On The Job: In The Field

Selective Coordination Vs. Arc Flash Protection?

NEC Article 240.87

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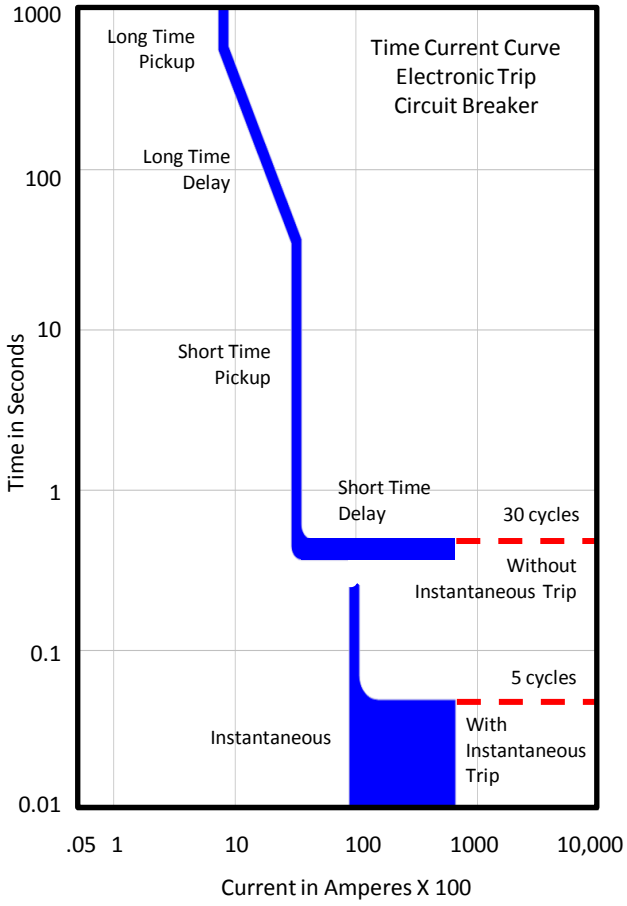
When selective coordination is critical, e.g., minimizing the extent of an outage, a common design practice is to use a main circuit breaker without an instantaneous tripping function and feeder breakers with one. Without an instantaneous, the main can time delay up to 30 cycles or 0.5 seconds based on the short time-delay setting as illustrated on the time-current curve (TCC). This allows the feeder breaker enough time to trip first and clear the fault.

Although this design might provide good coordination between the main and feeder breakers, what if the fault is an arc flash that occurs on the main bus? The main breaker's 30-cycle time delay would seem like an eternity in this case.

The goals of providing selective coordination by including a time delay and reducing the incident energy with fast clearing times are in direct conflict with each other. If the main circuit breaker trips instantaneously, it may limit the arc flash duration to five electrical cycles (0.083 seconds) based on the TCC. However, without an instantaneous trip, the main could take as long as 30 cycles to clear. Since the total incident energy of an arc flash depends on its duration, a six-fold increase in duration (30 divided by 5) would result in an equal increase in incident energy, possibly to a level too dangerous to perform any energized work, even with personal protective equipment.



The conflict between using a time delay for selective coordination and instantaneous tripping to reduce the arc flash duration led to the introduction of a new article in the 2011 edition of the National Electrical Code (NEC).

The new article, 240.87 Noninstantaneous Trip, states: "Where a circuit breaker is used without an instantaneous trip, documentation shall be available to those authorized to design, install, operate or inspect the installations as to the location of the circuit breaker(s).

"Where a circuit breaker is utilized without an instantaneous trip, one of the following or approved equivalent means shall be provided:

1 "Zone-selective interlocking

2 "Differential Relaying

3 "Energy-reducing maintenance switching with local status indicator."

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What are these three means that are referenced, and how do they help solve the conflict?
Zone-selective interlocking—Also known as ZSI, this scheme allows different zones of protection (main and feeders) to communicate with each other. If the fault is downstream from the feeder, the feeder will send a signal to the main, telling it to restrain from tripping instantaneously. Instead, the main will time out based on its other settings (usually short time delay).

This allows the feeder to clear the fault first. However, if the fault is between the main and feeder, the feeder does not see the event, so no restraining signal is sent to the main. In this case, it trips instantaneously. This allows the main to have high-speed fault-clearing capability for local bus faults, while allowing it to time-delay for feeder faults.

Differential relaying—The concept of this protection method is that current flowing into a protected device must equal the current flowing out of the device. If these two currents are not equal, a fault must exist within the device, and the relaying can be set to operate for a fast interruption. Differential relaying uses current transformers located on the line and load sides of the protected device, which typically would be a larger transformer, generator or substation bus.

Energy reducing maintenance switch—This switch allows a user to "temporarily" enable a "no intentional time delay" setting, i.e., instantaneous trip. Many electrical equipment manufacturers have introduced this type of switch with their equipment. Although the switch does not eliminate the arc flash hazard, it can reduce the duration with a faster clearing time. Once the energized work is completed, the maintenance switch is placed back to its normal position, which restores the device's original settings.

When it comes to the conflict between coordination and arc flash protection, each of the three methods found in this new NEC article can help provide the best of both worlds: Time delay for selective coordination when it is important and high speed clearing when it is necessary during energized work, which is work that should always be kept to a minimum!

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