Recent Trends and Innovations in Arc Flash Assessment

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New equipment and innovations are resulting in improvements in arc flash systems and providing a safer work environment for personnel involved in the maintenance of electrical equipment. Also, some old established methods are being revisited. Coordination of instantaneous devices in series is a new field, as well as the development of current limiting low voltage molded case circuit breakers. There are also innovations in the construction of low – voltage MCCs, a new breed of low - voltage trip programmers, remote racking of MCC buckets and more.

Arc Flash Statistical Data

Statistical information of the arc flash hazard is presented in Figure 1. This figure shows the number of buses at various voltage levels in the electrical distribution systems. Majority of buses, 84.7%, are at low voltage levels. Figure 2 presents the buses' arc flash energy; for instance, it indicates that 5% of the total buses have a hazardous incident energy level of 40–100 cal/cm^2 and on 1% of the buses the incident energy surpasses 100 cal/cm^2. Table 1 displays annual exposure for each equipment type. This table indicates that the annual exposure on low voltage MCCs is 365, on other low voltage devices 52, and on low voltage switchgear 12. The complete yearly exposures are 459, out of which 429 are on the low voltage devices, that is, 93.4%. The exposure on low voltage MCCs alone is 79.5%. This is in line with industry development, which is focused on low voltage devices. In the design stage, by simply decreasing the ratings of low voltage transformers, short- circuit levels can be decreased, which in turn affects the incident energy levels.

Table 1. Yearly arc flash exposures for different devices and voltage levels

Device	Yearly arc flash exposures
HV(>34 kV)	2
MV (1-34 kV)	4
MV MCCs	24
LV Switchgear	12
LV MCCs	365
Other LV equipment	52

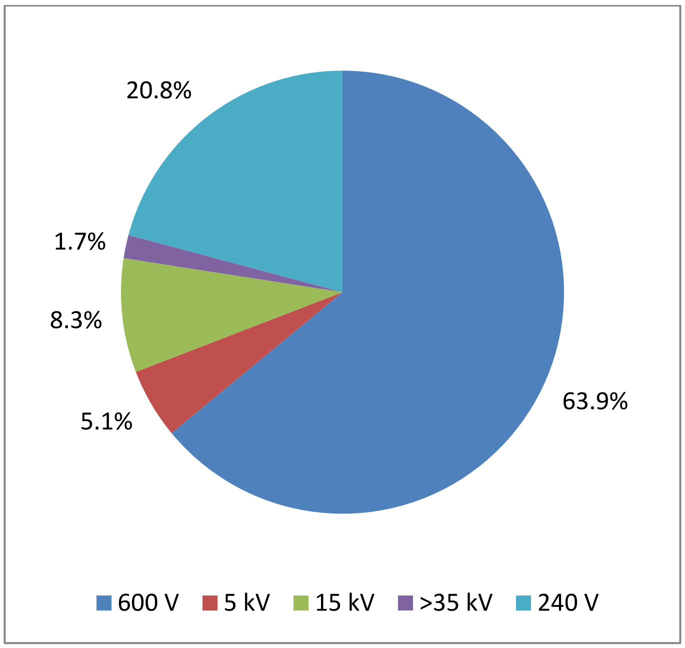

Figure 1. Statistical information of arc flash hazard with respect to different voltage levels in industrial electrical networks

