



DET-1002

2017 National Electric Code[®] Updates

NEC[®] 240.87 Arc Energy Reduction, for Circuit Breakers

NEC[®] 240.67 Arc Energy Reduction, for Fusible Switches

Table of Contents

2017 National Electrical Code Updates	4
240.67 Arc Energy Reduction - Part VI Cartridge Fuses and Fuseholders.....	4
240.87 Arc Energy Reduction - Part VII Circuit Breakers	4
Protection Thresholds	5
Circuit Breakers	8
GE ArcWatch® Technology.....	8
Wave Form Recognition (WFR)	9
Fusible Switches.....	11
GE's UL 977 Listed High Pressure Contact Switches, HPCII	12
Solution by Solution Description of How to Meet 240.87 and 240.67	13
1. Zone-Selective-Interlocking, 240.87 (B)(1)	13
2. Energy-reducing maintenance switch with local status indicator, 240.87(B)(3) and 240.67(B)(2)	14
3. Energy-reducing active arc flash mitigation system, 240.87 (B)(4) and 240.67(B)(3).....	15
4. An Approved Equivalent Means, 240.87(B)(7) & 240.67(B)(4)	17
Related GE Product Information and Related GE Services	18
Arc Flash Study.....	18
Best practices	18
Entellisys* 5.0 LV Switchgear - One Solution for All	18
Arch Flash Mitigation	19
2017 National Electric Code Updates	20
Technical Data	21
Protection	21
Architecture and Hardware	21
Metering and Diagnostics.....	21
Digital I/O and Control	21
External Communication	21

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2017 National Electrical Code Updates Mandating Additional Measures for Arc Flash Energy Reduction

The 2017 edition of the NEC has now has two section that address additional requirements for arc flash energy reduction.

One is 240.87 which address circuit breakers rated at 1200A or larger. And one is an entirely new section, 240.67, which describes somewhat similar requirements for fusible switches with fuses rated 1200A or larger.

NEC 240.87 Arc Energy Reduction - Arc Flash Circuit Breaker Requirements for 1200A or more (Note: Changes from 2014 NEC Edition are shown in orange.)

Part VI. Cartridge Fuses and Fuseholders

240.67 Arc Energy Reduction

Where fuses rated 1200 A or higher are installed, 240.67(A) and (B) shall apply. This requirement shall become effective January 1, 2020. (This section is completely new in the 2017 NEC.)

A) Documentation

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the fuses.

B) Method to Reduce Clearing Time

A Fuse shall have a clearing time of 0.07 seconds or less at the available arcing current, or one of the following shall be provided:

1. Differential relaying
2. Energy-reducing maintenance switching with local status indicator
3. Energy-reducing active arc flash mitigation system
4. An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc flash boundary as defined in NFPA 70E®-2015, Standard for Electrical Safety in the Workplace, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the disconnect switch or the settings of other devices is required during maintenance when a worker is working within an arc flash boundary as defined in NFPA 70E-2015, Standard for Electrical Safety in the Workplace.

Part VII. Circuit Breakers

240.87 Arc Energy Reduction

Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200A or higher, 240.87(A) and (B) shall apply.

A) Documentation

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s).

B) Method to Reduce Clearing Time

One of the following means shall be provided:

1. Zone-selective interlocking
2. Differential relaying
3. Energy-reducing maintenance switching with local status indicator
4. Energy-reducing active arc flash mitigation system
5. An instantaneous trip setting that is less than the available arcing current
6. An instantaneous override that is less than the available arcing current
7. An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc flash boundary as defined in NFPA 70E®-2015, Standard for Electrical Safety in the Workplace, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc flash boundary as defined in NFPA 70E-2015, Standard for Electrical Safety in the Workplace.

Informational Note No. 3: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when current exceeds the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level the circuit breaker will trip in the minimum possible time.

Informational Note No. 4: IEEE 1584-2002, Guide for Performing Arc Flash Hazard Calculations, is one of the available methods that provide guidance in determining arcing current.

Exactly how some of the allowed remedies in these code sections will be enforced may depend on local AHJ interpretation, the quality of the documentation provided for the remedy implemented and the ability of the AHJ to interpret that documentation. So it may be important to check with the AHJ to ensure that the method to be used will be acceptable. In addition it is clear that the intent of the writers of these code sections intend to improve the safety of the installation for those that must use and maintain the equipment for many years. However, the reality is that the letter of these code sections could be met without meeting the safety related intent. This document will explain how these requirements may be met, both the letter, and the intent.

Protection Thresholds Are Important

The methods defined by the code for energy reduction may be divided into two types. Those that explicitly require knowing the expected arcing current [240.87 (5) & (6), and 240.67 (B)] and those that do not explicitly state that requirement but should! Any “robust” arc flash energy mitigation solution should be implemented with the understanding of what the estimated arcing fault current may be in the circuit intended to be protected and the expectation that the sensing will operate below that range to assure the fastest possible protection when an arcing fault occurs. The further below the estimated arcing current the protection threshold is the more robust (reliable) is the protection.

Per IEEE 1584-2002, IEEE Guide for Performing Arc Flash Hazard Calculations, expected arcing current can be determined from three important parameters, two of which are typically known for electrical systems and another for which IEEE 1584-2002 offers some guidance.

- System phase-to-phase voltage
- System short circuit current
- Arcing gap

In the US the system voltages typically are 208V, 480V or 600V. The IEEE 1584 -2002 equations allow for a range of low voltage ratings up to 600V. Subsequent editions of IEEE 1584 may define equations for voltage range from lower voltage to medium voltage continuously.

Short circuit current is a parameter usually obtained via a short circuit study and will usually depend on information provided by the serving utility. Especially when the serving utility provides the transformer to which the service entrance equipment is connected. Short circuit current can be a tricky parameter to determine appropriately for the purpose of estimating an expected arcing current. The industry is used to estimating this parameter high. That is a conservative and appropriate course of action when the intent is to determine the minimum required short circuit rating of equipment and overcurrent protective devices. If equipment and protective devices are rated higher than the installed system actually needs the interests of insuring a safe installation are served. When estimating short circuit ratings the direction in which to bias error to be conservative is understood. However, when estimating the potential value of arcing current during an arcing fault it is important to not exaggerate the available bolted fault current towards a high value. The value used should be as accurate as possible, or a range of values should be used that includes the possible short circuit current available based on variations in system topology, upstream utility fault current and variations in the connected transformer’s impedance and even mistakes in the various assumptions used to determine system impedance. For the purpose of the intent of this code section the conservative course of action is to estimate this current low so that the needed setting is sensitive enough to sense whatever arcing current may occur. An error towards a low value in this case may provide a more robust implementation of the protection solution and ensures the method implemented works when needed. For calculating arc flash incident energy, the conservative course of action is to consider a “range” of potential fault currents.

