ASCO Power Technologies™

Transferring Motor Loads Between Power Sources

White Paper 119

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Transferring Motor Loads Between Power Sources

The most common applications for transfer switches include power distribution circuits that serve a mix of load types, including resistive loads for building lighting and heating as well as inductive loads such as motor-driven equipment. However, some transfer switches may supply a circuit that includes one or more large motors or may feed multiple circuits that serve primarily motor loads. Examples include air handlers in large commercial buildings, air conditioning compressors for data center cooling, or the many water pumps required to operate a wastewater treatment facility.

Where backup power systems supply circuits that primarily serve motor loads, consideration must be given to in-rush currents that result when motors are out-of-phase with the alternate power source. This document summarizes approaches for avoiding excessive in-rush currents that could trip breakers, damage motors and load equipment, and overload generators when transferring motor loads.

AVOIDING DAMAGE TO MOTORS

When an outage occurs on a primary power source, voltage on that source is decaying or absent. However, when loads are returned to the Normal source and when backup power systems are subject to routine testing, they are transferred between two sources that are both at full voltage. If completed without appropriate controls, transfer where motors and the alternate source are significantly out-of-phase can result in abnormal in-rush currents that can trip overcurrent protection devices and damage motor windings, insulation, couplings, and perhaps load equipment. Four provisions for mitigating these effects include:

- In-phase transfer
- Motor load disconnect circuits
- Delayed transition transfer switching
- Closed transition transfer switching

In-Phase Transfer

When switching between sources, automatic transfer switches (ATSs) monitor the voltage and frequency of the sources, then close on the alternate source only when these parameters are within acceptable limits. When motor loads are involved, in-phase monitoring can also be used to reduce in-rush currents, as follows.

Figure 1 shows sine waves representing phase voltages for two different power sources. Because their frequencies differ, they pass in and out of unity. If load is transferred when the voltages are dissimilar, current immediately flows from highest to lowest potential until the resulting forces cause the rotating generator and motor to synchronize. If this occurs when the phase angles vary widely, such as at t_1 in Figure 1, then the in-rush currents will be larger than if they occur near unity, such as at t_2.

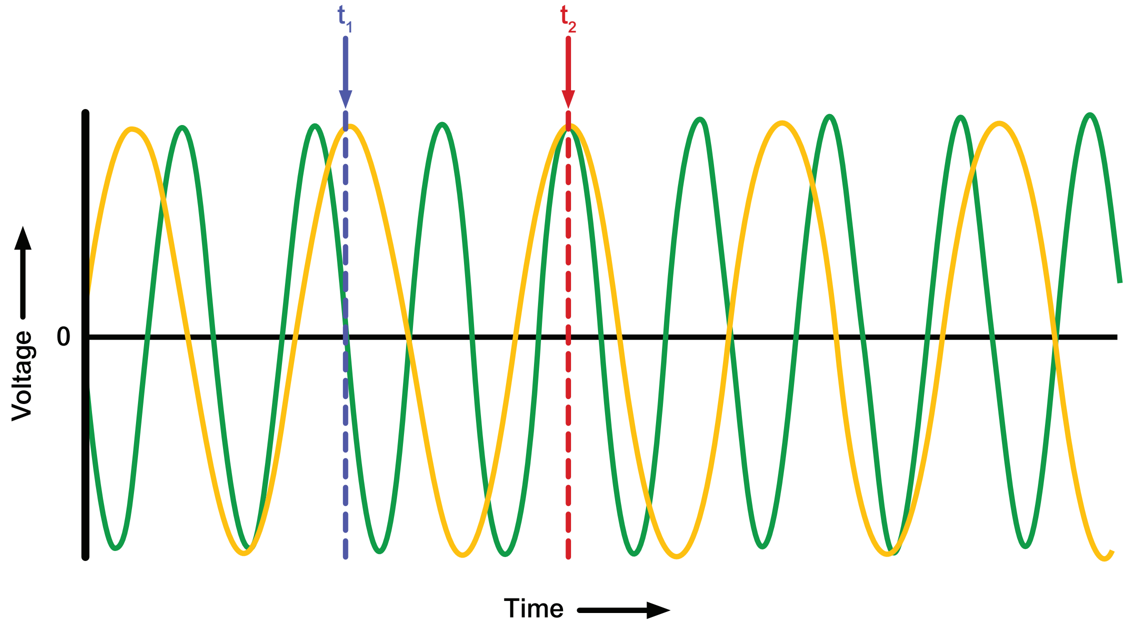

Figure 1: In-rush current at t_1, where the phase angle difference is~90 degrees, would be much greater than at t_2, where the difference approaches zero degrees. In normal applications, the frequencies would vary less widely than shown.

