ASCO Power Technologies™

Transferring Loads with Zero Power Interruption

White Paper 121

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In some load transfer applications, load equipment (or the operations they support) can be impacted by transitory power interruptions associated with transferring load between power sources. This document describes the operation and benefits of using transfer switches that operate without disrupting the flow of power to loads.

OPEN AND CLOSED TRANSITION SEQUENCES

In typical standby and emergency power systems, there is an inherent transient interruption of power to the load when it is switched from one available source to another. Without other provisions, standard transfer switches use an open transition ("break-before-make") switching sequence that results in voltage to load as shown in Figure 1.

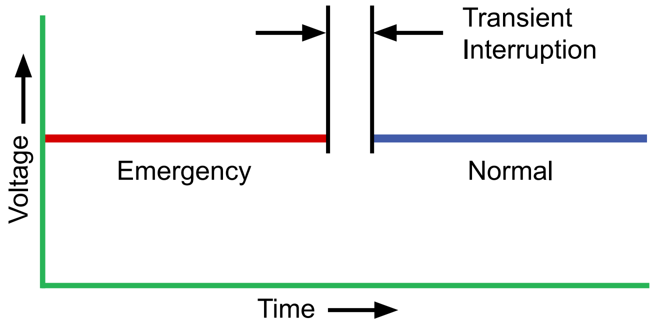

Figure 1: Voltage to loads during an open transition sequence

For many loads, a short momentary outage like the one above is inconsequential. However, some loads are affected by even the slightest momentary loss of power. There are also operating circumstances where it may be desirable to transfer loads with zero interruption of power when conditions permit. For these applications, transfer switches can be provided with contacts that overlap, such that they operate in a "make-before-break" sequence. These are known as Closed Transition Transfer Switches (CTTS), which provide power to loads as shown in Figure 2.

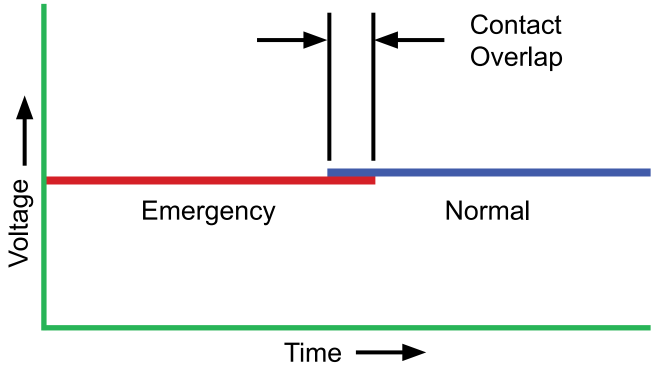

Figure 2: Voltage to loads during a closed transition sequence

With CTTS, transfer of load to an emergency source during a backup power system test and retransfer back to a normal source will occur without interrupting power to loads, provided that both sources are providing acceptable power. If either source is not presenting acceptable power, such as when an outage occurs on the normal source, the switch transfers the load in a "break-before-make" mode.

LOAD CHARACTERISTICS

Closed transition switches are most frequently used for sensitive electronic loads such as computer data processing, radar, communications, and medical imaging equipment. In most cases, any outage or unacceptable power disturbance will impact load equipment operation and can cause data loss. To mitigate these impacts and their costs, many of these systems are also fitted with an uninterruptible power supply (UPS). The required degree of protection is evaluated by considering the potential operational impacts of outages to a facility or organization and the associated economic costs. Thereafter, protection can be obtained by providing (1) a UPS, (2) an emergency or standby power system with closed transition transfer, or (3) a combination of both.

Notably, a system with a CTTS is not a substitute for a UPS. In addition to providing line conditioning, a UPS stores energy that provides power for a prescribed period of time when a power outage occurs. A CTTS assures only that there will be no momentary loss of power when load is transferred from one live power source to another, such as transfers for test purposes or retransfer to the normal source. By itself, CTTS will not avert an interruption when the normal power source fails.

APPLICATION FACTORS

In many applications, power interruptions to loads are a nuisance that can be mitigated by reducing the number of transient interruptions due to planned transfer operations. Loads connected to typical emergency power systems are often subject to considerably more outages resulting from scheduled backup system testing than due to actual utility power failures.