Arcing gap is usually determined based on guidance offered in IEEE 1584-2002, table 4, page 12. The table shown is an excerpt from the table in IEEE 1584-2002

Excerpt from:

Table 4 - Factors for equipment & voltage classes

IEEE 1583-2000, Pg. 12

SYSTEM VOLTAGE (kV)	EQUIPMENT TYPE	TYPICAL GAP BETWEEN CONDUCTORS (mm)
0.208-1	Open Air	10-40
	Switchgear	32
	MCC & Panels	25
	Cable	13

Generally, arc flash studies are performed using 32 mm gap for UL 1558 Switchgear and 25 mm gap for switchboards, panels and motor control centers (see excerpt from table 4). However, other values could be used if better information is available.

Factors that influence arcing current, and how, are:

- The higher the voltage and the higher the available short circuit current the higher the arcing current will be.
- The larger the arcing gap, the lower the arcing current will be.

The IEEE 1584-2002 model also defines a calculation of a 100% arcing current and an 85% arcing current in an attempt to capture data variance observed during the controlled laboratory tests used to develop the model. This range is not an attempt to capture potential variance due to real-world conditions, such as conservative utility data, incorrect impedance assumptions, variable topologies, source instability, etc. Following are some graphs that could be used to estimate arcing current for a range of factor values. To determine if a protective setting is low enough only the 85% arcing current is relevant, hence only the 85% value is shown in the graphs.

As can be seen from the graphs in figures 1, 2, and 3; below the arcing current (I_a) / available short circuit current (I_{bf}) ratio is not quite a linear relationship (constant fraction) with respect to available short circuit current, however it can be roughly estimated , for equipment gaps of 25-32mm as follows:

Fig. 1. 20% for 208 V

Fig. 2. 40% for 480 V

Fig. 3. 50% for 600 V

A closer inspection of the graphs below, or better still, and arc flash study should yield more exact results. However, as a rule-of-thumb-estimate prior to a full detailed short circuit study and arc flash study being available these ratios could be used as conservative estimates of the threshold below which protective device instantaneous settings need to operate to fulfill the requirements of the code and to ensure any protection provided will operate at optimal sensitivity.

Now the question may be; how realistic is it to expect circuit breakers, fuses or any other sensing to operate in at that needed setting when the protection may normally may be set in a system? Well, that depends...

Regardless of the method used to satisfy the requirements of the code section:

- Instantaneous protection - 240.87 (5) & (6)
- Energy Reducing Maintenance Switch - 240.87 (3), 240.67 (2)
- Differential 240.87 (2), 240.67 (1)
- ZSI - 240.87 (2)
- Acceptable alternative or active arc flash mitigation system - 240.87 (4) & (7), 240.67 (3) & (4)

The sensing that operates the protection should operate at some threshold current below the expected arcing current including all sensing tolerances. The lower the threshold the more robust, or reliable, the protection is.

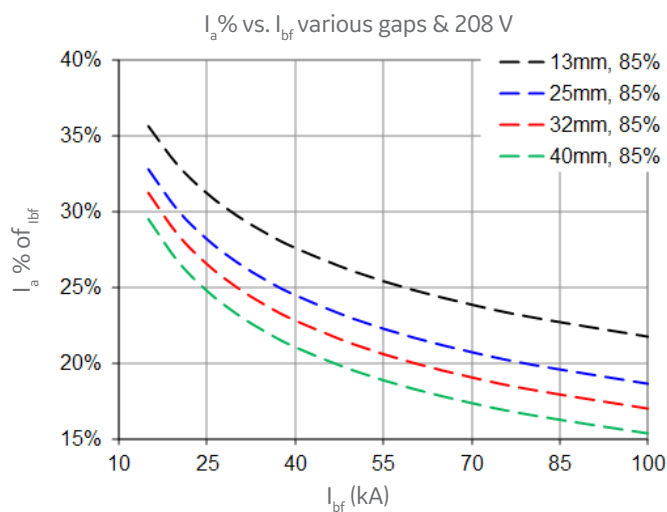


Fig. 1. Arcing Current (I_a) and available short circuit current ratio, 20% for 208 V

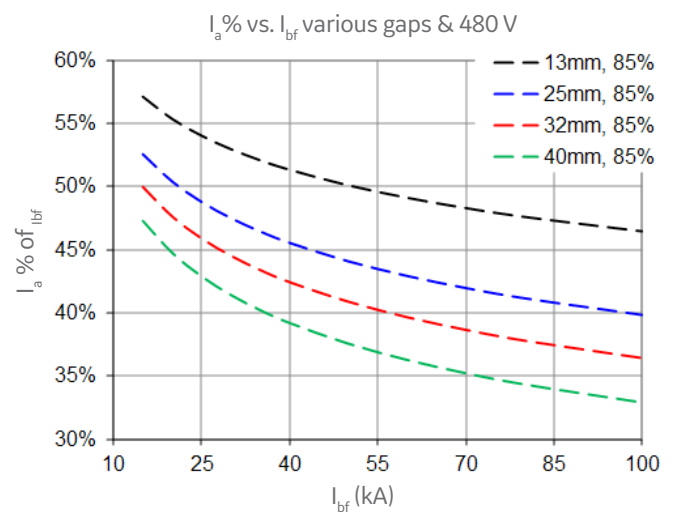


Fig. 2. Arcing Current (I_a) and available short circuit current ratio, 40% for 480 V

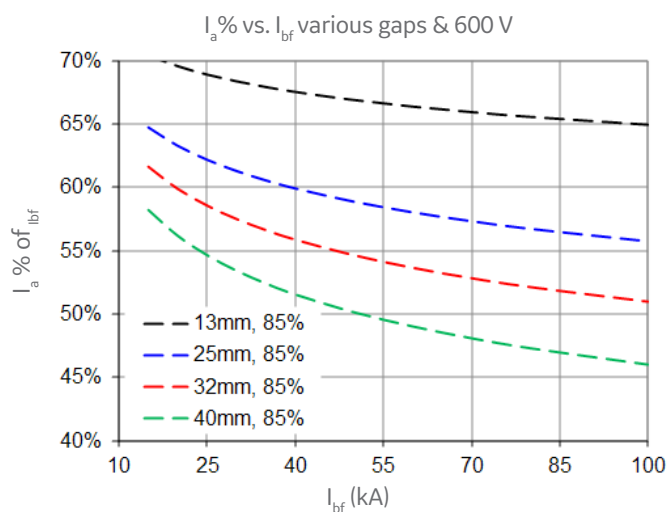


Fig. 3. Arcing Current (I_a) and available short circuit current ratio, 50% for 600 V

Available Technology

Circuit Breakers

Circuit Breakers are available in two types. Molded Case Circuit Breakers (MCCB) and Low Voltage Power Circuit Breakers (LVPCB). The MCCB category also includes Insulated Case Circuit Breakers (ICCB) which is a type of MCCB but share characteristics from traditional MCCB and LVPCB. ICCB and MCCB are listed to UL489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures. MCCB and ICCB always have instantaneous protection. Some manufacturers may call the maximum threshold for that instantaneous protection an Override. But in all MCCB it's there by one name or another. The maximum value may range from 9X the nominal frame size to 15X, or more in some rare cases. ICCB often have higher multiples of sensor or frame size than traditional MCCB. It is advisable to understand what the maximum setting is for the MCCB and ICCB rated at 1200A and above in the system are. If the maximum value is under the expected arcing current then the requirements of 240.87 will be easily met using the method outlined in (B)(5) or (B)(6). The AHJ may interpret the proposed solution in terms of the documented setting or installed fuse, or in terms of the maximum setting possible, or the slowest/largest fuse that "could" be installed.

