



Recent Trends and Innovations in Arc Flash Assessments

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RECENT TRENDS AND INNOVATIONS IN ARC FLASH ASSESSMENT

New equipment and innovations are marking improvements in arc flash systems and give a safer work environment for the staff involved in maintenance of the 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, new breed of low - voltage trip programmers, remote racking of MCC buckets etc.

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 hazardous incident energy level of 40–100 cal/cm² and on 1% of the buses the incident energy surpasses 100 cal/cm². 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 the 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 flash exposures
HV(>34 kV)	2
MV (1-34 kV)	4
MV MCCs	24
LV Switchgear	12
LV MCCs	365
Other LV equipment	52

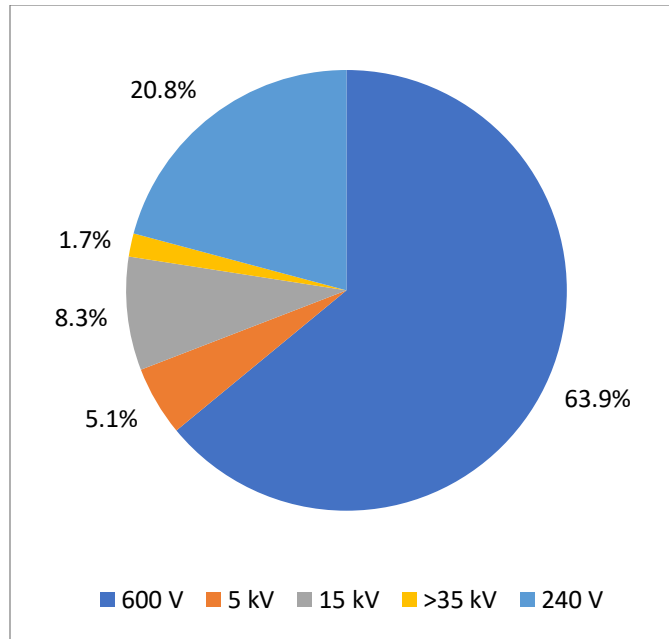


Figure 1. Statistical information of arc flash hazard with respect to different voltage levels in industrial electrical networks

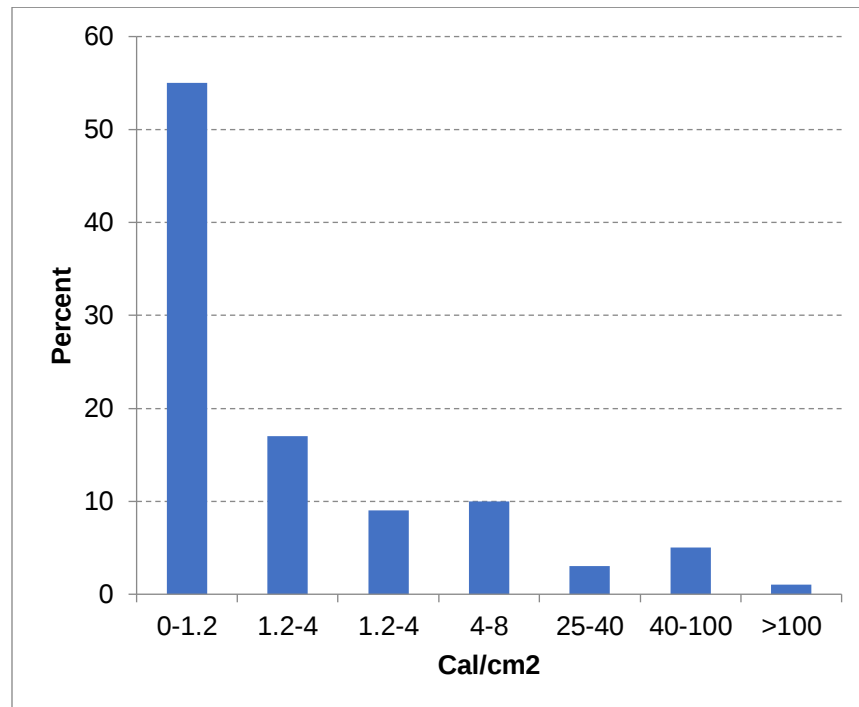


Figure 2. Incident energy release verses percentage of buses

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 with 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.

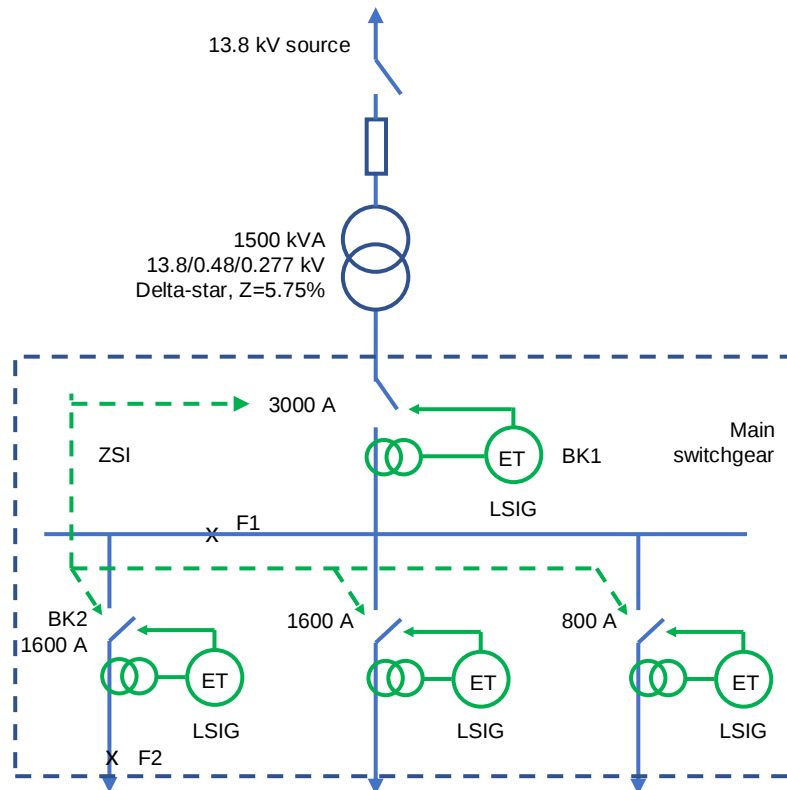


Figure 3. Zone interlocking scheme between feeder and main secondary circuit breaker of a low voltage transformer

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 F_1 , 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.

