White Paper

Transition Modes for Automatic Transfer Switches - Part 1

ASCO Power Technologies®

Transition Modes for Automatic Transfer Switches – Part 1

When selecting an Automatic Transfer Switch (ATS), it is necessary to specify the load transition mode that will best meet the needs of the application. The load transition mode indicates the sequence and timing of operations that transfer load between power sources. Some common load transition modes were summarized in our prior paper entitled ATS Selection Basics. The following narrative provides additional detail about each load transition mode.

Load transition modes can be categorized according to whether they transfer between sources with or without interrupting power to the load. *Open Transition* and *Delayed Transition* switching produce short-duration power interruptions each time load is transferred from one source to another. These modes are described in the following narrative. Two other modes complete transfers without power interruption, and are known as *Closed Transition* and *Soft-Load*. Part 2 of this paper will provide additional information about those load transition modes.

OPEN TRANSITION

The simplest mode for transferring load between two power sources is *Open Transition*. The associated sequence of operation for the switching contacts is often described as "break-before-make", which results in a momentary interruption of power. In ASCO ATSs, the sequence is completed in about 30 to 50 milliseconds (mS), depending on the size of the ATS. The sequence is shown in Figure 1 below.

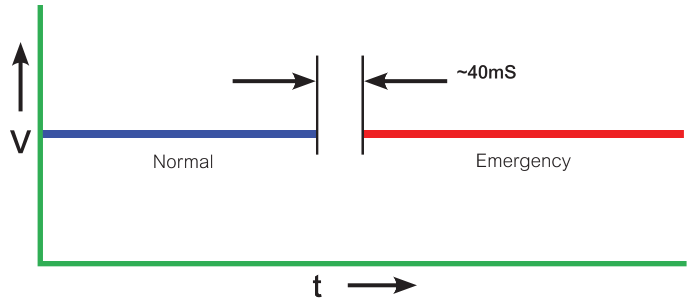

Figure 1: Open Transition Sequence

To operate the contacts, the simplest switching mechanisms use a solenoid-driven mechanical device linked to a flywheel, which is mounted on a shaft connected to the switching contacts. Energizing the solenoid pulls the linkage upwards, rotating the flywheel, shaft, and contacts so that the wheel's linkage attachment point approaches top dead center. The solenoid is de-energized as the inertia of the flywheel causes it to rotate towards the second source. The centrifugal motion of the flywheel drives the assembly into the alternate position and the contacts are mechanically locked in place. This arrangement provides contacts that are electrically operated and mechanically held, as required by the Article 700.5 of the National Electrical Code®. A schematic of a transfer mechanism and its sequence of operation are shown in Figure 2.

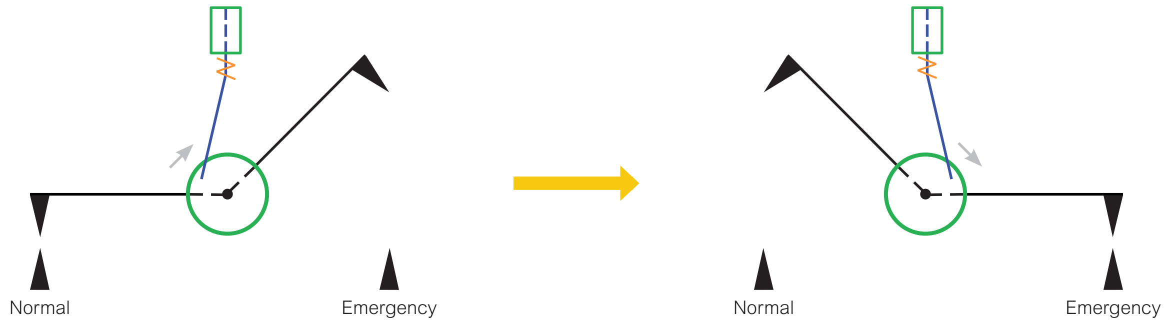

Figure 2: Load transfer from the Normal to the Emergency Contacts

Most ASCO open transfer switches use a dual-shaft mechanism. This allows ASCO to standardize production of switching mechanisms, and facilitates upgrade of units already in service. The dual-shaft arrangement with a mechanical interlocking bar and its operation are shown in Figure 3.

