Understanding Automatic Transfer Switches

Data centres, hospitals, factories, and a wide range of other commercial and institutional facilities that require continuous or near continuous uptime typically utilise an emergency power source, such as a generator or a backup utility feed, when their normal power source is unavailable. Transfer switches are responsible for quickly and safely transitioning all electrical power consumed by the circuit, equipment, or systems connected to the transfer switch output between those normal and emergency power sources. All electrical power consumed by the circuit, equipment, or system connected to the transfer switch output is defined as the load. A typical transfer sequence includes these steps:

- The normal power source fails.
- When power from the generator or the backup utility feed is stable and within prescribed voltage and frequency tolerances, the transfer switch shifts the electrical load to the emergency power source. Depending on the facility’s needs and preferences, that transfer either occurs automatically or is executed manually.
- When utility power is restored, the transfer switch returns the load from the emergency power source to the normal one. Again, this can happen automatically or manually, depending on the type of switch being used and its operation mode.

Understanding switching devices

Transfer switching equipment (TSE) is classified according to the short-circuit capability:

There are three different types of transfer switching equipment:

- Automatic Transfer Switching Equipment (ATSE)
- Manually Transfer Switching Equipment (MTSE)
- Remotely Transfer Switching Equipment (RTSE)

Of the ATSE type, of which we are interested here, there are three different classes of equipment:

- Class CC: Is an ATSE that is capable of making and withstanding but is not intended for breaking short-circuit currents and is based on devices fulfilling the requirements of IEC 60947-4-1. This is usually by use of interlocked contactors.
- Class PC: Is an ATSE that is capable of making and withstanding but is not intended for breaking short-circuit currents and is based on devices fulfilling the requirements of IEC 60947-3. This is usually by use of a motorised switching device.
- Class CB: Is an ATSE that is capable of making, withstanding and is intended for breaking short-circuit currents and is provided with over-current releases and is based on devices fulfilling the requirements of IEC 60947-2. This is usually by use of motorised circuit breakers.

Contactor type - CC

This is the most common and affordable switching mechanism type. In most cases, contactors are constructed as a double-throw switch where a single operator opens one set of power contacts while closing a second set. In an open transition design, a mechanical interlock is often employed to prevent simultaneous closure of both contact sets. In a closed transition design, the mechanical interlock is absent.

Advantages

- Contactor switching mechanisms can support open or closed transition
- Transfer switches equipped with a contactor switching mechanism are generally the most economical
- Contactor switching mechanisms are fast and flexible

Disadvantages

- Contactor switching mechanisms don't include integral overcurrent protection, so the power contacts are not self-protecting. In the event of a fault, the contacts will typically remain closed and protection is dependant on upstream fuses or circuit breakers
- At rated current, short circuit current may be lower when compared to a circuit breaker switching mechanism
- Contactors but don't offer overcurrent protection

Motorised Switch type - PC

Motorised Switch mechanisms are large self-contained units, and capable of handling very high currents. The two-step stored energy technology they utilise can be operated both mechanically and electrically. Their high, interrupt rating also makes Motorised Switch mechanisms a good fit for applications vulnerable to large fault currents but must be protected by upstream fuses or circuit breakers.

Advantages

- Motorised Switch switching mechanisms offer high withstand and current ratings
- Rapid closing speed facilitates quick closed transitions
- Unlike contactor switching Motorised Switch switching offer mechanical and electrical transitions

Disadvantages

- Motorised Switch switching mechanisms are larger than contactor designs
- Motorised Switch switching mechanisms are typically the most expensive than contactor designs but can be cheaper the circuit breaker designs

Circuit Breaker type - CB

Routinely used for closing and interrupting a circuit between separable contacts under both normal and abnormal conditions, moulded case switches feature simple designs and can support either a mechanically operated, toggle, rotary handle or a motor operator. When configured for use in a transfer switch, a pair of moulded case circuit breakers are operated via a common, interlocking mechanical linkage. The linkage can be driven manually or automatically. When overcurrent protection is needed, moulded case circuit breakers equipped with a thermal-magnetic trip element are used.

Advantages

- Contacts are self-protecting at high fault currents due to integral over current and short circuit protection
- Moulded case switching mechanisms provide a compact, cost effective solution, as they eliminate the need for additional upstream protective devices.
- Moulded case switching mechanisms can be configured with integral overcurrent protection that provides "lock-out" functionality and eliminates automatic transfers into a fault condition
- Moulded case switching mechanisms provide high withstand currents at lower ratings, eliminating the need to oversize transfer switch frame size to meet specification requirements

Disadvantages

- Moulded case switching mechanisms are generally more expensive than contactor switching mechanisms
- Moulded case switching mechanisms don't generally support closed transitions

Types of transition

Transfer switches switch between normal and standby power supplies by open or closed transition. Determining which is most suitable depends on the type, safety and security needed by the load.

Open transition

Open transition is a ‘break before make’ transfer. This means the transfer switch breaks its connection of one power supply before making a closing to the other supply. This means there is always a break in supply during transfer.

Most transfer switches include delay timers which typically lasts either an adjustable or pre-determined amount of time between one the opening of one supply and the closing of the other.