In-rush current can thus be limited by ensuring that transfers occur only when phase angle differences are within acceptable limits. Transfer switches can be equipped with in-phase monitoring to ensure that transfers occur only when phase angle differences are within acceptable limits, nominally 60 degrees or less on the same phase.

Importantly, the time required to execute transfer must be accounted for to ensure that transfers complete before phase angle differences increase to unacceptable amounts. Using a transfer switch that requires ~40 milliseconds to operate on a 60 Hz power distribution system means that 2.4 cycles could pass during a transfer. In-phase monitors account for these dynamics and close on the alternate source within desired phase angle differences. Because voltage, frequency, and phase angle are all within acceptable limits, in-phase transfers occur without excessive in-rush currents and their resulting effects. Note also that this application differs from source paralleling applications, where phase angle differences must typically be much smaller before closing on a second power source.

Motor Load Disconnect Circuits

Where motor loads can momentarily be deenergized without unduly impacting operation, Motor Load Disconnect Circuits can also be used to transfer motor loads. These circuits disconnect motor loads prior to transfer between power sources. This is accomplished by means of a pilot contact installed on a transfer switch that signals each motor or its controls to disconnect to prevent interaction with other system loads (Figure 2). After transfer, this pilot contact closes to permit the motor controller to restart. This solution allows running motors to slow or stop before reconnecting. This reduces or eliminates the residual voltage they would otherwise present. If loads for multiple motors are being transferred, provisions for sequential starting can limit in-rush current that would occur if the motors restarted simultaneously.

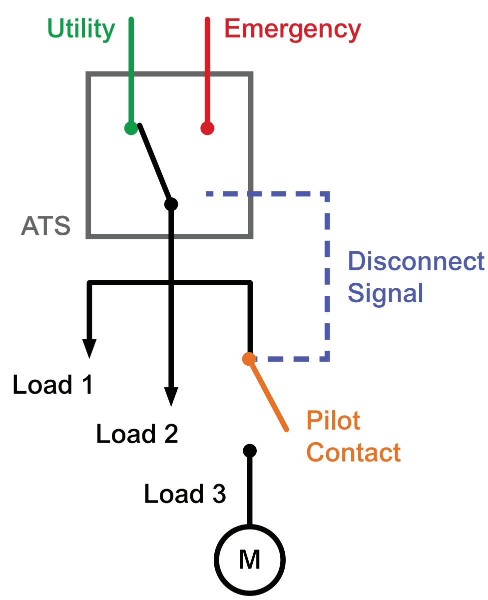

Figure 2: A motor load disconnect circuit solution

Delayed Transition Transfer Switching

Transfer switches with a timed center-off position can provide a similar effect to using motor load disconnect circuits. Also known as *Delayed Transition Transfer Switches*, these disconnect the entire ATS load from the first power source, remain disconnected from both sources for a user-settable time interval, then connect the load to the second source. A conceptual diagram is shown in Figure 3.

