WHITEPAPER

Reduced Energy Let Thru

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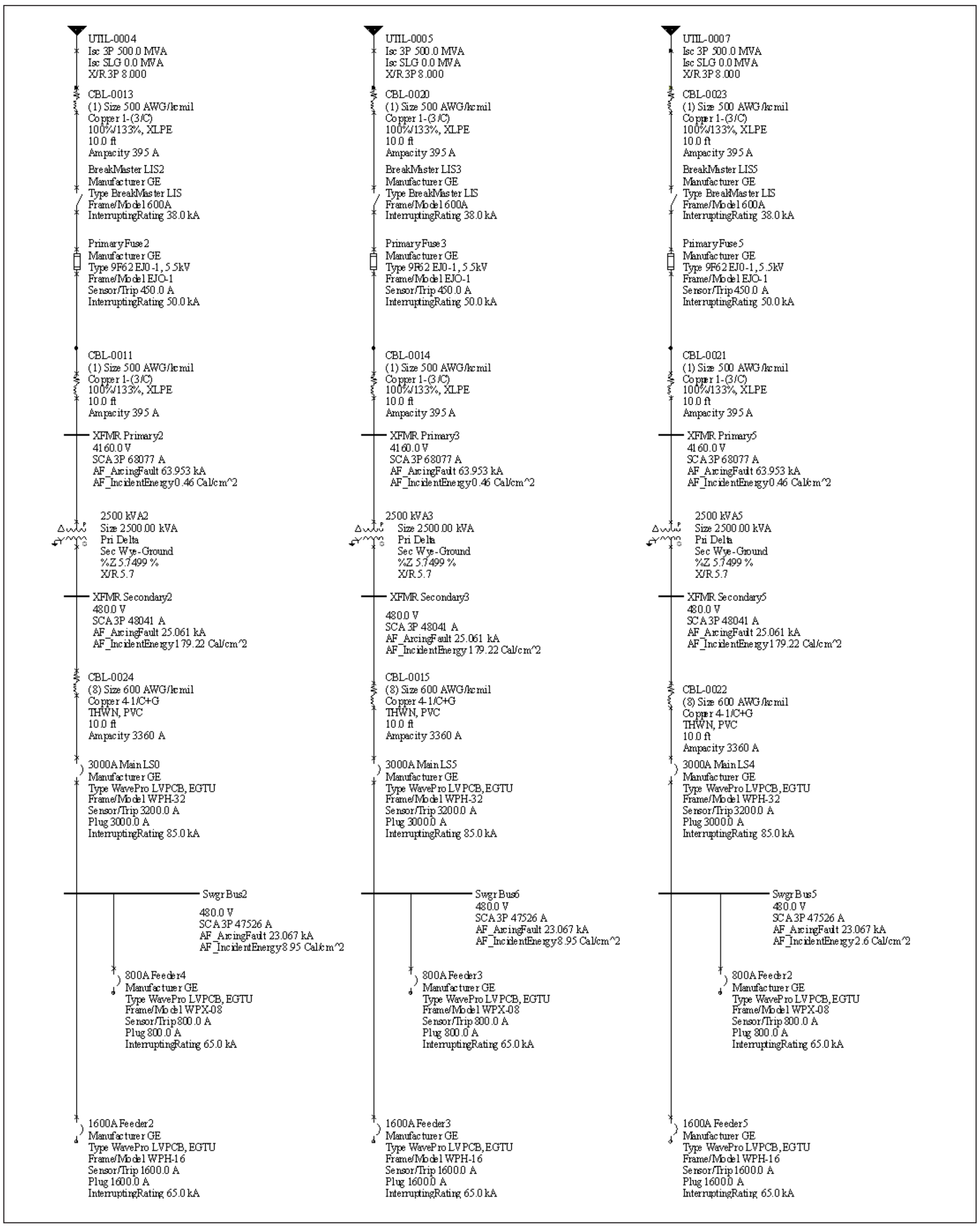
There is an increasing concern in the electrical industry about arc flash energy levels and the associated dangers when working on energized equipment. This concern is not limited to the design of new systems, but also the retrofitting of existing systems to incorporate features to limit the arc flash energy exposure of technicians working on energized equipment. The intent of this paper is to explain what RELT (Reduced Energy Let-thru) accomplishes, how it benefits electrical equipment users and how the system is implemented. The methods used in the calculations of the incident energy levels are based on the guidelines of IEE 1584 and NFPA 70E 2012.