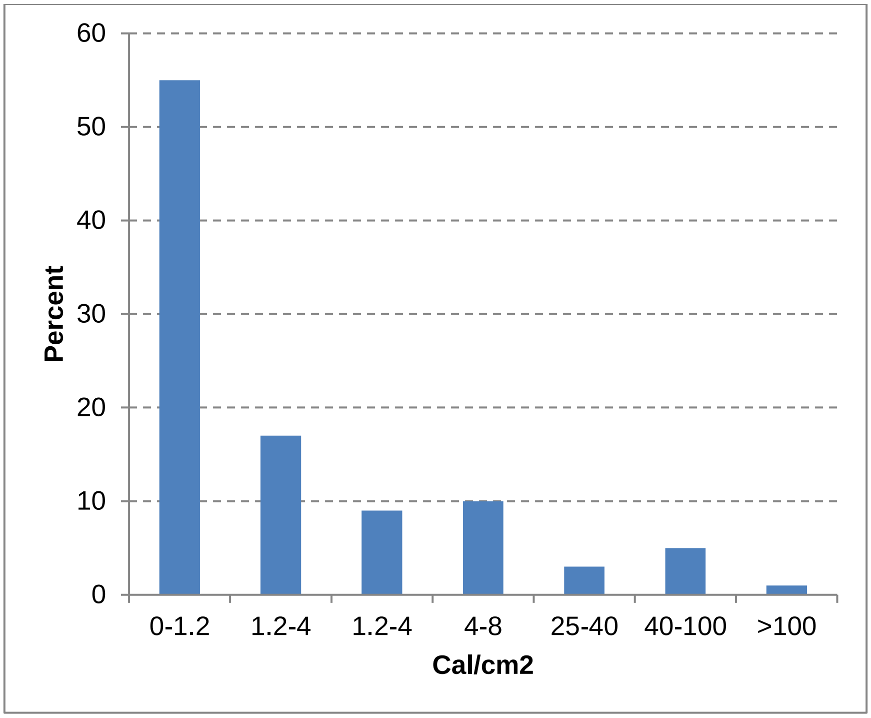

Figure 2. Incident energy release versus percentage of buses

Zone-Selective Interlocking Arrangements

Zone - selective interlocking (ZSI) is an old concept revisited for arc flash mitigation. It can also be used for medium voltage electrical systems and maintain the selective coordination between main, tie and feeder circuit breakers allowing fast operation between equipment desired zones. This is accomplished through wired connections between trip elements and protection relays. If a feeder discovers a fault, it sends a restraint signal to the main circuit breaker, but for a short circuit on the bus, the main circuit breaker does not receive a downstream restraint signal and operates without any delay. The restraint logic is not instantaneous, and there is certain time delay related to it so that there is no unrestrained tripping of the main. For security, a delay of 20ms can be used, although it is different from manufacturer to manufacturer. Typically, attention has to be paid to motor loads. A motor load will increase the bus fault current, and the feeder circuit breaker should not emit a restraint signal upstream when the motor contribution short circuit current goes through it. There can be multiple sources of power to a bus, and when several sources feed into a fault location, the zone interlocking system will be challenging to use, and differential protection can be used.

Low Voltage ZSI Arrangements

Common low voltage distribution from a substation transformer is presented in Figure 3. The feeder circuit breakers and main circuit breaker use ZSI scheme.

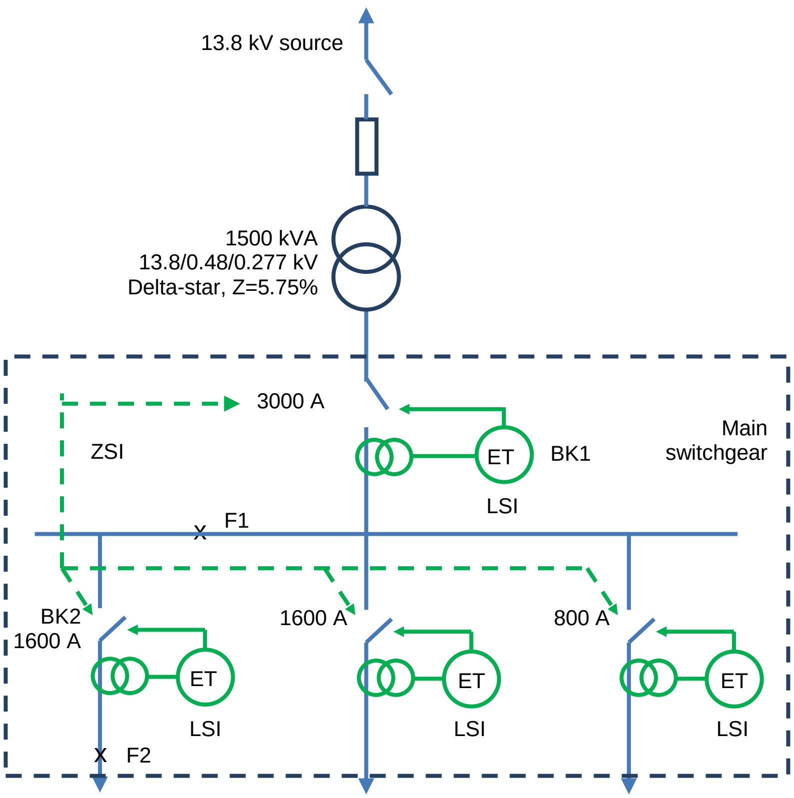

Figure 3. Zone interlocking scheme between feeder and main secondary circuit breaker of a low voltage transformer

For a fault at location F_1, the main circuit breaker does not get a restraint signal, and it operates with no intentional delay. For a fault at location F_2, the main circuit breaker gets a blocking signal and operates on short-time delay, allowing the feeder circuit breaker to first break the short circuit current. Figure 4 presents yet another arrangement.