Low Voltage Power Circuit Breakers are listed to UL 1066, Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures. LVPCB may offer very high instantaneous protection thresholds and may offer the user flexibility to turn instantaneous protection completely off. Some may include an Override, but some may not. If using LVPCB one should know what instantaneous setting will be used and what the override level will be, if one is provided, after the coordination study is performed.

Low sensitive instantaneous settings are necessary for good robust Arc Flash protection however they can be difficult to achieve if a system is coordinated for good selectivity. However, the ability to implement low sensitive instantaneous settings while maintaining selectivity is one of the functions at which GE excels due to GE's Arc Watch® technology!

Traditionally selectivity is often achieved by increasing protection thresholds and increasing protection delays to allow downstream devices to operate before upstream devices operate for the same fault current. GE's Arc Watch® technology provides a way to achieve selectivity with lower instantaneous pickup thresholds. GE's Publication DET-760¹ provides details on how to achieve this with various GE circuit breaker products featuring GE's Arc Watch® selectivity and arc flash protection technology. GE's Arc Watch® technology relies on two intertwined technologies: GE's Waveform Recognition Instantaneous algorithm and GE's fast and powerful Zone-Selective-Interlocking (ZSI).

GE ArcWatch® Technology

GE Zone Selective Interlocking (ZSI) Application Guide for GE EntelliGuard TU™ and MicroEntelliGuard™ Trip units in UL listed circuit breakers (UL 489 & UL 1066) and UL listed GE HPC II™ Power Switches (UL 877)



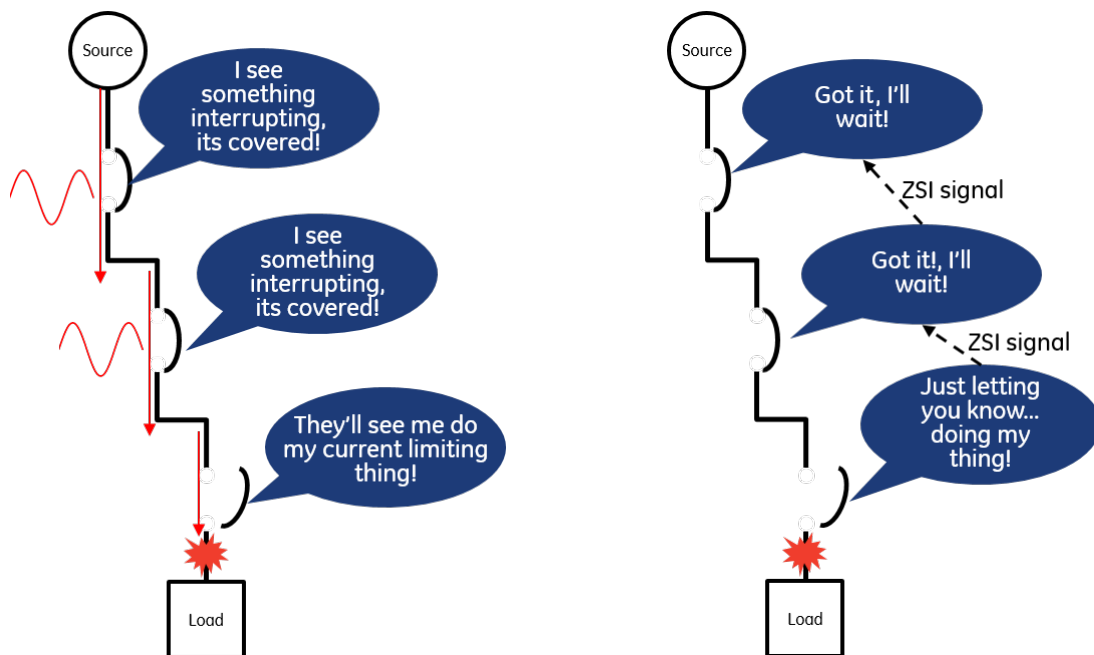
GE's ZSI implementation includes several unique abilities. The two most relevant to this discussion are Instantaneous ZSI and Threshold ZSI. ZSI allows multiple tiers of large circuit breakers to operate as a system with small overloads or large faults.

¹ <http://www.geindustrial.com/publibrary/search/keyword/760> GE's Guide to Instantaneous Selectivity, DET1001 on ZSI application.

Each circuit breaker will only operate when needed and act as back up only when necessary. GE's I-ZSI capability provides the one of the fastest interlocked protection in the industry. The dedicated threshold allows it to operate separately and in addition to any short time protection the circuit breaker may employ. You can get instantaneous protection, selectively, regardless of the size of your system or main circuit breaker. The T-ZSI function allows threshold of upper tier devices in large systems, such as main or ties, to implement completely overlapping short time and instantaneous thresholds while still maintaining full selective coordination². This may be particularly important in 208 V systems or weak systems with low short circuit current. See GE DET-760D for additional details on selective coordination with GE CB and DET1001 for additional detail on applying ZSI.

Wave Form Recognition (WFR)

GE's Adjustable Waveform Recognition Instantaneous algorithm allows a circuit breaker (upstream from a panel or MCC that has current limiting fuses or circuit breakers) to be set very sensitive and still it at arcing current levels. What's more, the setting is not dependent on a complex coordination study; it simply depends on the device with which you are trying to be selective. The required tables to see the needed settings are shown in GE's publication DET-760D and can also be seen in the time current curves for the current limiting molded case circuit breakers.



WFR: The trip unit can see the current limiting device downstream interrupt by simply looking at the fault current waveform

ZSI: The interrupting trip unit tells upstream trip units its interrupting via the ZSI restraint signal

These simple diagrams represent how the circuit breakers interact using ZSI or WFR to simultaneously provide selective coordination & arc flash mitigation.

