer switches are usually mounted in a separate cabinet from other distribution equipment in your facility. The cabinets used for indoor mounting have a UL “NEMA 1” label that indicates that the cabinet is intended for use indoors. Transfer switches that are installed outdoors should have a UL NEMA 3R or NEMA 4R label on them. Use of an ATS designed for indoor mounting out of doors can cause facility damage or equipment failure.

Optional features in ATS equipment that may help you

Manual retransfer: Rather than retransferring to the normal service after a preset time delay, most transfer switches can be set up to stay connected to the generator set until an operator signals that retransfer can be done. These facilities include loads that are sensitive to the switching outage that occurs when the

Power Generation

transfer switch operates. By waiting until a convenient time to perform the retransfer to normal power, the loads are not disrupted at a time when users will notice the problem.

Pre-transfer signals for sensitive loads: Some loads, such as elevators and some types of cash register systems, are disrupted when there is a sudden loss of power and a short time later, a sudden return of power. For example, if you have ever been in an elevator when the power fails, you know that the elevator immediately stops, and the stopping point may well be between floors. If the elevator control system is confused by the sudden failure in power or return of power, a signal to tell the elevator controller that the ATS is about to operate can allow the elevator to move to the next available control, open the doors and wait. Then while the power is failed no one is trapped in the elevator. The power can then turn off without incident. The pre-transfer signal is also used if the transfer switch operates too quickly from live source to live source. Again, the signal allows the load to turn off, the switch to operate, and then the load can turn on again without causing disruption in the facility distribution system or damage to the loads.

Switched neutral (4-Pole) transfer switches: Transfer switches that serve three-phase/four-wire loads can be either 3-pole or 4-pole (switched neutral) type transfer switches. The physical differences between 3-pole and 4-pole transfer switches are shown in the illustration below. In a 4-pole transfer switch, all the phase poles plus the neutral are provided with power transfer contacts. In a 3-pole transfer switch, the neutral does not utilize power transfer contacts, but rather is provided with a solid bus-bar connection

4-POLE TRANSFER SWITCH INCORPORATES A SWITCHED NEUTRAL, WHILE A 3-POLE ATS HAS A SOLID NEUTRAL.

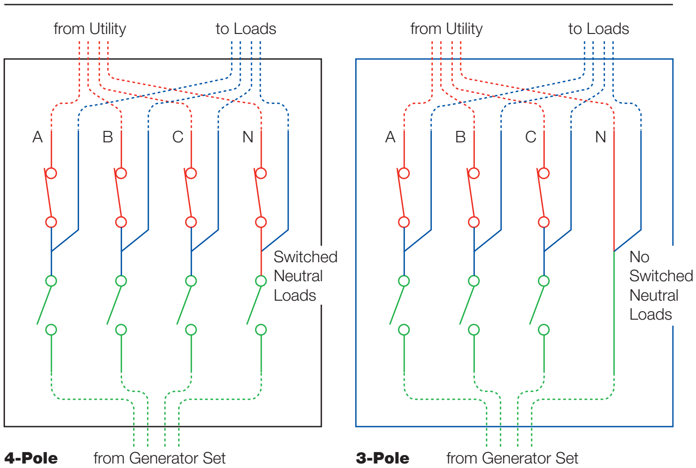

FIGURE 1.

point. 4-pole transfer switches are used in 277/480VAC applications where the facility power distribution system incorporates ground fault protection. Note that ground fault protection (GFI) is not the same as GFCI (ground fault circuit interrupter) equipment. GFI is required in some applications to protect distribution equipment and loads, while GFCI is used in low voltage circuits to protect people from electric shock.

Frequency sensing: Frequency sensing is normally provided on the generator source for the purpose of monitoring of an ATS so that the user can be sure that the generator set is operating at the proper speed prior to connecting loads. Most modern generator sets automatically adjust voltage as a function of speed, making it unlikely that the generator set will operate at improper voltage and improper speed, but some codes still require this feature.

Frequency sensing is also available as an optional feature for utility source. This feature is primarily designed for applications where there is a weak utility grid. (A weak utility grid is one in which the grid is relatively low in capacity relative to the largest loads in the system. In a weak grid environment frequency variations will occur which are not present in stiff grid systems, such as a common in North America.) Frequency sensing on the utility source can be used to detect potentially disruptive frequency swings on a weak grid, or as another factor in qualifying source acceptability.

Programmed transition: Transfer switches that serve large motor loads (greater than 20HP), UPS, and other inductive loads are often provided with programmed transition capability. When inductive loads are disconnected from a power source, they produce output voltage for a short period of time. If the ATS switches too quickly from source to source, the load-generated voltage is paralleled to the oncoming source voltage. Interconnecting voltages from multiple sources that are not synchronized will cause damage to loads, and nuisance tripping of circuit breakers. To prevent this problem, the transfer switch operating speed from source to source is intentionally slowed down, so that the load-generated voltages decay to a safe level before they are connected to the new source.