The concept behind RELT is to provide a method to lower the arc flash incident energy levels while working on or near energized equipment. Electricians and electrical maintenance personnel are becoming increasingly familiar with arc flash hazards. These personnel are also aware of the different arc flash hazard levels and the need for the proper PPE (personal protective equipment) associated with each hazard level. The RELT system when activated helps to mitigate the arc flash hazard by limiting the duration of the fault current to the fault through the use of a user selectable and settable secondary instantaneous pickup setting.

There have been many excellent articles written on the calculations associated with evaluating arc flash energy levels and it is assumed that the reader has a fundamental knowledge of this subject so this paper will not re-iterate that topic in detail. The thing to remember with the arc flash energy levels is two key components, which are the magnitude of the arcing fault current available and the length of time this fault current is available before the overcurrent protective device operates to clear the fault. The RELT system is an alternative user selectable instantaneous pickup setting for the electronic trip unit. By selecting a lower pickup point for the instantaneous trip function of the breaker, the time factor in the calculations is reduced, thus lowering the arc flash energy which can be experienced by the user. A lower pick-up point is selected because arcing fault currents in LV systems are about 50% of the bolted fault current and the instantaneous pick-up point selected for the system coordination may be higher than the arcing current. An important factor to consider when performing coordination studies is that for any point that the instantaneous setting is above the available arcing current, the trip unit will not provide any arc flash energy reduction. To analyze how this system will benefit the user, a comprehensive fault current, device coordination and arc flash hazard study including incident energy analysis must be performed on the system while operating in its normal state. The appropriate arc flash hazard labels would then be installed on the equipment so the user knows what the hazard risk is when approaching and working on this equipment. To determine the alternate instantaneous setting while in the RELT mode, a second coordination study and arc flash hazard study must be performed. By reducing the instantaneous setting of the overcurrent device while in the RELT mode, downstream coordination with other devices will be impacted and an evaluation must be done by the engineer doing the study with the equipment user to maximize the safety of the system while minimizing the impact to the system coordination.

Since RELT is an alternative setting for the instantaneous trip pickup level at the trip unit, the user must be able to activate this alternative setting and have positive feedback that the system is activated. Activation can be accomplished by a 24Vdc signal which can be initiated through a switch mounted on the electrical equipment, or through the same switch which can be located outside of the arc flash boundary for that piece of equipment. Additionally, if the electronic trip unit is equipped with communication capabilities, the command can be activated via serial communications utilizing either Modbus or Profibus. The serial communication activation would be advantageous to a facility that employed a comprehensive SCADA or Power Monitoring system. As part of the work procedures, the activation of the RELT would be through the overall monitoring and control system. Once the system is activated, the user will require positive feedback that the RELT has been activated. When a hardwired system is utilized, the trip unit can provide a contact closure that illuminates a lamp to indicate to the user that the system is activated. This light can be in the form of an illuminated switch (utilizing the same switch that activates the system) or a separate indicating lamp. If the system is activated through serial communications, the feedback that the system is activated would be to the remote HMI through the serial communications. After the RELT functioned is activated, the user can commence the maintenance procedure, but he also needs to know that without proper work procedures which are enforced or without direct control over the RELT feature, the system could be put back into its normal position which could expose the worker to an incident energy level for which he is not prepared.

To illustrate how RELT can lower the incident energy, a simple substation one-line is used for illustration with three scenarios. All three scenarios utilize a 2500 kVA substation with a primary current limiting fuse, a secondary main 3000A ANSI rated breaker and then a 1600Aand 800A feeder breaker. The three scenarios involve the settings for the secondary main breaker. Scenario 1 utilizes only long time and short time trip functions (LS) for the secondary main breaker which would be typical for an instantaneous selectively coordinated system (.01 sec). Scenario 2 utilizes long time, short time and Instantaneous trip functions (LSI) for the secondary main which would be typical for a non-instantaneous selectively coordinated system (0.1 sec). The third scenario shows the same main breaker but with the instantaneous pickup in the RELT mode which would be used to limit the incident energy for downstream maintenance. The following is a depiction of the one-line analyzed. Note that the one-lines are identical except for the settings of the 3000A secondary main breaker.



