

Eliminating Power Transients When Switching Large Inductive Loads

Overview

When large inductive loads — loads consisting of large motors and/or transformers — are transferred between two live power sources (e.g. a normal source and an emergency source) which may not be in synchronism, efforts should be made to eliminate line current transients that occur during this type of switching. This situation exists either when retransferring from the emergency source to the restored normal source after a power outage, or transferring in either direction while testing the emergency power system. Through the proper selection of transfer switches, emergency/backup power system designers can dramatically reduce and effectively mitigate these transients and the problems associated with them.

Effects of Out-of-Synch Transfers

When a running motor is disconnected from its power source, the residual voltage produced by the motor's generator action will decay in amplitude and frequency as the motor slows down. This may take a considerable length of time, depending on the type of motor and the nature of the connected load. So, even if two power sources are in synchronism when a transfer is initiated, induced voltage transients can still cause high currents at the moment such motor loads are actually transferred.

Similarly, when a transformer is disconnected from its power source, a certain amount of time is required for the magnetic field to collapse. The release of energy stored in the transformer's windings and core can generate high currents at the time of transfer — *even if the two power sources were in synchronism when transfer was initiated*. These current surges are the result of an out-of-phase transfer between two sources and can exceed the instantaneous trip settings of protective devices in the system, resulting in tripped circuit breakers.

Compensating for Out-of-Synch Transfers

Three methods commonly utilized to prevent such transients from occurring include: 1) A time delay operator interlock system; 2) A synchronizing check function; and 3) A dual-operator transfer switch.

Following are explanations of how each method eliminates these power transients, as well as with the pros and cons associated with their use.

Time Delay Operator Interlock Function

A time delay operator interlock function can be programmed into the transfer switch's controller and powered by the transfer switch's control circuit. This function disconnects large motors and/or transformers just prior to transfer and automatically reconnects them after an adjustable time delay during which they will have had time to de-energize. With this arrangement, normal inrush current is experienced upon reconnection to the live power source.

Advantages:

- Can be inexpensively added to a transfer switch
- Time delay can be easily adjusted to suit load requirements
- Flexibility to select disconnect prior to transfer or after transfer

Disadvantages:

- Requires external wiring from the transfer switch to the motor or transformer disconnect device. This method typically requires multiple circuits — one for each motor or transformer controlled — and is difficult to implement in older installations.

Synchronizing Check Function

A synchronizing check function inhibits load transfer until the two live power sources are in synchronism. This function can be adjusted to permit the transfer switch to operate only when the replacement power source is electrically within approximately 10 degrees of the connected power source. Depending on the differences in frequency and phase angle between the two power sources and the contact-to-contact transition time, the transfer is made at or very near synchronism. This function can be used to control unidirectional transfers (emergency to normal) or bidirectional transfers.

Advantages:

- When the load does not include heavy transformers and the system is adjusted properly, the transfer of motor loads can be accomplished without any appreciable power dip.

Disadvantages:

- The synchronizing check function is an inherently passive one, fully dependent upon the selection and adjustment of the emergency power generator's governor. The exact time of transfer initiation cannot be controlled. If the frequency of the target source is more than two cycles out of synch, or if the connected power source is unstable, the transfer switch will not transfer until the target source frequency is in synchronism. If the switch is unable to retransfer to the utility source, it will remain connected to the emergency source until that source is lost (e.g. the engine generator runs out of fuel).
- The synchronizing check function has no control over the rate of decay experienced from the time a motor load is de-energized until the transfer switch closes to the target power source. Depending on the switch's contact-to-contact transition time, a heavily loaded motor could go out of synch in the time needed for the transfer. This problem could be magnified in larger transfer switches which have longer contact-to-contact transition times.
- The synchronizing check function does nothing to prevent the power transients that occur when transformers are switched at high speed. Because the sinusoidal line voltage wave form deteriorates once the transformer is disconnected, the magnitude of these power transients is determined by the length of time required for the transformer voltage to decay. This, in turn, is dependent upon the type of load served by the transformer. A synchronizing check function, therefore, *does nothing* to eliminate the transients that occur when switching transformers at high-speed.

- The synchronizing check function is totally ineffective during manual transfer under load.
- The synchronizing check function is also totally ineffective when transferring between a live and a failing power source (single phase or brown-out condition). If the transfer switch logic senses a partial failure of a source, the synchronizing check function must be bypassed to allow transfer. In such a case, an out-of-phase transfer cannot be avoided and could very well trip the circuit breaker that feeds the only good power source. If this happens, *all power to the critical load will be lost.*

Dual-Operator Transfer Switch

The dual-operator transfer switch design eliminates high current surges by intentionally delaying load transfer, thereby allowing disconnected electrical loads to de-energize before reconnecting them to an alternate power source. This is accomplished by introducing a time delay between the opening of the closed power contacts and the closing of the open power contacts. Preset at the factory, the default delay is the length of time it takes to complete a normal transfer with a dual-operator switch and is typically sufficient to eliminate current surges. This delay period can, however, be adjusted to whatever length of time is necessary to achieve the desired results.

Advantages:

- Foolproof operation under all transfer conditions, including manual operation
- Successful operation is totally independent of the frequency of the two power sources.
- Because a dual-operator transfer switch is an active device, the exact time of transfer initiation can be controlled.
- Requires no wiring or coordination between the transfer switch and electrical equipment or between normal and emergency power sources.
- Flexibility of control schemes. For instance, when utilized in conjunction with a multiple-engine, generator control switchboard, the dual-operator design accommodates load shedding. By switching the main contacts to a center-off position, a dual-operator switch eliminates the need for separate load shedding devices.

Disadvantages:

- When transferring loads between two live sources, dual-operator switching can cause a momentary interruption in power.

Conclusion

In summary, the dual-operator transfer switch is by far the most reliable method of switching large inductive loads (consisting of large motors and transformers) because it is flexible, simple, and foolproof. With this type of switching, excessive line currents which can approach short circuit levels are eliminated, and only in-rush currents are experienced.