Phase angle sensing between sources (In-phase monitor, phase check): Transfer switches that don't have the ability to control operating speed can be provided with phase angle sensing to allow the sources to drift into synchronization before the ATS switches between live sources. This can mitigate the effects of fast switching of inductive loads, but is not 100% effective.

Automated exercising (tests ATS and exercises genset): Most transfer switches incorporate timers to automatically initiate testing and exercising of a generator set. Generator sets are typically exercised (run under load) once per month for about 30 minutes. When the ATS load is used for exercising the genset, the exercise provides the dual purpose of testing the operation of the transfer switch, so this is recommended practice.

Closed transition transfer: As previously noted, most transfer switches are open transition, but some utilize a closed transition sequence of operation between live sources, which means that when transfer of power occurs between live sources, it occurs via a very brief (100 mS) paralleling of the genset with the utility. When closed transition is used, loads don't see a "switching" outage when returning to normal power after an outage or when exercising the genset. There may be a disturbance on transfer, however, and it may be sufficient to disrupt some loads.

Bypass switches: Transfer switches are always energized and serving the most critical loads in a facility, so if the ATS needs work, it may involve switching off power to these critical loads. Where that's not practical, transfer switches can be provided with bypass capability. The bypass is a manually operated transfer switch that is connected in parallel to the automatic transfer switch. The ATS is mounted on a drawout carriage so that it can be safely removed without de-energizing the loads. So, when the ATS needs work, the manual bypass is engaged, the ATS is drawn out, the repair is accomplished, the ATS racked in, and the manual bypass is disengaged. All this occurs without any type of disruption to the loads. The problem: an ATS with bypass costs 2-3 times more than a simple ATS, and takes up more space.

FIGURE 2: Bypass/Isolation transfer switch.

Maintenance

Transfer switches are near zero maintenance devices, in that they need no maintenance other than to be kept clean and dry. They require only an annual service to do that cleaning and to be sure that the cables to the loads are kept tightly attached to the ATS. Some customers use a thermography program to monitor the transfer switch for over temperature conditions that might indicate loose cables or power contact decay. Contact your transfer switch manufacturer for more information on thermography.

Common questions and problems

1. **What is a transfer switch?** A transfer switch is a device that is used to connect one of two sources of power to a common load. An automatic transfer switch automatically starts your generator set on a power failure, and connects loads to the generator set.
2. **How does the transfer switch work?** A transfer switch senses the level of voltage serving critical loads in a facility, and if the voltage level is not correct, it will start a generator set and connect those critical loads to the generator set until the voltage level of the normal source is acceptable. At that time the loads are automatically reconnected to the utility service.
3. **What are the various settings?** Most of the settings in a transfer switch are related to either the setting of the voltage level that the transfer switch uses to decide when to start the generator set, or the settings of time delays for various functions.
4. **How do I determine what are the correct settings for my situation?** The settings for voltage level depend on the type of loads you have in your facility. The time delays are set mostly based on how long you can go without normal power.
5. **How often should the switch be exercised?** The best thing to do is to use the transfer switch to exercise the generator set, so once per month the switch is operated. When you have more than one transfer switch on a generator set, or have loads that you don't want to interrupt for generator exercising, you can get by with one exercise per year on the transfer switch. If you do that, you should regularly monitor the switch using a thermography program to verify that it is operating properly.

About the author

Gary Olson graduated from Iowa State University with a Bachelor of Science Degree in Mechanical Engineering in 1977, and graduated from the College of St. Thomas with a Master of Business Administration degree 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.

6. **What maintenance is required for the switch and how often?** Transfer switches generally don't need much maintenance. They should be disconnected from all power sources once per year; cleaned, inspected, and tested. This work should be done by a qualified technician.

7. **How does the switch sense a power failure/abnormality? Are there different types of sensors? If so, which is best?** Transfer switches usually sense the acceptability of the utility power source by monitoring the voltage of the utility service. It is normal for utility voltage to vary between 90 and 105% of nominal voltage levels, so if it moves beyond that range for very long it might be time to switch on your generator.

   There are different technologies for sensing voltage, but the differences between them are difficult to briefly explain. Your best practice is to use equipment from experienced transfer switch manufacturers and their suppliers who can work with you to pick the right product for your application.

8. **When should the neutral be switched?** You should work with a qualified professional engineer to decide what is the best for you facility based on current and future loads and the type of equipment in your facility. Usually you will find that if you have a 480 volt, 3-phase, 4-wire service that is larger than 1000 amps or if you have this type of service and your distribution system incorporates ground fault protection, you will need a switched neutral.

For additional technical support, please contact your local Cummins Power Generation distributor. To locate your distributor, visit www.cumminspower.com.

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