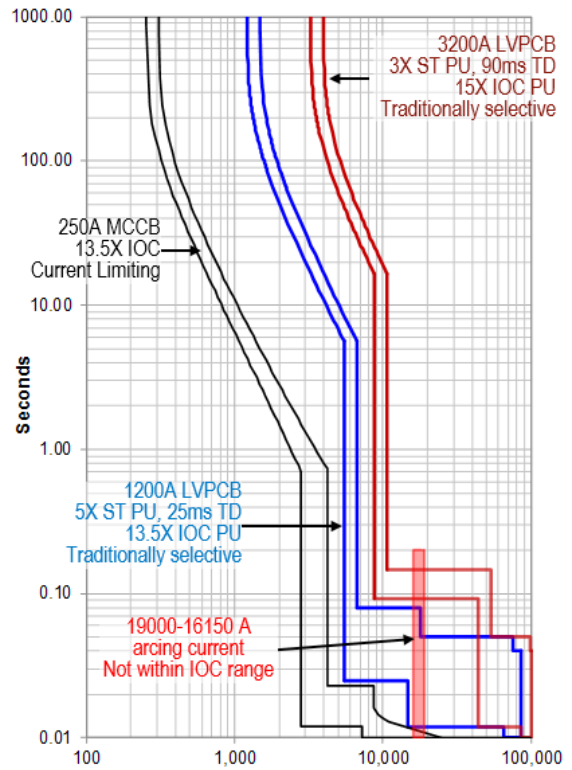
² See definition of Coordination, Selective (Selective Coordination). NFPA 70 (NEC) – 2017, section 100, page 70-35

GE WFR and I-ZST Example:

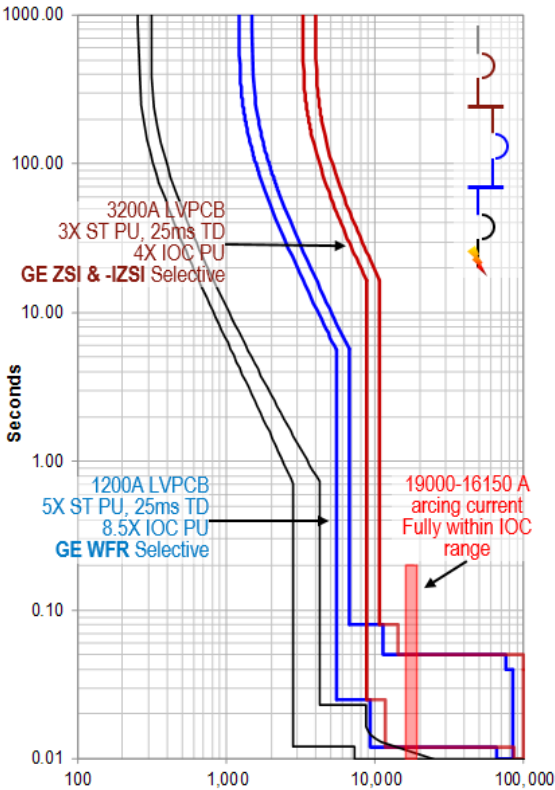
Time-Current-Curve 1 (TCC-1), shows three CBs set to be selective in a traditional manner; pickup thresholds and delays set so that curve overlap is minimal. The 19kA – 16.15kA arcing current on the TCC shows the 1200A CB instantaneous adjusted too high and not fully to the right of the arcing current. The instantaneous does not protect for the expected arcing current, what 240.87 intends to prevent.

TCC-2 represent the same 3 circuit breakers but this time the CBs are set using GE Arc Watch technology; The 1200A feeder is set at a lower IOC pickup that is good enough to be selective with the 250A feeder up to 85kA even though the 1200A CB IOC is set to 8.5x1200, or 10,200 A. The 3200A main upstream is set slightly to the right at 4x3200, or 12,800A. The 3200 A circuit breakers ST delay is now set at the same delay as that of the 1200A feeder; 25ms commit almost instantaneous.

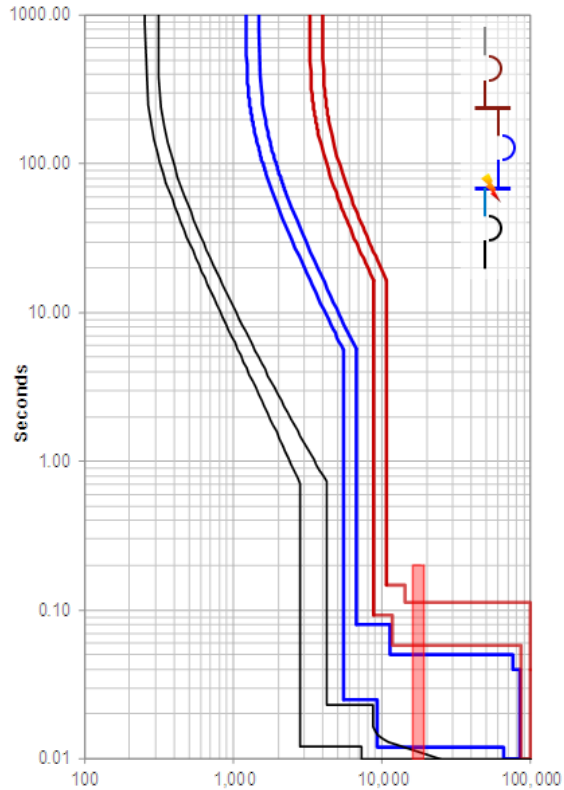
Though the CBs in TCC-2 do not seem selective because the curves overlap, they are selective thanks to GE's Arc Watch® technology. WFR allows the 1200A CB to discern when to trip and when not to trip due to the 250A current limiting circuit breaker's response to fault current. And, as shown in TCC3, the 3200A circuit breaker gets out of the way when it receives the ZSI restraint signal from the 1200A circuit breaker. GE's Arc Watch ensures fast instantaneous protection at any level in the system meeting the user's electivity goals and NEC 240.87 demands simultaneously.



TCC-1. Traditionally selective system: desensitized thresholds & slowed delays. Does not meet 240.87 requirements at either the 1200 A or the 3200 A CB



TCC-2. GE WFR, ZSI and I-ZSI selective system: sensitive thresholds & minimum delays meets letter & intent of 240.87 for both the 1200 and 3200A CB



TCC-3. 3200A CB shifts ST and IOC to allow 1200A CB to protect for downstream fault. 3200A remains selective up to 85kA

Fusible Switches

Section 240.67 adds similar requirements to those found in 240.87 but for fused disconnect switches with 1200 A or larger fuses. This requirement is harder to comply with, hence the deferment to January 2020 enforcement. Nevertheless it is very important to comply with the code today because it can significantly enhance safety. Fuses are non-adjustable devices. They are excellent short circuit protective devices. Generally, nothing is faster if the fault current is high enough to cause them to operate in their current limiting range. However they can be slow if the current is less than that needed to cause them to operate in the current limiting range. Also, after one fuse melts the others see different fault current and may operate slower. Circuit breakers, on the other hand are three pole devices and all poles operate together.

There is language that allows the fuse to be sufficient protection if the arcing current is shown to cause the fuse to operate at 70 milliseconds or faster. Such exact determination may be difficult when the exact arcing fault currents are not known, and in any case to achieve the best possible protection the fuses should be operating in their current limiting range. Fuses must meet the applicable UL fuse standards which define a maximum ratio for the current limiting threshold (Current Limiting threshold A/Fuse rating). The table shows the Current Limiting Ratio and rating in amperes specified as the maximum allowed by applicable UL standards. Specific manufacturer's products will usually be lower than these values, but may vary by exact sub-type of fuse rating and manufacturer. If the values in the table are considered, the analysis will be conservative.

As should be evident in the table below, the threshold at which fuses are reliably current limiting may be quite high. As was previously discussed, arcing currents can be low, especially for lower voltage systems such as 208V systems. The combination of low arcing currents and high current limiting thresholds makes adding supplemental protection to fused system even more important than adding it to circuit breaker systems.

Luckily there is a simple solution for this dilemma: GE HPCII UL 977 listed switches.