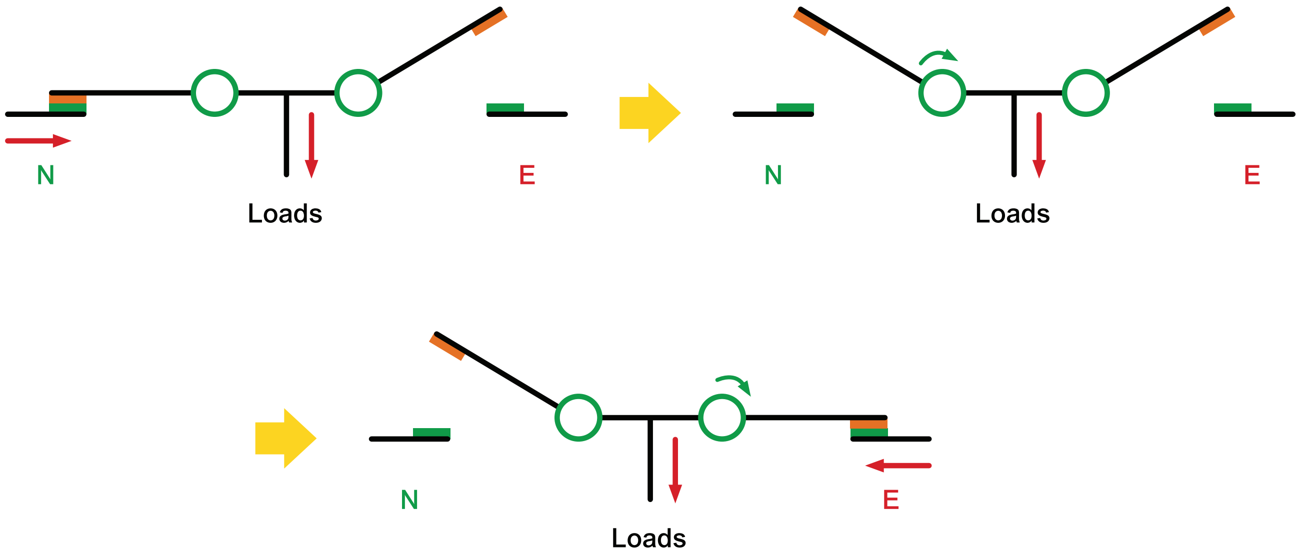

Figure 3: A delayed transition sequence, where the transfer mechanism contacts disconnect from the Normal source, hold a center-off position, then connect to the Emergency source.

One advantage of this arrangement, provided that restarting multiple motors in sequence is unnecessary, is that interconnections between the transfer switch and motor controls are not needed. Conversely, its operation deenergizes all the loads downstream of the ATS, not just select motors.

Evaluation of the potential impacts to operation of process control pumps, digital equipment, boilers, large air handlers, and other sensitive equipment and processes should be completed to determine whether this type of switching is appropriate to the application. Where appropriate, it offers a single solution for mitigating in-rush currents to all motor loads downstream of an ATS. For more information about transition modes, see Part 1 of the ASCO document entitled *Transition Modes for Automatic Transfer Switches*.

Closed Transition Transfer Switching

Switches that momentarily overlap connection between two power sources can provide another solution. Known as *Closed Transition Transfer Switches*, they close the contact on the second power source before opening on the first, thus avoiding any power interruption and minimizing disturbance. Overlap duration is typically less than 100 milliseconds. The operating sequence of a closed transition transfer mechanism is illustrated in Figure 4.