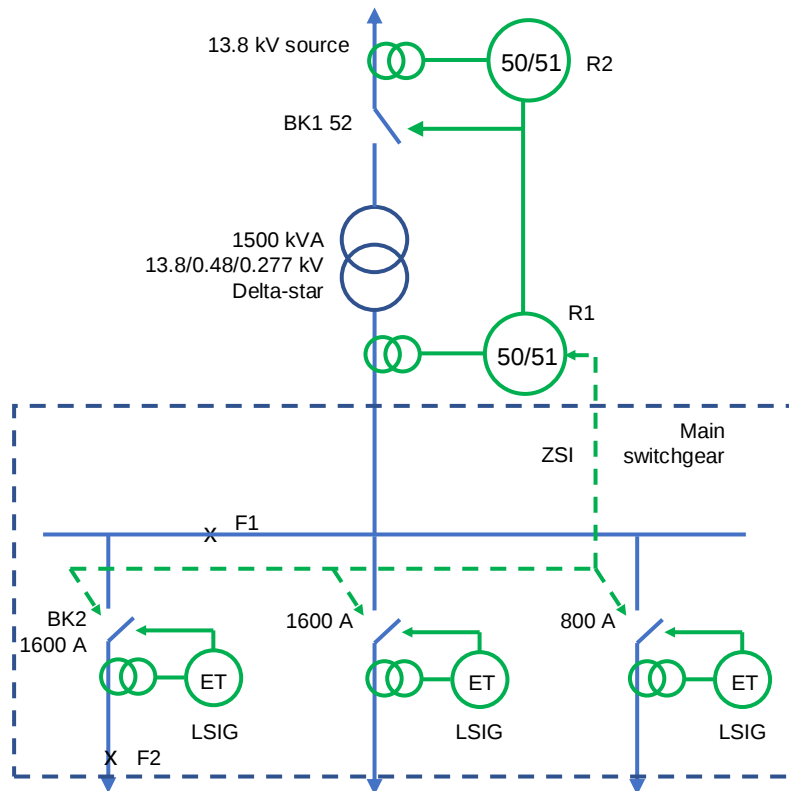


Figure 4. Zone interlocking mechanism between feeder and main secondary circuit breaker and also primary breaker of a low voltage transformer

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 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.

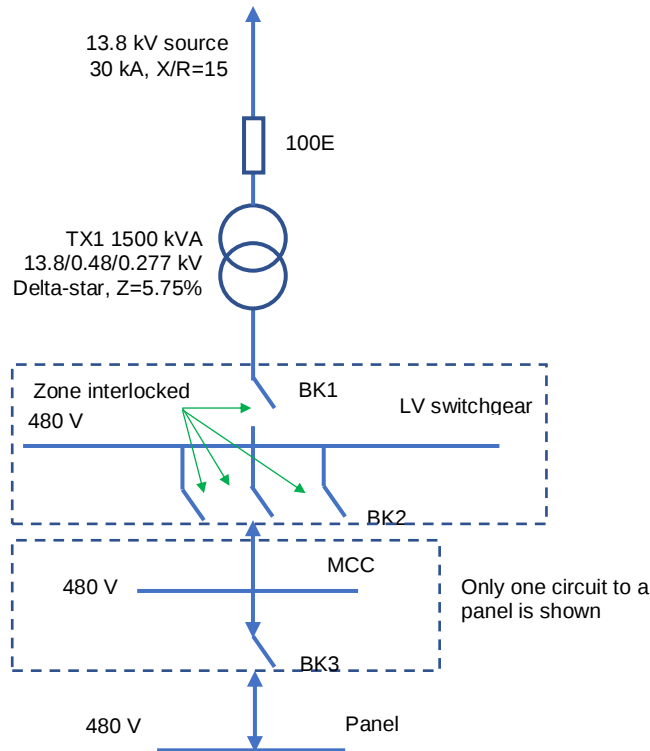


Figure 5. A low voltage electrical distribution system for zone interlocking assessment

The coordination presented in Figure 6 displays the zone interlocking options. For a bus short circuit, no signal to block the trip is got from feeder circuit breakers BK2, and circuit breaker BK1 removes the short circuit with its short-time delay band. In coordination, conservative steps are taken, and the short-time band maximum clearing time is considered. For a fault on the downstream of circuit breakers BK2, the main circuit breaker BK1 does not get any restraint signal and the normal coordination is applicable. That means the characteristic remains where it is. Therefore the feeder circuit breaker selectively removes the fault. With zone interlocking, the incident energy release is considerably reduced. In Figure 6, it looks that there is no coordination between the instantaneous characteristics of circuit breaker BK2 and BK3. Nevertheless, circuit breaker BK3 is a current-limiting circuit breaker, and the coordination on instantaneous basis can be achieved. Even though these two circuit breakers do not seem to coordinate in the TCC plot, on a current let-through basis, these breakers do coordinate.



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