UL Defined Maximum Current Limiting Thresholds Ratios

FUSE CLASS	RATIO
CLASS RK5	65
CLASS RK1	30
CLASS J	30
CLASS CC	30
CLASS L	30 (601-1200 Amps)
CLASS L	35 (1201-2000 Amps)
CLASS L	40 (2001-4000 Amps)

Current Limiting Thresholds in Amperes

CLASS L FUSE SIZED	CURRENT LIMITING THRESHOLD
1200	36000
1600	56000
2000	70000
3000	120000
4000	160000

GE's UL 977 Listed High Pressure Contact Switches, HPCII

GE's HPC switches are available with several features able to fulfill the requirements of 240.67 today, and more.

The main capability is the ability to provide an optional "Energy Reduction Maintenance Switch", RELT switch in GE parlance. The GE RELT function allows the user to turn on and set sensitive protection in range that may extend from 2X to 15X the switch rating which are well below the fuse's current limiting threshold and sensitive enough to sense and operate with almost any arcing fault current that could be expected. This allows the switch to economically provide the remedy described in 240.67 (B) (2) as per example described in TCC-4.

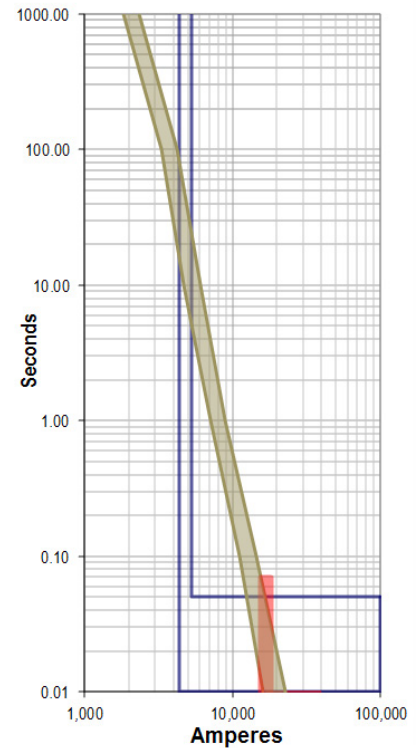
GE HPCII switches are also able to provide continuous instantaneous protection using the previously described GE's WFR instantaneous algorithm which makes the switch as selective as a circuit breaker while still provide current limiting fuse protection for high fault currents.

Users may select to implement constant selective instantaneous protection or temporary Energy Reducing Maintenance Switch protection, or both.

The GE HPCII switch is also able to implement I-ZSI in combination with the WFR instantaneous to interlock with any upstream circuit breakers that might be used upstream.

The GE HPCII switch is the cost effective solution to meet NEC 240.67 today and can provide a safer electrical system without resorting to complex or expensive solutions.

No need to wait for 2020 when you can provide safer systems, today!



TCC-4. 1200A Class L Fuse & 1200A GE HPCII Switch with RELT set 4X (4800A)

Solution by Solution Description of How to Meet 240.87 and 240.67

1. Zone-Selective-Interlocking. 240.87 (B)(1)

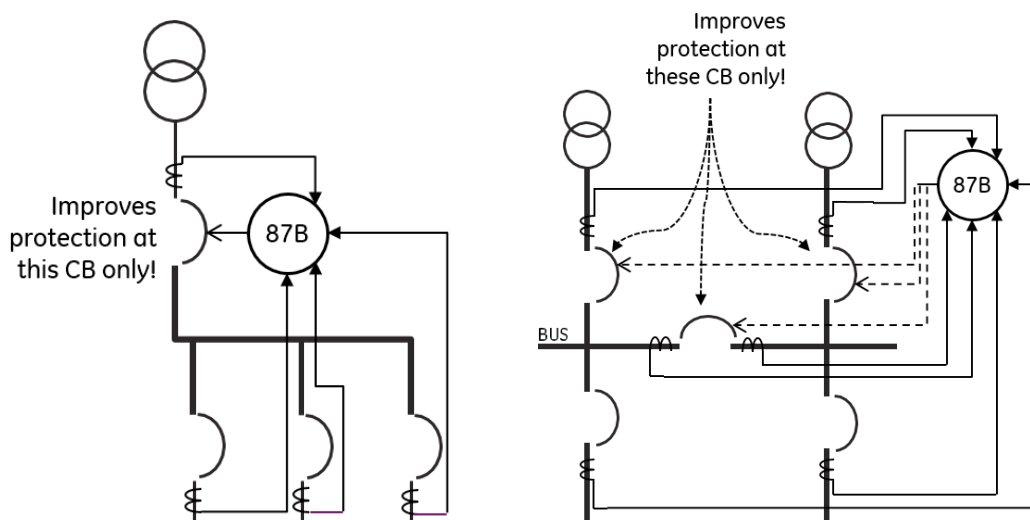
This requirement implies that the over 1200 A circuit breaker that must meet this requirement is able to operate instantaneously while being part of a ZSI scheme. Not all circuit breakers may be able to do this. Furthermore it is to be expected that the instantaneous threshold of the circuit breaker is sufficiently below the expected arcing current to ensure the circuit breaker will respond instantaneously to an arcing fault. GE circuit breakers with the I-ZSI capability should be able to provide this capability in most cases if set properly.

2. Differential Relaying (Bus Differential)³, 240.87(B)(2) and 240.67(B)(1)

Bus differential senses differences in current flowing into and out of a protected zone in the power distribution system. If the bus differential relay detects a difference that exceeds the set pickup level, it trips all the protective devices feeding (sources) that zone. The result is fast, selective protection for that zone.

A bus differential implementation connects a bus differential protective relay to dedicated CTs on every circuit in the protected zone. It provides fast protection and only operates when there is a fault in the zone, providing selectivity and protecting against in-zone faults. However it is important to realize that it improves the protection provided by the source devices in the zone. So in the diagrams below it improves protection provided by the mains and ties. It does not improve protection provided by the feeders. Furthermore Differential Relaying tends to be an expensive, space consuming and complex solution for low voltage systems. It is rarely used in LV switchgear or switchboard applications. One exception however is GE Entellisys Low Voltage UL 1558 listed switchgear. The GE Entellisys system is able to provide cost effective differential implementation as well as Instantaneous Zone-Selective-Interlocking and WFR instantaneous protection⁴ to meet 240.87 (B) (2) requirements.

Bus differential relays may be obtained from various manufacturers including GE Multilin.



240.67 (B)(1) also differential relaying to be used as a remedy for switches. However that would be an unusual implementation. GE HPCII switches could be used with differential relays to meet this requirement. However the WFR instantaneous or the GE RELT function, both available in the switches would be more cost effective solutions.