Periodic Testing

Around the world, there are various regulatory requirements and industry standards for periodic testing of emergency power systems. (For additional information, see ASCO documents entitled *Testing Hospital Backup Power Sources*, *Testing Hospital Power Backup Systems in the United Kingdom*, and *Load Testing for Healthcare Compliance*).To comply with codes, standards, or best practices, a backup power system may perhaps be tested weekly. With conventional transfer equipment, this results in two transient interruptions each week (one on transfer and the other on retransfer), equaling 104 momentary outages each year. In addition, facilities served by a reliable provider may experience a few additional utility outages each year.

If a CTTS is used, all live-to-live transfers, including all retransfers to normal, would occur without transient interruptions. Only normal-to-emergency transfers, where the normal source is no longer available, would result in transient interruptions. Transient interruptions could be reduced by approximately 90 percent annually, amounting to thousands of avoided transient interruptions over the service life of equipment. Using a CTTS to avoid these power interruptions may be very appealing for many types of loads.

Preemptive Transfer to Emergency Power

Failures of the normal power source should be anticipated as a condition of operation. Closed transition transfer switches are often preemptively used where power failures can be anticipated, such as when stormy weather is forecast or when power utilities call on users to reduce peak-hour power consumption according to contracted agreements.

In advance of these events, personnel can start engine-generators and then, using closed transition transfer, transfer loads from the normal source to a genset(s) without any interruption of power. When the weather clears or peak hours expire, loads are retransferred back to the normal source without interruption. Any application where it is desirable to avoid nuisance transient interruptions is a candidate for CTTS switching.

Redundant Protection for Transient and Extended Outages

Critical digital loads usually require the protection of both a UPS and a standby power system. The standby power system, complete with an engine-generator set(s) and an automatic transfer switch(es), is needed because the amount of time that a UPS can supply power is limited, usually to a matter of minutes. Such a system may be made more reliable by using a CTTS rather than a conventional open transition transfer switch, which would briefly cause the UPS to cycle. As noted, a UPS would not be subject to the transient interruptions that would otherwise occur during routine testing. This redundant protection and its added reliability are often well worth the small added cost of CTTS, particularly for larger loads.

Reluctance to Test

There are cases where emergency and standby power systems are not routinely tested as often as they should be. For example, some facilities could be reluctant to test frequently because of the possible effects of transient interruptions on critical and sensitive equipment. If such loads were transferred with zero power interruption, both regulatory compliance and power system reliability can be increased.

Transformer Switching

Transformers with primary windings connected to the load terminals of open transition transfer switches can draw very high inrush currents during transfers of load from one source to another. This can cause unnecessary stress on electrical equipment and result in tripping of overcurrent protective devices. With CTTS, high inrush currents and their corresponding effects can be avoided.

It is good engineering practice to locate transfer switches close to loads. Therefore, most applications do not locate transformers between transfer switches and load equipment. For those applications with load-side transformers, closed transition transfer can be used to minimize disturbances.

Transferring Motor Loads

Closed transition sequences offer advantages for transferring motor loads. Conventional open transition switching introduces transient interruptions when loads are switched to a different power source. Spinning motors maintain a residual voltage when disconnected from a power source.

Frequency and phase angles increasingly differ from the power sources when motor speed decays. Subsequently connecting a power source to motor loads can thus cause inrush currents. When large inrush currents occur, they can result in electrical and mechanical stresses on equipment and trip overcurrent devices. These effects are avoided when CTTS is used because power to motors is continuous. The benefit of this advantage scales with the size of the motors. For additional information, review the ASCO Power Technologies white paper entitled *Transferring Motor Loads Between Power Sources*.

DESIGN CONSIDERATIONS

Closed transition transfer is only feasible between two live sources that are in or close to synchronism. Therefore, consideration must be given to transferring from a failed (or failing) power source to a live source. If the normal utility source should fail, there should be no momentary interconnection of sources when the load is transferred to the emergency source. This can only be accomplished by a “break-before-make” transfer.

