Recommended use of LSIG-equipped Circuit Breakers in UPS Applications

Background

LSIG (long time, short time, instantaneous, ground) equipped circuit breakers are often required by code in the application of larger UPS systems. Specifically, UPS systems fed by 480 volts, or higher, and protected by circuit breakers of 1000 amps or greater must have a means of ground fault protection in the service or feeder for that UPS (See NEC 215.10, 230.95, 240.13, 517.17). In addition to its primary function of protection from faults, the adjustability of an LSIG trip unit allows coordination of the breakers in the electrical path during a fault event. This ensures that the breaker closest to the fault will trip first, before, or instead of, the upstream protection. This isolates the fault without unnecessarily shutting down unaffected equipment.

UPS considerations

Modern UPSs are used almost exclusively in mission critical applications; these may include data centers, medical imaging, factory floor automation, or other similar critical loads. An UPS with an input or output isolation transformer may require LSIG breakers upstream and downstream of the UPS for effective fault protection. However, any UPS that does not include an isolation transformer in its power train (transformerless UPS) is typically protected by the single LSIG breaker incorporated in its input feeder. Since the UPS is transformerless, the GFCI protection remains through the UPS output until the first isolation transformer which may be in a PDU (Power Distribution Unit). Thus, a downstream fault will pick up the LSIG in the feeder or service source circuit breaker, thus limiting the need for additional LSIG as fault protection on the UPS output.

Since the modern UPS is transformerless, currents on the input of the UPS rectifier can reflect on the input LSIG breaker (Rectifier input breaker, RIB) during transfers between the UPS inverter and utility source. Since the frequency of these currents are 180Hz (3phase at 60Hz), it could further derate the ground fault trip portion of the circuit breaker by approximately $\sqrt{3}$.

In fact, the presence of LSIG devices in the other circuit breakers surrounding the transformerless UPS may create issues with unintended breaker tripping and should be applied with care. The section below describes some of these issues with common UPS configurations and recommends methods of mitigating the risk of nuisance trips.

Configurations

Note: for all configurations below, the shaded bus/breakers depict where there are paralleled sources that can have interchange currents during operation and utility/ inverter transfers.

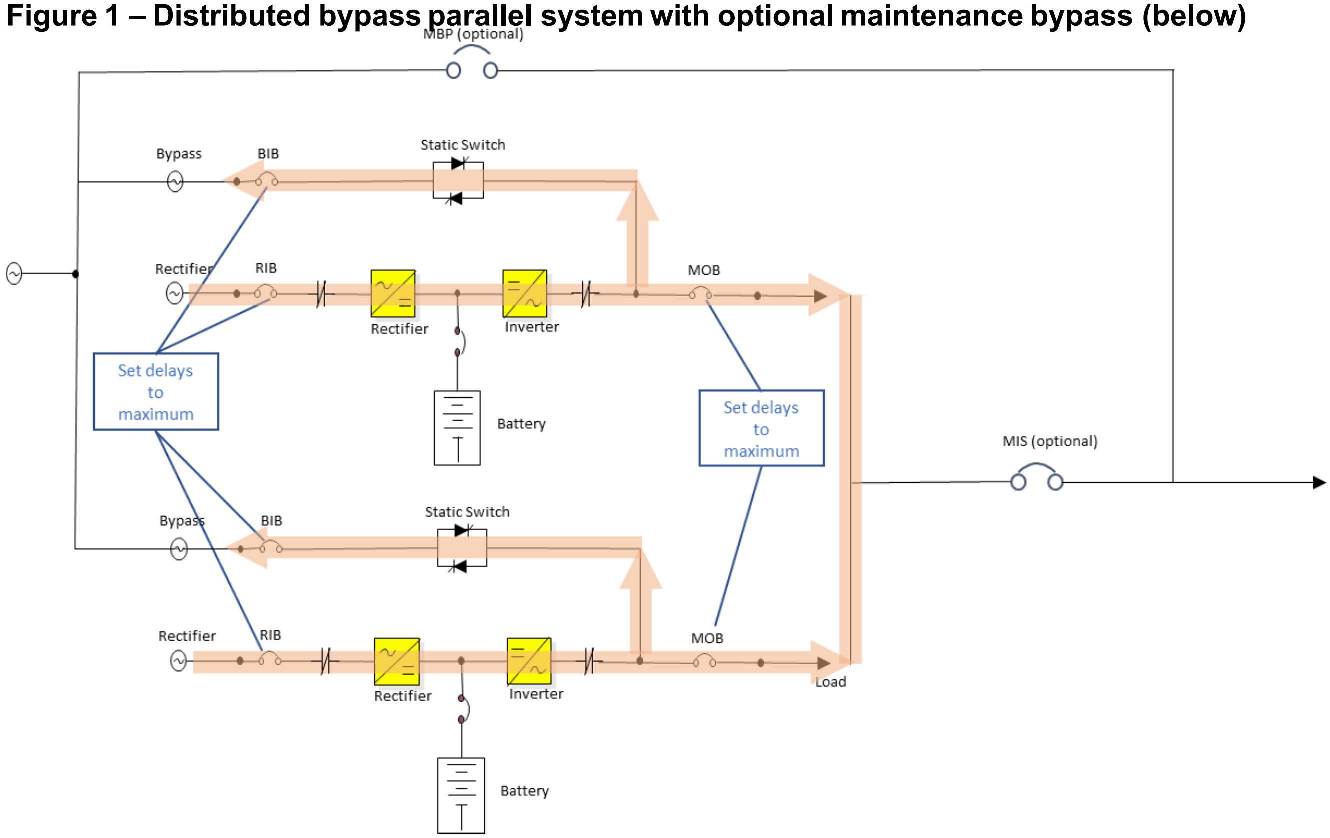
Parallel connected UPS – Distributed Bypass and Central Bypass