Consider that the current sensors (CTs) linked to 50/51 protection relay R1 are installed in the transformer secondary terminal enclosure, and the protection relay itself is installed on the low-voltage switchgear. For a short circuit on the load side of the feeder circuit breaker F_2, it emits a signal to protection relay R1, and the standard settings can be used for coordination. For a short circuit fault at location F1, there is no ZSI signal, and the R1 uses a definite time delay, which is way faster than the delay necessary for coordination. It can be concluded that a coordination step between two elements in series is much decreased, reducing the arc flash hazard.

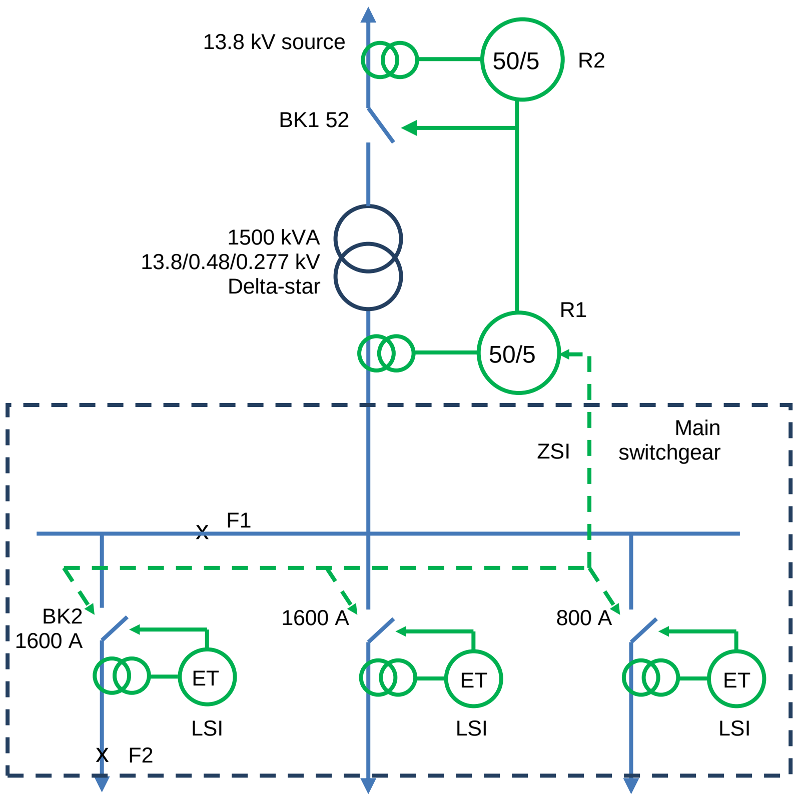

Figure 4. Zone interlocking mechanism between feeder and main secondary circuit breaker and also primary breaker of a low voltage transformer

Example 1

Figure 5 presents a part of a distribution system from a 1500-kVA substation transformer. The main circuit breaker BK1 and feeder circuit breakers BK2 are zone interlocked. Figure 6 presents a three-step coordination. The 400-A circuit breaker BK3 supplying the panel is a current limiting circuit breaker. Circuit breakers BK1 and BK2 are LVPCBs using electronic trip programmers.

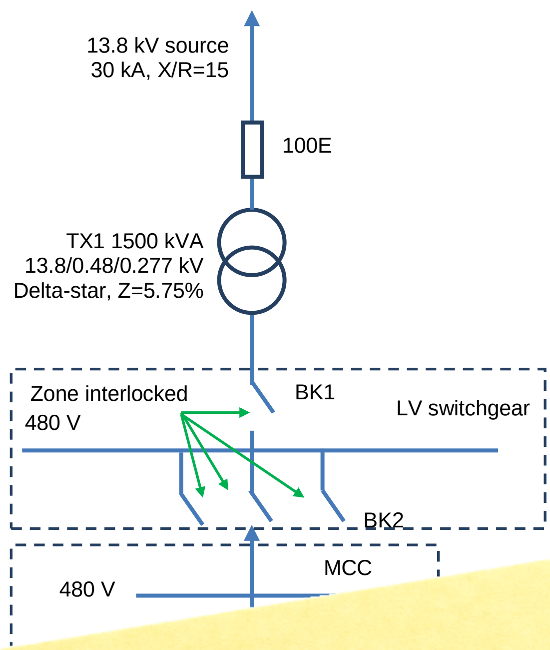

Figure 5. A lo ... zone interlocking

The coordination pr ... king options. For a bus short circuit, no sig ... uit breakers BK2, and circuit breaker BK1 ... time delay band. In coordination, conser ... nd maximum clearing time is considered. I ... kers BK2, the main circuit breaker BK1 ... rmal coordination is applicable. That mea ... where it is. Therefore the feeder circuit breaker selectiv ... ves the fault. With zone interlocking, the incident energy