Closed transition automatic transfer switches automatically select transition sequences according to the condition of the two power sources. Transfer switch controllers typically sense voltage and frequency to determine the mode of operation required. Referring to Figure 3, if the normal source fails, the normal source contacts would open first and then the emergency contacts would close, similar to open transition switching. When the normal source is restored and the emergency source is still providing figure 4, closed transition would be used to retransfer loads to the normal source, whereby the normal contacts close first and then the emergency contacts.

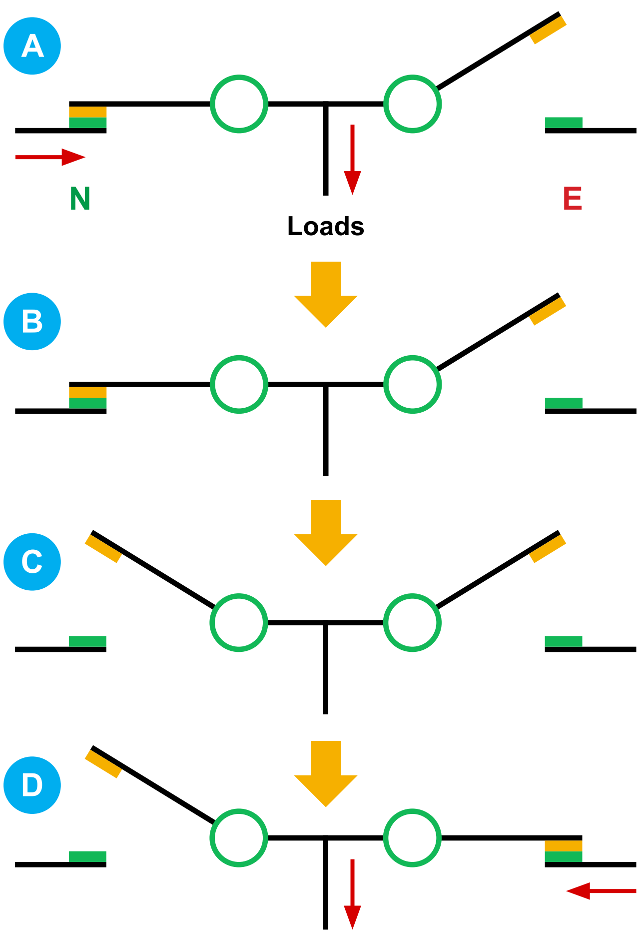

Figure 3: Contact positions for open transfer to emergency source, where (A) voltage is supplied until (B) an outage occurs, then (C) the normal contact opens, and (D) the emergency contact subsequently closes.

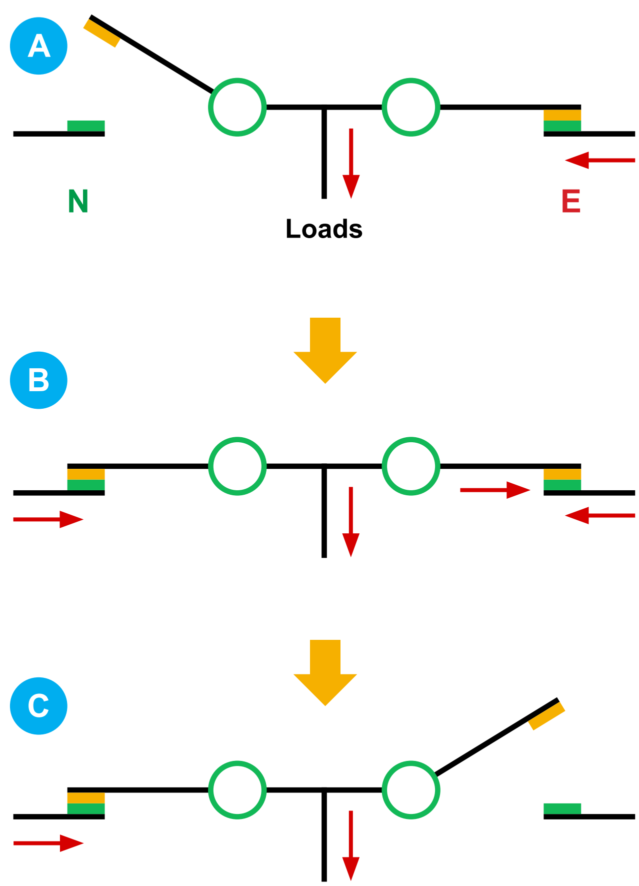

Figure 4: Contact positions for closed retransfer to the normal source, where (A) voltage is supplied by the emergency source until (B) the normal contact closes and (C) the emergency contact subsequently