Two or more UPSs in parallel constantly make small adjustments in the phase of their inverters to facilitate precise load sharing between the UPS modules. Thus, the UPS inverter outputs in a parallel configuration will always ‘push’ or ‘pull’ power to facilitate equal load distribution on the inverter outputs. This ‘push’ and ‘pull’ adjustments in phase can result the back-feeding of one or more of the UPS module’s outputs; this interchange of output current between the inverters goes through the output paralleling path, which includes the output breakers, or MOBs (see figure 1 and 2 below). If these breakers are equipped with LSIG, they may sense the unbalanced current and trip, depending on the sensitivity of their settings.

UPS transfer from bypass source onto UPS inverter – Any configuration

When a UPS is transferred from bypass to inverter operation, the inverter is controlled to shift its phase with respect to the bypass source to ensure a smooth transfer, while the two sources are briefly paralleled. In a single UPS, distributed bypass parallel system, or a central bypass parallel system, this action takes place while the inverter output source is paralleled with utility source. Again, this action can be seen by the feeder for the bypass as an unbalance or back feed, tripping the breaker unn ecessarily.

Figure 1 – Distributed bypass parallel system with optional maintenance bypass (below)

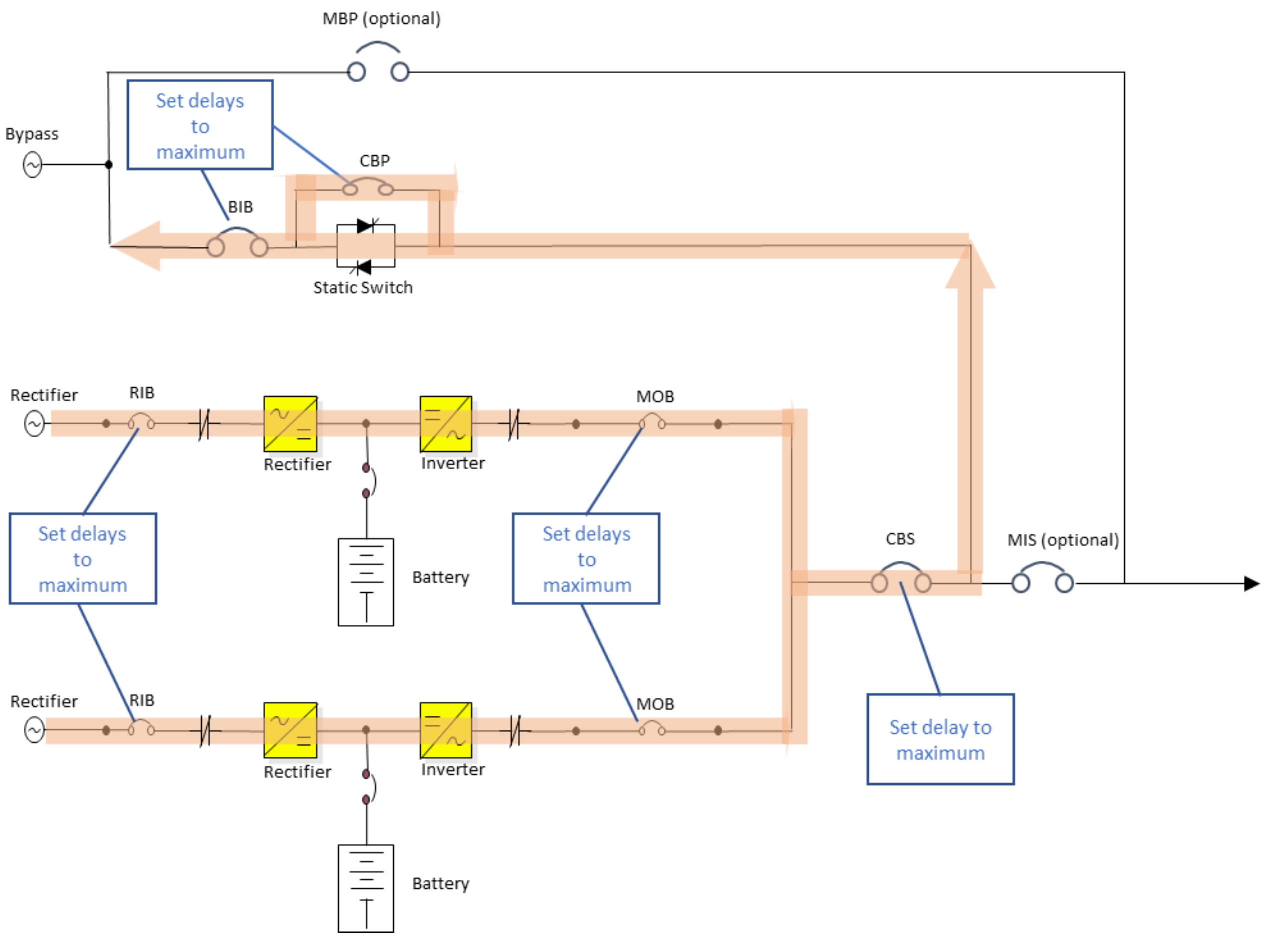


Recommendation or solution (figure 1)

Set the time delay to maximum (typically 500 msec), on the (BIB) bypass feeder breaker Set the time delay to maximum (typically 500 msec), on the (RIB) rectifier feeder breaker Set the time delay to maximum (typically 500 msec), on the (MOB) UPS output breaker Set the time delay as required in the facility for the (MIS) System output breaker

Set the time delay as required in the facility for the (MBP) Maintenance bypass breaker

Figure 2 – Central bypass parallel system with optional maintenance bypass (below)