Advantages

- Building a delay into the transition process can prevent higher than normal electrical current (also known as “inrush current”) from developing. Inrush current can occur when an inductive load is rapidly reconnected to a non-synchronized power source. It can be an issue in applications where a residual voltage is briefly maintained at the load due to the generator effect created by a rotating motor or by the stored energy released from a transformer’s windings or core
- Operation is independent of electrical synchronization between both sources of power
- A transfer between power sources can be initiated automatically or manually

Disadvantages

- Unless some type of stored energy system, such as an uninterruptible power supply (UPS), is located downstream of the transfer switch, loads will experience a brief interruption in power during the transition delay period

Closed transition

A closed transition is a “make before break” transfer, in that the transfer switch makes a connection to the new power source before breaking its connection to the old one. As there’s no gap between disconnection and connection, downstream loads receive continuous power throughout the transfer process. Switches configured for closed transitions usually transfer power automatically as soon as both power sources are closely synchronized in phase, voltage, and frequency. The overlap period during which both sources are simultaneously connected, or “paralleled,” usually lasts no more than 100 milliseconds to comply with local utility interconnect requirements.

Advantages

- Critical loads can continue to operate, without an interruption in power, during loaded generator engine testing
- Energy costs can be reduced through “peak shaving,” which is the ability to control usage from a utility during intervals of high demand in order to limit or reduce demand penalties during a given billing period
- Depending on the application, may eliminate the need for a UPS to be located downstream

Disadvantages

- Transfer switches sophisticated enough to execute a closed transition tend to cost more
- Some utilities require closed transitions to comply with interconnect requirements aimed at preserving power quality and protecting utility service personnel and equipment. In some cases, this can require the inclusion of protective relays in the electrical circuit
- Closed transitions must be executed by an automatic controller. Manual operation is not possible as microprocessor logic is needed to manage source synchronization
- Closed transitions can produce higher fault current, due to the 100-millisecond period when both power sources are paralleled. As a result, the consulting engineer may specify a higher withstand close-on rating (WCR), which could require oversizing the transfer switch amperage rating 4 Transfer switch

Understanding operation modes

Power transfers involve two processes: initiation and operation. Initiation is what starts the transfer. Operation is what completes it. Most transfer switches can support multiple operation modes through the addition of configurable options.

Manual mode

In manual mode, both initiation and operation are performed manually, typically by pushing a button or moving a handle.

Advantages

- With moulded case or Motorised Switch designs, transfers can occur under load as a failsafe if the automatic controller and/or control circuitry sustain damage or become inoperable
- Human operator has maximum control over the transfer process
- Transfer is independent of the automatic controller

Disadvantages

- An operator must be physically present to initiate a transfer— even overnight and on weekends
- Transition delay time is dependent on the operator and therefore may increase when compared to automatic mode transfers, which are described below
- Limited to open delayed transitions, as open in-phase and closed transitions require microprocessor logic to manage source synchronization
- On some transfer switch designs, operators must open an outer safety door to access the switching mechanism, exposing them to energized electrical equipment and potentially requiring them to wear personal protective equipment
- Facilities with emergency and legally required installations are usually prohibited by law from using manual mode unless their transfer switch is capable of performing an automatic transfer in certain especially urgent situations

Non-automatic mode

In non-automatic mode, the operator manually initiates a transfer by pressing a button or rotating a switch that causes an internal electromechanical device to electrically operate the switching mechanism.

Advantages

- As with manual mode, operators are in complete command of transfer initiation
- Transitions complete more rapidly than with manual mode because of the electromechanical device that electrically operates the switching mechanism
- Non-automatic transfer switches tend to cost less than an automatic type

Disadvantages

- As with manual mode, a human operator must be present to initiate a transfer, and there’s no support for open in-phase or closed transitions

Automatic mode

In automatic mode, the transfer switch controller completely manages both initiation and operation. Initiation is triggered when the automatic controller senses an unavailability or loss of source power and operation is typically performed by an electric solenoid or motor.

Advantages

- Transfers and re-transfers can be completed in the shortest time possible
- As the transfer switch executes the entire transition process itself, there's no dependence on a human operator
- Users enjoy greater flexibility, as they can select from automatic, non-automatic, and manual operation modes using programmable set points and/or an integral control panel
- Automatic mode meets NEC requirements applicable to emergency and legally required systems

Disadvantages

- Automatic transfer switches tend to cost more than devices that operate only in manual or non-automatic mode

Bypass isolation mode

Traditional transfer switches feature a single switching mechanism. In contrast, Life Safety Transfer Switches include a bypass isolation transfer switches include dual switching mechanisms that provide redundancy for critical applications. The primary switching mechanism handles day-to-day distribution of electrical power to the load, while the secondary switching mechanism serves as a backup. During repair or maintenance procedures, a technician can bypass power around the primary mechanism through the secondary mechanism to ensure that critical loads remain powered without interruption. Life Safety Transfer Switches can include single line or double line bypass switching.

Advantages

- Operating in bypass isolation mode allows users to service transfer switches safely without compromising availability
- The secondary switching mechanism provides built-in redundancy if the primary mechanism malfunctions or requires routine inspection

Disadvantages

- Transfer switches with bypass isolation mode are usually more expensive, as they require dual switching mechanisms
- Dual switching mechanisms also make switches with bypass isolation mode larger than traditional transfer switch types

Conclusion

Transfer switches support multiple operation modes and transition types and feature a range of different switching mechanisms. With the help of the information in this white paper, however, facilities managers can sort through their options and choose the right switch for their specific requirements.