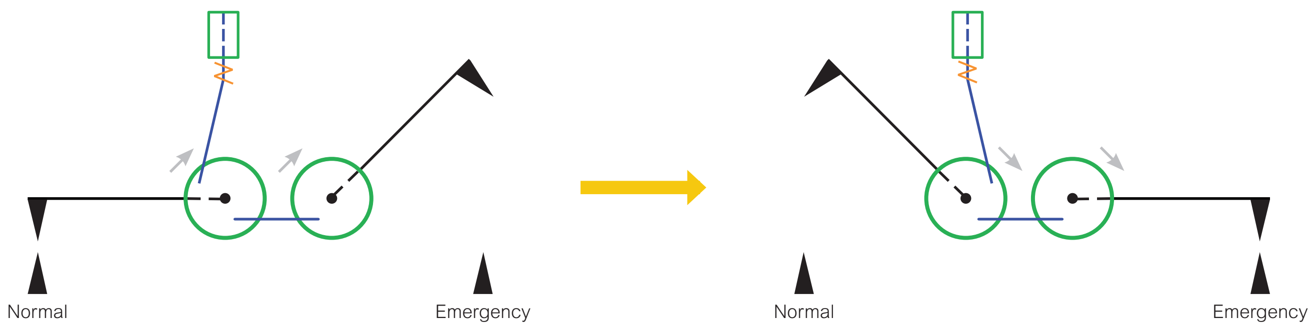

Figure 3: Load transfer from the Normal to the Emergency Contacts using a dual-shaft transfer mechanism

Open transition switches are used in a wide range of industries. They offer straightforward operation and long service life for load applications that can tolerate momentary power interruption whenever loads are transferred between sources. However, this characteristic can be problematic where high inrush load currents occur on contact closure following an interruption, and/or where load equipment and/or users cannot tolerate even the slightest power interruption.

Managing Motor Loads

The occurrence of high inrush currents depends on the types of loads that are served by a transfer switch. Active loads such as motors store energy on their rotating mass. When power is disconnected, these devices become self-excited generators that can deliver a substantial amount of energy until they slow and stop. In addition, as the motor slows, the phase angle changes and the motor begins to go in and out of synchronism with the alternate power source. If the transfer switch were to close on a power source when the motor is nearly in-phase, the motor inrush current would not be appreciably different than the normal inrush current that occurs when the motor starts, which is typically up to 6 to 8 times the running current. However, if the connection is made when the motor is 180 degrees out of phase with the power source, the inrush current could be 12 to 18 times the running current, subjecting the motor and the motor coupling to tremendous forces and potential damage.

Two approaches exist for managing high inrush currents. One is to delay connection of a load to an alternate source to allow the generated voltage from the motor to decay. This approach can be a simple and acceptable means of avoiding high inrush currents, provided that interruption in operation can be tolerated by the user. Methods for controlling delay include providing a control contact from the ATS to disconnect a specific load for a specific amount of time prior to transfer. Another method is to ensure that transfers occur when the power source and the motor are in-phase or nearly so.

In-Phase Monitoring

A disadvantage of waiting for load-side voltage to decay is the associated disruption of power to the load. As previously stated, when equipment and/or users can tolerate disruption, switching delays may be an acceptable approach. Nevertheless, the intended function of a transfer switch is to transfer load to provide reliable power. In-phase monitoring can help facilities effect transfers without power disruption and uses a single solenoid type ATS shown in Figures 2 and 3.

In order to ensure that transfers occur when phase angle differences are within acceptable limits, a phase angle monitor can be used with ATS controllers. This feature measures the real-time phase angle difference between the both power sources, and then signals the ATS controller to transfer when the two sources approach synchronism. Major ATS manufacturers offer this capability. In-phase monitoring is a selectable feature in ASCO's standard ATS controllers.

Closing on circuits with spinning motors can result in large inrush currents. In-phase monitoring and delayed transfer reduce or avoid inrush currents and their resulting effects.

Delaying Transfer

The second approach to switching active loads is to allow residual load-side voltage to decay before closing on the alternate source. One method for allowing voltage to decay prior to load transfer is to disconnect a specific device, such as a motor starter or variable frequency drive, using an accessory on the ATS. Whenever an ATS transfers load between two live sources, it signals the accessory, which disconnects power to specific equipment. The transfer occurs thereafter, and the equipment is reconnected after a user-specified delay. This approach is particularly suited for applications where an ATS serves multiple load types that include inductive and resistive loads. Major ATS manufacturers offer transfer switch accessories for this purpose. In ASCO's product line, Accessory 31Z provides this capability for introducing delay to specific equipment.