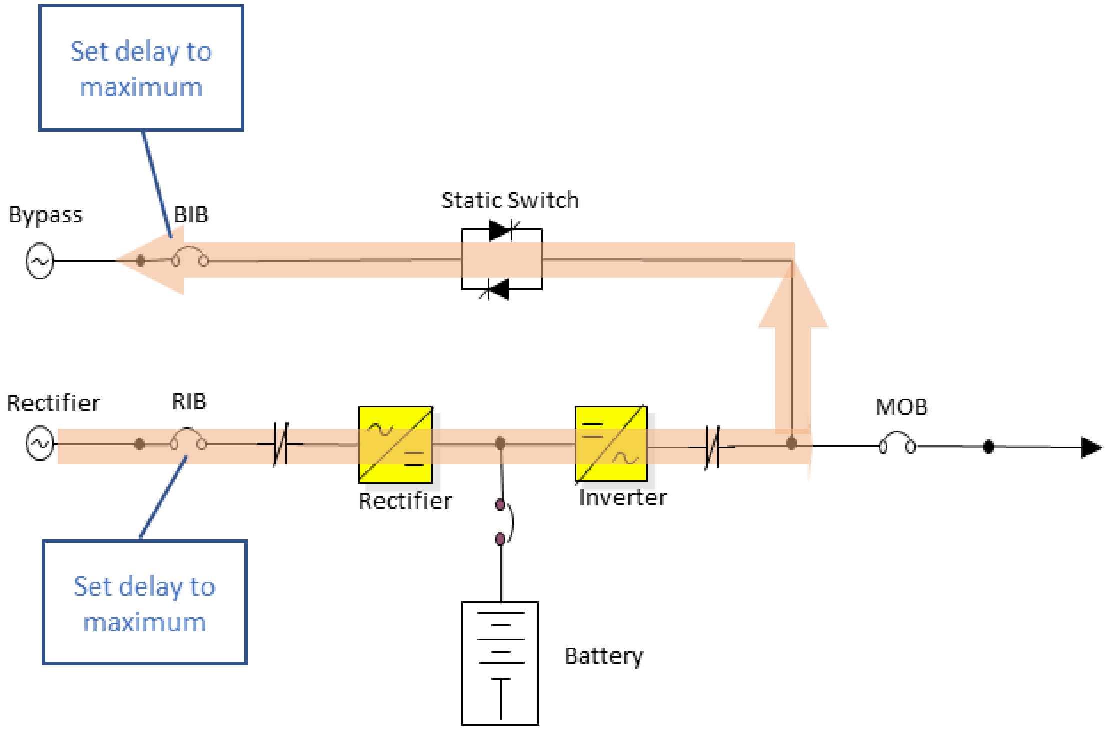
Recommendation or solution (figure 2)

Set the time delay to maximum (typically 500 msec), on the (BIB) bypass feeder breaker Set the time delay to maximum (typically 500 msec), on the (RIB) rectifier feeder breaker Set the time delay to maximum (typically 500 msec), on the (MOB) UPS output breaker Set the time delay to maximum (typically 500 msec), on the (CBS) inverter bus breaker Set the time delay to maximum (typically 500 msec), on the (CBP) bypass breaker

Set the time delay as required in the facility for the (MIS) System output breaker

Set the time delay as required in the facility for the (MBP) Maintenance bypass breaker

Figure 3 – Single UPS (optional maintenance bypass not shown) (below)



Recommendation or solution (figure 3)

Set the time delay to maximum (typically 500 msec), on the (BIB) bypass feeder breaker Set the time delay to maximum (typically 500 msec), on the (RIB) rectifier feeder breaker Set the time delay as required in the facility for the (MOB) output breaker

Note on Maintenance or "wrap around" bypass breakers

These breakers are utilized for maintenance operation of the UPS and do not normally allow parallel operations with the inverter output. Since there is no direct connection with the UPS power conversion devices, these breakers are typically equipped and adjusted per facility and NEC requirements. These breakers are shown in the figures as:

MBP: maintenance bypass breaker; wraps around the UPS power conversion circuits, providing power to the critical load while the UPS is being serviced

MIS : maintenance isolation breaker; in series with the UPS output, isolating the UPS output bus from load power.

Other considerations:

UPS rectifier input breaker trips during battery test

When the UPS performs an automatic or manual battery test, it back feeds current (watts) back into the breaker that feeds the UPS rectifier, sometimes labeled RIB. The level of current varies depending on how much load is on the output of the UPS, and the duration of the test (minutes), makes time delay adjustment unlikely.

Solution

Disable the battery test or change the setting to run the test with 'output load' only.

Isolation transformer equipped UPS conversion to transformer-less type UPS

Often to facilitate reuse of existing electrical infrastructure within a facility, older transformer equipped UPS will be replaced with modern transformerless UPS in a similar configuration. In these situations, the existing switchboards and circuit breakers are reused. Because the transformerless UPS that is replacing the transformer equipped UPS has different electrical characteristics (and often higher differential currents) during parallel operations with the utility source, LSIG equipped breakers could trip that previously operated normally with the transformer equipped UPS.

Recommendation or solution

Maintain above recommendations for parallel connected UPS, as applicable

Summary

The use of LSIG trip features with transformerless UPSs requires consideration and planning beyond what was previously necessary with isolation transformer-based UPS systems. However, the utilization of a single LSIG in the main feeder or service to the UPS will save money and reduce complexity, while still meeting the national electrical code requirements for fault protection on larger feeders. During the design and planning stages, consultation with the circuit breaker vendor and the UPS vendor is strongly recommended.