AUTOMATIC TRANSFER SWITCH

NEUTRAL POSITION DELAY & IN-PHASE MONITOR

ENGINEERING BRIEF

EB003 Rev 1 95/05/15

When transferring large motors and/or transformers between two sources of power which may not be in synchronism (i.e. the normal power source and the emergency power source), consideration must be given to the elimination of the "bump" that is felt when the electrical load is suddenly disconnected from the first power source and immediately connected to the second power source.

When a motor that has been running on line is suddenly disconnected from its power source, the residual voltage produced by the motor (which acts as a generator under these circumstances) will decrease in amplitude and frequency as the motor slows down. Although the motor may take a long time to actually stop, the voltage will decay very quickly to safe levels. Similarly, when a transformer is disconnected from the line, time is required for the magnetic field to collapse.

The "bumps" are caused by the momentary flow of extremely high line current because of an out-of-phase condition during motor transfer, and because of induced voltage transients during transformer transfer. The high current flow can exceed the instantaneous trip settings of protective devices in the system and can be severe enough to trip circuit breakers, cause damage to shafts, couplings, etc. This condition is especially pronounced in the case of a fast-operating transfer switch, such as a solenoid operated type with all contacts on a common shaft.

Two methods are commonly utilized to prevent the "bump" from occurring. One is the Neutral Position Delay (T.T.I. option code NDT). The other is the In-Phase Monitor method. The following is an explanation of each of these methods, along with the relative advantages and disadvantages.

I. IN-PHASE MONITOR

The in-phase monitor inhibits load transfer until the two power sources are in synchronism. The monitor is adjusted to signal the transfer switch to operate when the incoming power source is within approximately ten electrical degrees of the connected power source. Depending upon the difference in frequency, the phase angle between the two power sources, and in the contact-to-contact transition time, the transfer is made at or near synchronism.

A. ADVANTAGES

1. Transfer of motor loads is accomplished without an appreciable power dip when the system is adjusted properly, when heavy transformer loads are <u>not</u> included.

B. DISADVANTAGES

1. Successful transfer is totally dependent upon the selection and adjustment of the governor in the emergency power source. A governor which is faulty, maladjusted, or has too much "droop" may prevent transfer. If the frequency is more than two cycles out of synchronism, or the connected power source is unstable, the transfer switch will remain in the emergency position indefinitely, or until the frequency is corrected.

2. The in-phase monitor detracts from the reliability of the system because a complex electronic component is added to an otherwise simple, straightforward control system.

3. The in-phase monitor does not have control over the amount of slippage that is experienced from the time a motor is de-energized until the transfer switch closes to the incoming power source. A heavily loaded motor can go out of synchronism between the time it is de-energized until the time it is re-energized, particularly in larger sizes of transfer switches which have longer contact-to-contact transition times.

4. The in-phase monitor does <u>nothing</u> to prevent the "bump" that is felt when switching transformers at high speed because the sinusoidal line voltage wave form is not maintained after the transformer is disconnected. The amount of the "bump" is determined essentially by the amount of time required for the transformer voltage to decay. This, in turn, is dependent upon the type of network supplied by the transformer. Therefore, a high speed transfer switch with an in-phase monitor <u>does nothing</u> to eliminate the "bump" that is felt when switching transformers.

5. The in-phase monitor is totally ineffective during manual transfer under load. In fact a snap action transfer switch with all contacts on a single operating shaft could present problems during manual transfer if the need for in-phase monitor had been identified, since a manual transfer would probably be out of phase.

6. The in-phase monitor is totally ineffective if transfer to the generator source is necessary due to a failing utility source (single phase or brown-out condition). If the transfer switch logic senses a partial failure of a source, the in-phase monitor must be bypassed to allow transfer. In this case, an instantaneous out-of-phase transfer cannot be avoided and may very well trip the circuit breaker that feeds the only good power source. Then <u>all power is lost to the critical load</u>.

7. If the generator fails while it is powering the load while utility source is available (during test or the time delay before returning to normal), there is no protection against an out-of-phase transfer. This could also cause loss of the only remaining good source of power needlessly (in this instance, the faster the switch transfer, the more likely there is to be a problem since there is less time for the motor field to decay).

II NEUTRAL POSITION DELAY "NDT"

The NDT design eliminates the high current surge by deliberately introducing off-time during load transfer, thereby allowing the disconnected electrical loads to de-energize before reconnecting them to the alternate source of power. This is accomplished by introducing a time delay between the opening of the closed contacts and the closing of the open contacts. In fact, the inherent time it takes to complete a normal transfer with a T.T.I. motor operated switch (approximately 1 second) is sufficient to eliminate the "bump" or current surge without even adding the extra time delay of NDT.

A. Advantages

1. Foolproof operation under all conditions of transfer.

2. Successful operation totally independent of the frequency of the two power sources.

3. Flexibility. For instance, when utilized in conjunction with a multiple-engine, generator control switchboard, the NDT design lends itself to load "dumping" by switching the main contacts to an "off" position, thereby eliminating the need for separate load dumping devices.

4. Cost is considerably lower than in-phase monitor.

5. NDT is more reliable and much easier to service than an in-phase monitor.

B. Disadvantages

1. A momentary dip in power when transferring loads between two live sources (less than 60 cycles unless extended by time delay relay).

CONCLUSION

In summary, the Neutral Position Delayed transfer switch is by far the most reliable method of switching large motors and transformers because it is flexible, simple, and foolproof. Upon transfer, the user experiences only in-rush current rather than excessive line currents which may approach short circuit values.

POINTS OF INTEREST

1. In a lengthy technical working paper presented by I.E.E.E. entitled "Source Transfer and Reclosing Transients in Motors" it was stated:

   "The following are the two basic approaches to preventing damaging currents and torques caused by interruption-reconnection incidents:

   (1) Delayed reclosing or transfer, which allows time for the residual voltage of the motor(s) to decay to a level which is safe regardless of reclosing angle.

   (2) In-phase transfer or reclosing, in which the transfer or reclosure is timed to

occur when the residual and oncoming system voltages are close enough in phase relation to avoid damaging transients, regardless of residual voltage magnitude.

While both methods work quite well and are widely used, they both have advantages and disadvantages. In many applications, delayed reclosing has the virtues of simplicity, reliability, and economy; on the other hand the relatively long open interval which is sometimes required to permit the motor voltage to decay may be unacceptable. In-phase transfer provides the minimum service interruption, but depends for safe operation on accurately sensing the phase relation between the two voltages. This requires sensitive solid state or electromagnetic relaying and control logic which adds cost and complexity."

The paper further states that:

*"For typical systems composed of *relatively small integral-horsepower induction motors and lagging-power-factor static loads, an open circuit interval of 1 second is virtually always sufficient."*
**Up to 300 HP.*

The committee which developed this paper comprised several prominent industry members, including two from Westinghouse and two from Asco.

2. As a rule of thumb, neutral position delay may be applied as follows:

    a. For motors up to 100HP - no delay required.
    b. For motors 100HP-300HP - specify NDT set at one second.
    c. For motors over 300HP - specify NDT set at two seconds.

If power factor correction capacitors are applied at the motor terminals (as opposed to centrally on a system), further consideration may be required for delay times - consult T.T.I.

Wound-rotor motors are not suitable for either in-phase or neutral delayed transfer. They should be isolated and restarted.

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