DELAYED TRANSITION

Another method for delaying transfer is to use an ATS with a center-off position for the switching contacts. Using this approach, the ATS disconnects all loads from both power sources for a brief amount of time, set by the user, to allow the decay of voltage from inductive loads. Thereafter, the switch closes on the alternate source to re-power the equipment. This sequence is shown in Figure 4.

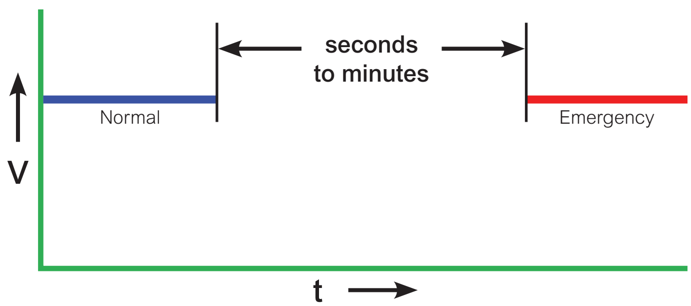

Figure 4: Delayed Transition Sequence

For delayed transition, contact operation is similar to the two-mechanism sequence in Figure 3; however, the rotating shafts are electrically operated by separate solenoids. The contacts operate sequentially in three steps, as shown in Figure 5.

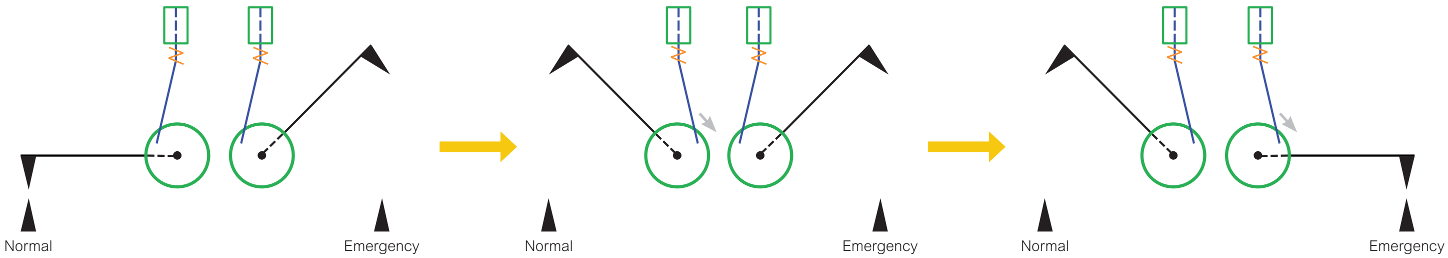

Figure 5: Load transfer using a Delayed Transition mechanism

Delayed transition switches are typically used where loads are primarily motors. They are also used in systems serving inductive loads that store energy. In some facilities, this could include transformers located downstream of an ATS. In a medical facility, inductive loads include magnetic resonance imaging equipment. Delayed transition transfer allows the energy to decay to tolerable levels before connection to an alternate source.

In some applications, power interruption must be avoided for operational or safety reasons. Power loss may be unacceptable for certain loads such as elevators. In order to avoid stranding passengers, it is necessary to provide a means for elevators to reach a building floor to allow passenger egress. ATS accessories can interact with an ATS controller to signal elevator controls that transfer is about to occur. The elevator controls then send the elevator to the nearest floor of the building and open its door before power is interrupted. Signaling for this application can be provided by major manufacturers, and ASCO's Accessory 31Z provides the necessary communications.

SUMMARY

Open Transition switching is the simplest transition mode, and provides reliable load transfer switching for a wide range of applications. However, the associated momentary disconnection and reconnection of power can cause large inrush currents if active or inductive loads are present downstream of the ATS. These can be managed by introducing equipment-specific delays using transfer switch accessories, or by using a ***Delayed Transition*** ATS to delay reconnection of active or inductive equipment.

For applications where even momentary power interruption cannot be tolerated, a transfer mode that provided uninterrupted power must be selected. ***Closed Transition*** and ***Soft-Load*** switches transfer loads between power sources without power interruption. These transition modes will be addressed in Part 2 of this paper.

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