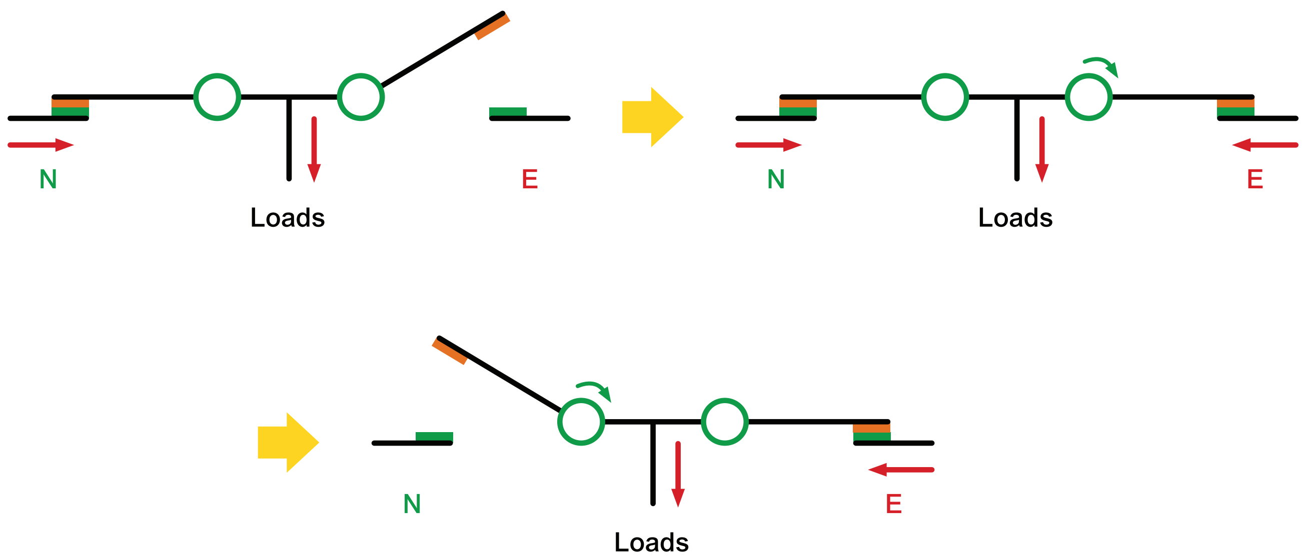

Figure 4: A closed transition sequence where the Normal and Emergency sources are momentarily paralleled.

The benefit of this solution is that power flow is never interrupted, and transfers occur only when the voltage, frequency, and phase angle of the sources are all very close, thus avoiding large in-rush currents. For this reason, Closed Transition Transfer Switches are commonly used in mission-critical applications, including healthcare facilities and data centers.

Nevertheless, deploying these switches requires consideration of several factors. Overlap can only be achieved when both sources are present and properly synchronized by voltage, frequency and phase angle. If one power source is failing, transfer may be difficult to achieve. Transfers during routine testing and retransfers from generators to utility service following an outage can only be completed when both sources are at full voltage.

Because this solution momentarily parallels the backup power system with utility power, the possibility of installing closed transition switches should be coordinated closely with the utility that provides service to a facility. For more information on this topic, review the ASCO document entitled ***Connecting Closed Transition Transfer Switches to Utility Services***. For more information on closed transition operation, see **Part 2** of the ASCO document entitled *Transition Modes for Automatic Transfer Switches*.

PREVENTING OVERLOAD OF THE EMERGENCY SOURCE

Onsite generators are a typical source of backup power. These usually have limited ability to supply the total in-rush and starting currents of the total connected load. For economic reasons, generators are often sized to provide a specific amount of load current plus a limited motor starting capacity. In such cases, it may be necessary to delay reconnection of loads when transferring to generator power. Nevertheless, industry codes such as the ***National Electrical Code®*** as well as ***NFPA 110 - Standard for Emergency and Standby Power Systems*** require backup power to reach life-safety loads in 10 seconds or less. For more information on regulatory requirements, review the ASCO Tech Brief entitled ***Standards for Backup Power*** and the ASCO white paper entitled ***Testing Hospital Backup Power Sources***.

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1. *Using transfer switches with individual time delays for transfer to Emergency power:* Where several transfer switches are present, time delays can be used so that switches sequentially close on the Emergency power source. A sequence can be established after considering priorities for the respective loads, individual motor in-rush requirements, and the remaining starting kVA of the generator.
2. *Transfer switches with provisions for disconnecting a single load prior to transfer and reconnection.* Discussed above under "Motor Load Disconnect Circuits", this prevents a load, such as a motor load, from being reconnected until several seconds after transfer.
3. *Transfer switches with provisions for sequencing multiple discrete loads onto a generator.* Multiple signal circuits can be used to sequence several motor loads onto generator power when they are fed by the same transfer switch. Time delays are typically adjustable to optimize a sequence for an application.

SUMMARY

Transferring large motor loads to an alternate power source requires provisions to avoid in-rush currents that could damage equipment and overload generators. Four approaches include (1) monitoring phase angle differences to facilitate in-phase transfer, (2) using disconnect signaling circuits to manage specific motors, (3) slowing or stopping all motor loads by using delayed transition transfer switches, and (4) avoiding even momentary power interruption by executing closed transition load transfers. Limiting in-rush currents using transfer delays and controls signal circuits for single and multiple motor applications are useful approaches for avoiding generator overload.

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