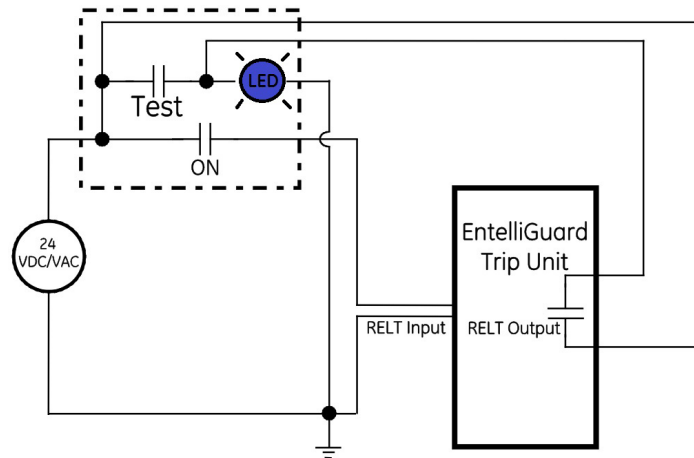
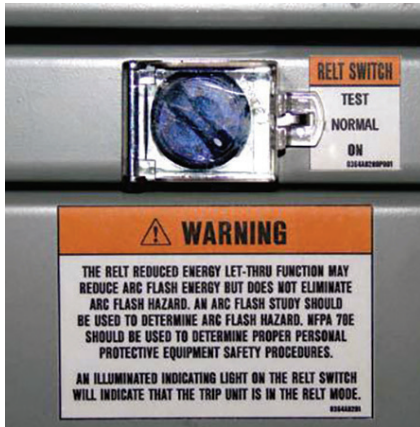
³ Bus Differential Relays are identified on one line diagrams by a circle with the designation 87B inside.

⁴ <http://www.geindustrial.com/products/switchgear/entellisys-50-low-voltage-switchgear> Entellisys[®] 5.0 Low-Voltage Switchgear.

3. Energy-reducing maintenance switch with local status indicator, 240.87(B)(3) and 240.67(B)(2)

This solution is described in 240.87 (B)(3) and 240.67(B)(2). GE is able to provide this capability in both circuit breakers and switches.

Not all maintenance switches are created equal. The status indication should indicate the status of the protective device, usually a trip unit, not just the status of the control circuit. The GE RELT function in all trip units and the GE HPC switch may be controlled by injecting a 24V signal or through Modbus communications. Regardless how it is controlled the trip unit or switch controller will provide a feedback contact closure that indicates the electronics has received and processed the command to engage the RELT mode of protection.



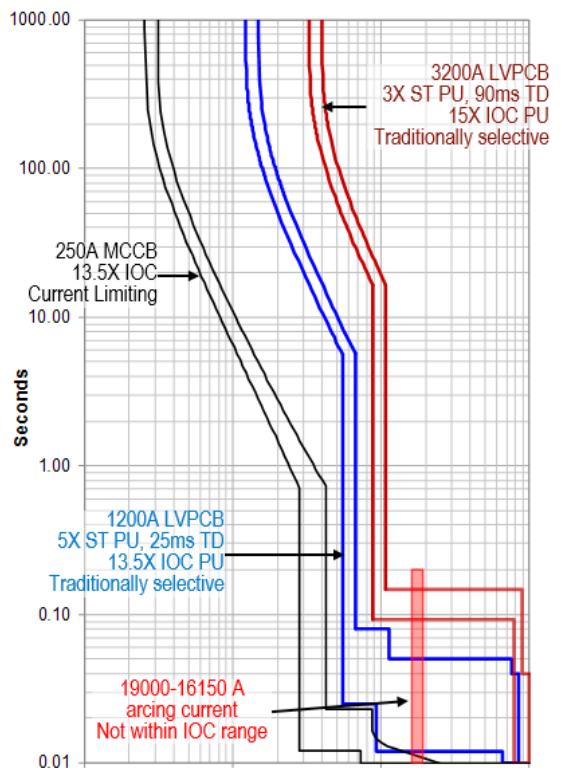
The concept behind the Energy Reducing Maintenance Switch (called RELT in GE products) is to help mitigate the arc flash hazard by limiting the duration of the fault current using an alternate instantaneous threshold. The RELT instantaneous can be adjusted from 1.5 to 10 or 15X times the circuit breaker sensor. The function will trip the circuit breaker instantaneously. Selecting a more sensitive pickup point for the instantaneous trip function of the circuit breaker allows the time factor in the calculations to be reduced, thus lowering the incident arc flash energy which may be experienced by personnel during an arc flash event.

To determine the instantaneous setting while in the RELT mode, a coordination study and arc flash hazard study should be performed. The tables discussed earlier may be a helpful estimating tool during the design phase of the project. By reducing the instantaneous setting of the overcurrent device while in the RELT mode, downstream coordination with other devices may be impacted and an evaluation should be done by responsible the engineer to maximize the safety of the system without impacting system reliability more than necessary. RELT mode operation provides compliance to NEC 240.87 but it does not provide 24/7 arc flash energy reduction. Furthermore, within the hierarchy of hazard control measures⁵ it is considered administrative control and hence not as good a solution as 7x24 instantaneous protection, however, from the perspective of the NEC both solutions are equal.

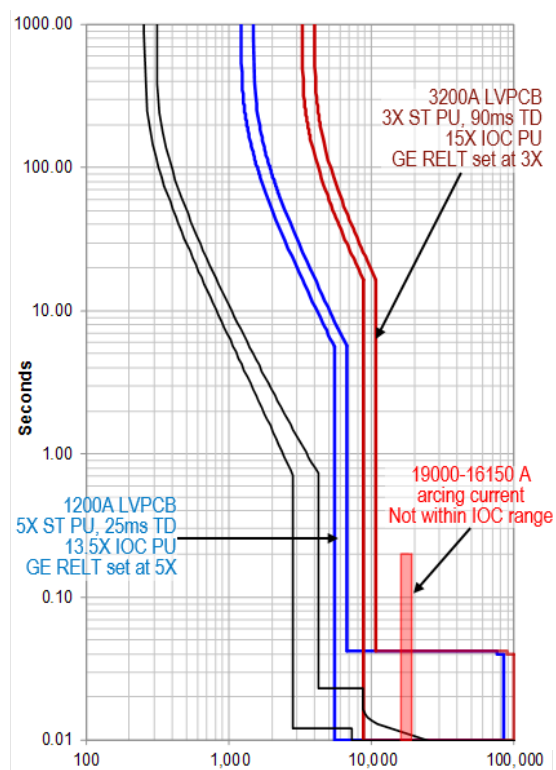
TCC-5 is an example of a 1200 A and a 3200A CB that are set to be selective in a traditional manner, with high instantaneous settings and slowed short time delays. As can be seen the expected arcing current of 19-16kA is below the instantaneous of the 1200A CB and below the override of the 3200A CB. If GE WFR and I-ZSI is not used then the Energy maintenance switch (GE RELT) is an option to meet 240.87 requirements.

In TCC-6 the GE RELT function is enabled and set low on both the 1200 A and 3200 circuit breakers. The fast instantaneous protection enabled is now well below the expected arcing current and the protection is as fast as it can be.

⁵ See NFPA 70E-2015, Article 110.1 (G), page 70E-16



TCC-5: Traditionally set CB: desensitized thresholds & nested delays. 1200A and 3200A CB do not meet 240.87 requirements prior to use of Energy Reducing Maintenance Switch.