SENSING AND TRANSFER CONTROLS

The transfer switch controller's voltage sensing and mode selector functions automatically determine whether transfer should occur using a particular transition sequence. If the normal source fails, the transfer switch initiates starting of the genset(s) and transfers the load to the emergency source using a "break-before-make" sequence. When the normal source is restored for an acceptable amount of time, the switch transfers back to the normal source without interrupting the load, using a "make-before-break" sequence.

Closed transition transfer switch controls typically include a provision for simulating a normal source failure. This causes a closed transition transfer to occur in both directions (normal-to-emergency and emergency-to-normal) because both sources are presenting acceptable power.

Transfer controls typically include four recommended time delays to further enhance transfer switch operation. They are:

1. Time delay to override a momentary normal source outage for open transition mode. On ASCO units, this is typically adjustable from 0.5 to 6 seconds
2. Time delay on transfer to the emergency source. On ASCO units, this is typically adjustable from 0 to 1 minutes.
3. Time delay on retransfer to the normal source. On ASCO units, this is typically adjustable from 0 to 30 minutes.
4. Time delay for unloaded running of emergency engine generator set. On ASCO units, this is typically adjustable from 0 to 5 minutes.

NEED FOR UTILITY APPROVAL

With closed transition transfer, a genset is momentarily connected in parallel with the normal source, typically to a utility electrical service. This can be acceptable where paralleling of sources is not sustained and lasts only for a fraction of a second. Therefore, protective relaying is unnecessary for many applications. Furthermore, with combination closed/open transition, there is no transfer of an available fault current on the outgoing bus that could otherwise exceed the breaker rating.

Nevertheless, using a CTTS usually requires approval from the utility company. In some cases, a utility may require a protective relay arrangement that can unparallel the power sources in the event of a fault. For more information, see the ASCO publication entitled *Connecting Closed Transition Transfer Switches to Utility Services*.

OTHER CONSIDERATIONS

The cost of a closed transition automatic transfer switch is only incrementally more than a conventional open transition automatic transfer switch. However, the combined cost of a UPS with a conventional emergency power system is considerably higher than a closed transition emergency power system without a UPS. Consequently, the modest incremental cost for closed transition switches can be easily justified for many applications.

There are applications that require emergency power systems where the cost of adding a UPS is prohibitive. However, for some of these applications, closed transition switching can often be justified. Proper selection of a transfer switch/UPS configuration can be made following a careful analysis of load characteristics, required reliability, and costs.

Bypass-Isolation Transfer Switches can also be obtained with closed transition capabilities. This arrangement permits testing and maintenance of the transfer switch without interrupting power to loads. For more information, see *Part 1* and *Part 2* of the ASCO publication entitled *Application and Design Factors for Automatic Transfer and Bypass-Isolation Switches*.

SUMMARY

Closed Transition Transfer Switches enable load transfer between sources without interruption of power to loads by paralleling two power sources for very brief periods of time. They are used most often in applications where the load equipment or the operations they perform cannot tolerate even transitory interruptions. Because CTTS occurs when two sources present acceptable power, transfers due to outages must occur using a break-before-make sequence. Where even these less frequent events cannot be tolerated, uninterruptible power supplies are used to provide short-term ride through power.

Because of the frequency of backup power testing events, most transfer switching cycles occur when two sources present acceptable power. In a typical application, using CTTS can avoid 90 percent or more of the transient interruptions that other systems would experience. CTTS benefits users where facilities preemptively engage backup power for foreseeable events, desire redundant protection for both momentary and extended outages, would otherwise be reluctant to test using building load, and seek to mitigate nuisance overcurrent device tripping caused by transformer switching. Sensing and transfer controls, switching sequences, the use of bypass-isolation transfer switches, and other design considerations have also been described herein.

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