TCC-6: Traditionally set CB with Energy Reducing Maintenance Switch (GE-RELT) enabled at both the 1200 and 3200 A CBs. Fast instantaneous protection thresholds well below expected arcing fault current. Letter & intent of 240.87 are met.

4. Energy-reducing active arc flash mitigation system, 240.87 (B)(4) and 240.67(B)(3)

The NEC does not explain what an active arc flash mitigation system is. However, the most popular interpretation maybe a crowbar system operated from an Arc Flash Relay (light sensing relay) or sensitive current sensing. If the protection is operated by an arc flash relay one should keep in mind that device is volume protection, not circuit protection. For example if there is a 1200A feeder in a switchboard, and arc flash relay operating an active mitigation systems in the switchboard may be suitable protection for the entire switchboard. However if that 1200A circuit breaker protects a remote MCC that MCC is not protected at all because the light sensitive relay will not sense the arc flash event at the remote MCC. A crowbar system operates by creating a bolted fault in the systems and collapsing voltage very quickly so an arcing fault cannot be sustained. The fact that maximum theoretical bolted fault current may flow presents a risk for the transformer, bus systems and other systems components. GE gets around both these concerns with the GE Arc Vault®.

The GE Arc Vault Protection System will contain an arc fault in less than 7ms, resulting in incident energy at 18" from the arc event at less than 1.2 Cal/cm², with the circuit breaker compartment doors open, in a 480V 65kAIC system⁶. It features an activation switch (ACT) that can be used during routine maintenance to put the low-voltage equipment into a high-protection mode. When an arc flash event occurs, the system will send a signal to the arc containment device. The arc is then diverted to the containment system in less than one-half cycle depending on fault conditions. At the same time the decision to divert the arc is made, the system will also send a signal to open an upstream circuit breaker. This will turn off the system in approximately.

Sensing is based on current and the system is set up to be used in a maintenance mode so the current sensing setting can be set low enough to be robust protection in every situation.

The Arc Vault Protection System can be retrofitted onto GE and non-GE low voltage switchboards, switchgear and motor control centers to expand its application for most existing facilities. Depending on site conditions, the design enables a retrofit installation to be completed within as little as a day of outage. The GE Arc Vault Protection System can be retrofit without having to replace the existing low voltage equipment lineup.



⁶ Based on calculations performed per IEEE 1584-2002, IEEE Guide for performing Arc Flash Calculations.

5. An Approved Equivalent Means, 240.87(B)(7) & 240.67(B)(4)

This section of the NEC 240.87 will likely be subject to numerous interpretations. In order to qualify to the level of protection afforded by any and all arc flash solutions, an arc flash study should be performed by a competent engineer. An arc flash study with recommended trip settings may be accepted as an equivalent means; compliance is subject to local AHJ approval.

Potential methods to do this may be to use an arc flash relay to operate a main circuit breaker or even a transformer primary side device. However it should be realized that a light sensing arc flash relay will only sense the light from an arc flash only where the sensors are located. Remote equipment at the far end of conductors will not be protected by the relay. The intent of the requirements within 240.87 and 240.67 are not clearly explained in the code, but it is a reasonable assumption that the intention is to protect the conductors and end use equipment connected to the affected overcurrent devices. An arc flash relay will not, generally, accomplish that because it is only able to sense light within the volume where the sensors are deployed.

Related GE Product Information and Related GE Services

Arc Flash Studies

GE's comprehensive arc flash hazard studies, designed to assist in addressing the recommendations of the National Fire Protection Association's (NFPA) Standard 70E, helps employers implement employee electrical safety programs. Key elements of an arc-flash hazard safety program are:

- Arc-flash hazard studies - Calculates current NFPA® and IEEE 1584 based levels, communicates personal protective equipment (PPE) requirements, and defines safe approach distances in a given environment
- Mitigation strategies - Customized hazard reduction solutions to fit system and operational needs
- State-of-the-art products - Designed to easily retrofit existing equipment and provide the highest levels of protection and reliability
- Installation and commissioning - Over 100 years of field engineering experience, product knowledge, access to product information and access to industry's top experts enables GE to provide prompt, comprehensive service

Results of GE's arc flash hazard study provide the calculated IEEE-based arcing currents, incident energy and arc flash boundary for each system location. Warning labels and work permits can be created using these results. For consistency of results, limited duplication and lower overall PPE recommendations, GE recommends that short-circuit and coordination studies be updated concurrently with the arc flash hazard study:

- Short Circuit Study – Calculates three-phase bolted faults
- Protective Device Coordination Study – Uses equipment settings to determine devices' opening times
- Arc Flash Hazard Analysis – Calculates arc flash related values under multiple scenarios, when needed, to analyze the effects of low and high fault currents creating worst-case arc flash hazard conditions. Maximum and minimum utility short-circuit conditions are included

Best practices and things to think about:

1. Know your local AHJ and what is being enforced/accepted locally.
2. Understand what NEC Edition has been adopted in your state.
For the latest updates on the NEC 240.87 please visit <http://www.electricalcodecoalition.org/state-adoptions.aspx>
3. Be able to at least estimate arcing current that will be provided after an arc flash study is done. If in doubt be conservatively "low"
4. Larger CB generally will have their instantaneous set higher than arcing currents in 480V systems. Assuming all 1600A and larger devices will need some in addition to normal instantaneous is probably wise unless GE WFR and I-ZSI are used.
5. 1200A MCCB will usually have IOC maximum setting of ~ 12,000A. But in a 208V system that may still be too high.
6. If implementing maintenance switches understand how the AHJ interprets "local" status indication. Local to the CB or switch whose setting was changed or local to the equipment protected by that CB or switch?
7. Thought 240.67 is not being enforced now adhering to its requirements does increase safety and the Energy Maintenance switch is easily available in UL 977 list GE HPCII® Power Switches available in switchboard construction from 800-4000 A
8. An option if load permits is to make 1200A feeders just slightly smaller than 1200A where possible – 1175A Spectra Rating Plugs are available for 1200A frame GE Spectra Molded Case circuit breakers available in switchboards and motor controls centers.
Cat# SRPK1200A1175



Entellisys 5.0 LV Switchgear Overview - One Solution for All

If the desire is to design the best GE Entellisys LV switchgear may be an option. GE Entellisys switchgear automatically provides almost all remedies identified in 240.87; Bus differential protection, ZSI and RELT! All can be provided simultaneously without adding any extra hardware.

Entellisys switchgear is manufactured in GE's ISO 9001 certified facility in Burlington, Iowa. It complies with ANSI standards C37.20.1 and is UL Listed to standard 1558. The switchgear has been conformance tested according to ANSI C37.51. Entellisys switchgear also meets the requirements for the CSA label up to 600V.

Entellisys equipment has been tested and meets the IBC-2009 requirements and has been approved by OSHPD, the Office of Health Planning and Development for applications in healthcare facilities. EntelliGuard E Low Voltage Power circuit breakers comply with ANSI C37.50 and are UL listed to 1066.

Arc Flash Mitigation

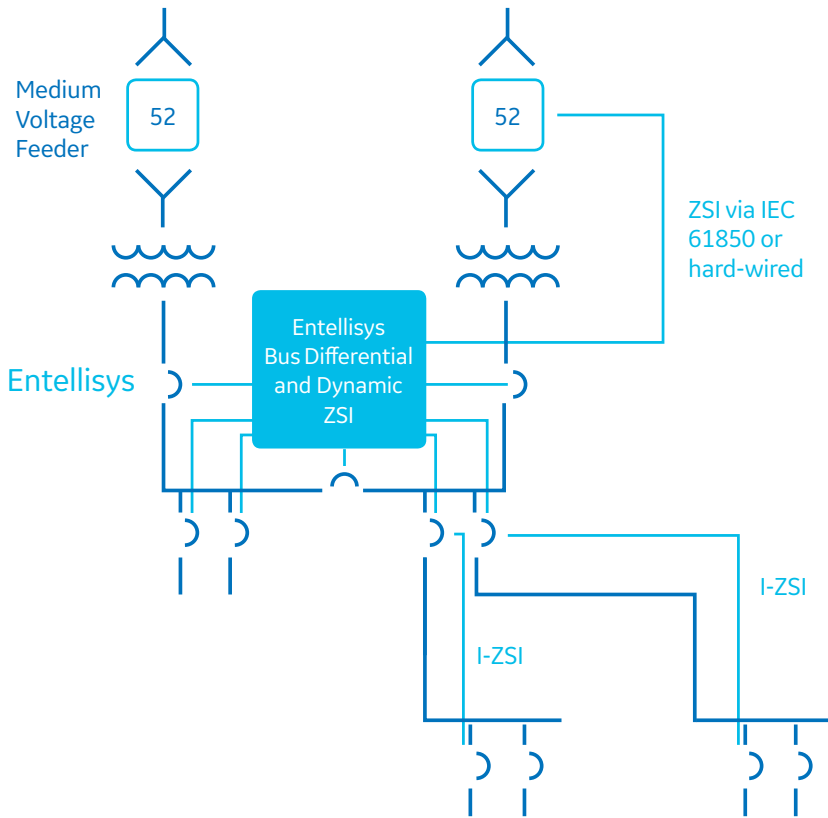
Selectivity without compromising protection, Dynamic ZSI within the gear gives you the best of both worlds - fast protection and selectivity by automatically coordinating in real-time. Instantaneous ZSI (I-ZSI) input from Downstream GE motor control centers, switchboards and panelboards, in addition to selective coordinated Instantaneous (waveform recognition) provides selectivity and protection. ZSI upstream to MV relays via IEC-61850 or hard wired completes the selectivity and protection needed in your power system. Reduce incident energy and maintain selectivity with bus differential protection and dynamic zone selective interlocking.

HMI placement in the Control Stack and remote circuit breaker racking keeps operators outside the arc flash boundary; in addition, Reduced Energy Let-Through (RELT) enables pre-set overcurrent and ground fault settings for faster, more sensitive protection when the operator needs to enter the arc flash boundary.

Integrated high-resistance ground fault (HRGF) sensing detects and identifies faulted phase and locates faulted feeder circuit with fault and alarms and re-alarms. HRGF tripping priority minimizes downtime due to phase-to-phase fault in the event a second HRGF occurs on different phase.



2017 National Electric Code Updates



NEC 240.87 REQUIREMENTS	MCCB, ICCB & LVPCB TRIP UNITS	ARC FLASH RELAY (MULTILIN)	ARC VAULT	ENTELLISYS SWITCHGEAR
Instantaneous below arcing current	•	•		•
Zone-selective interlocking	•			•
Differential Protection				•
Energy-reducing maintenance switch with local status indication	•			•
Energy-reducing active arc flash mitigation system		•	•	
Approved equivalent means		•	•	•

NEC 240.67 REQUIREMENTS	GE HPC		ARC FLASH RELAY (MULTILIN)	ARC VAULT	
Instantaneous below arcing current	•		•		
Zone-selective interlocking	•			•	
Differential Protection			•		

Entellisys Switchgear Technical Data Summary

Protection

DESCRIPTION	STANDARD	OPTION
O/C - LSI (switchable S or I - able to select LS, LI or LSI)	•	
Selective Discrimination IOC (Waveform Recognition)	•	
Ground Fault		•
Switchable GF (not UL listed)		•
Ground fault alarm only	•	
Voltage package		•
High current alarm		•
Freq. and Power package		•
Dynamic ZSI within Entellisys		•
ZSI Out via discrete I/O	•	
I-ZSI In from downstream GE trip units ¹	•	
ZSI Out, bi-directional, via IEC 61850	•	
Bus Differential (ZSI included)		•
Reduced Energy Let-Thru Mode		•
HRGF - detection only		•
HRGF - Feeder location		•
HRGF - Priority tripping		•
Multiple Source GF (for 4W systems with multiple sources)	•	
Flex Relays		•
Redundant trip coil		•
Emergency Stop		•

¹ GE trip units ETU and MET

Architecture and Hardware

DESCRIPTION	STANDARD	OPTION
HMI		
Qty 1 mounted in lineup	•	
Redundant HMI in lineup		•
HMI in wall mount cabinet		•
Keyboard and keyboard tray	•	
Conformal Coating		
Messenger		•
CPUs		•
HMI		•
Separate Control Stack		
CPUs, HMI, UPSs in stand alone independent stack		•

Metering and Diagnostics

DESCRIPTION	STANDARD	OPTION
Metering		
Basic - A and V on all circuit breakers	•	
Expanded/Detailed package		•
Demand package		•
Harmonics package		•
Diagnostics		
Sequence of Events recording	•	
System-wide waveform capture		•
Waveform capture on high current ²		•
Demand alarms		•
Alarms (email capability)	•	
Maintenance Information		
Circuit breaker indication for mechanical and electrical life	•	

² The High Current Trigger is packaged with WF Capture.

Digital I/O and Control

DESCRIPTION	STANDARD	OPTION
Discrete I/O		
64 Points - non-redundant		•
64 Points - redundant		•
128 Points - non-redundant		•
128 Points - redundant		•
Control		
Synch-Check relays		•
Automatic throwover		•

External Communication

DESCRIPTION	STANDARD	OPTION
Communication ports for external connection		
Copper - 8 ports	•	
Fiber		•
Firewall (located in lineup or control stack)	•	
Remote Software³		
Viewer Software		•
User Interface Software		•
Time synchronization via SNTP	•	
IEC 61850 GOOSE (digital values)	•	
Other Devices		
Remote racking device		•
Test kit		•

³ Capable of communicating with 25 systems

More information on all GE electrical distribution equipment
www.geindustrial.com

ArcWatch and Selectivity
www.geindustrial.com/arcwatch
DET - 760, DET - 1001

Entellisys* Switchgear
www.geindustrial.com/switchgear

Arc Flash Hazard Protection
www.geindustrial.com/arc-flash-hazard-protection
DET - 1003

Arc Flash Services
www.geindustrial.com/services/power-delivery/arc-flash-services

Bus Protection
store.gedigitalenergy.com/Bus.asp

National Electric Code**
www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=70

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