To understand the effect of the instantaneous setting of a main breaker on the incident energy on the switchgear bus, you must look at the point between the 3000A main breaker and the feeder breakers noted above as SWGR Bus. For the one-line labeled LS, the data block indicates that at the switchgear bus the Arc Flash incident energy is 8.95 Cal/ cm^2. Adding the instantaneous trip function to the 3000A main breaker as shown on one-line LSI, does not reduce the incident energy. One would expect that the incident energy would be reduced with the addition of the instantaneous trip function. However in this scenario, the instantaneous trip setting is selected at 7X for coordination purposes with the downstream devices. This setting though, is above the available calculated arcing fault current level, thus it does not provide any reduction in the arc flash energy available on the switchgear bus. In this scenario, if the instantaneous trip level was reduced even .5X to 6.5X, the incident energy would be reduced significantly to 3.02 $cal.cm^2$. The design and power systems engineer should always consider the impact of the settings selected for coordination and the impact they have on the arc flash energy downstream of the device. The third one-line above labeled LSI-RELT utilizes the secondary setting in the RELT mode for maintenance. In this case it was set at 1.5X which reduces the incident energy on the switchgear bus to 2.6 Cal/cm^2. This is a significant reduction in the available arc flash energy and as you can see the alternate RELT setting will reduce the incident energy to a point where protection to the worker is well within the "Everyday Work Clothing " level as defined in NFPAA 70E.

While the benefits of the RELT maintenance mode for personnel protection are clear, there are a number of scenarios for the implementation of RELT and there are possible limitations to its use. RELT applied to the main device in a lineup as described above has the capability to lower the incident energy on the bus in the switchgear, but it also can be applied to a feeder breakers to lower the incident energy for equipment connected to the load side of the feeder breaker. There are several issues which the design engineer must consider when selecting RELT functionality and determining the secondary instantaneous settings which will be activated with RELT. The first and foremost is the possible loss of selective coordination. If the instantaneous trip function could be set low enough to achieve an acceptable level of incident energy reduction while maintaining selective coordination, then the breaker should be set at that level. However, in most instances, the instantaneous trip function is set at a high enough level for downstream devices to clear a fault before the upstream device will trip, thus maintaining selective coordination. The design engineer should be aware of any restrictions with local codes, owners or other authorities for even a temporary compromise of selective coordination within the system with the implementation of RELT. Hospitals, data centers and other industries where selective coordination is either mandated or desired may not be the best types of projects to implement a RELT scheme just to lower the incident energy level for maintenance personnel to work on energized equipment.

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The time current coordination (TCC) plots shown here illustrate the levels of selective coordination available with the scenarios previously described.

01 The left scenario shows instantaneous selective coordination for all times above .01 sec between the main and the feeder breakers in the switchgear.

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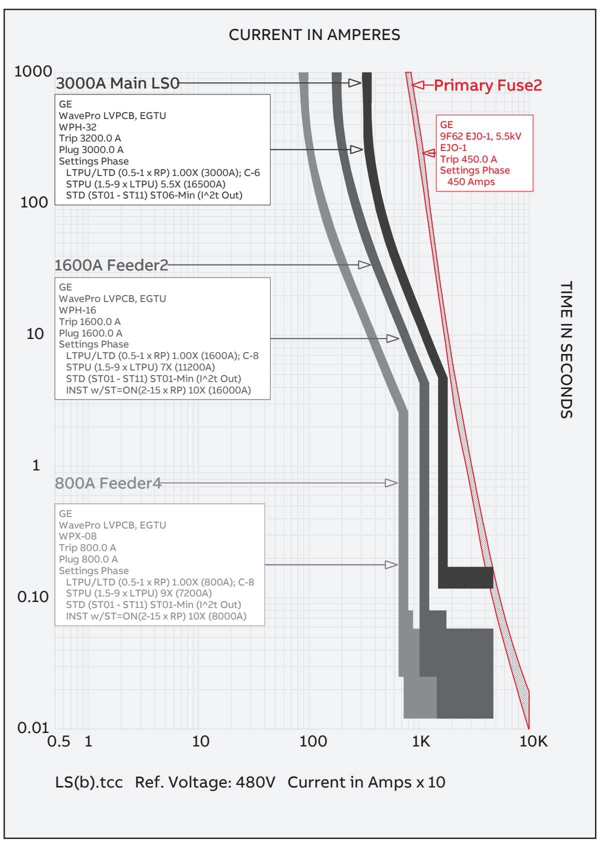
02 This second TCC illustrates the main with instantaneous trip function and selective coordination for time levels exceeding 0.1 sec which is applicable in many jurisdictions.



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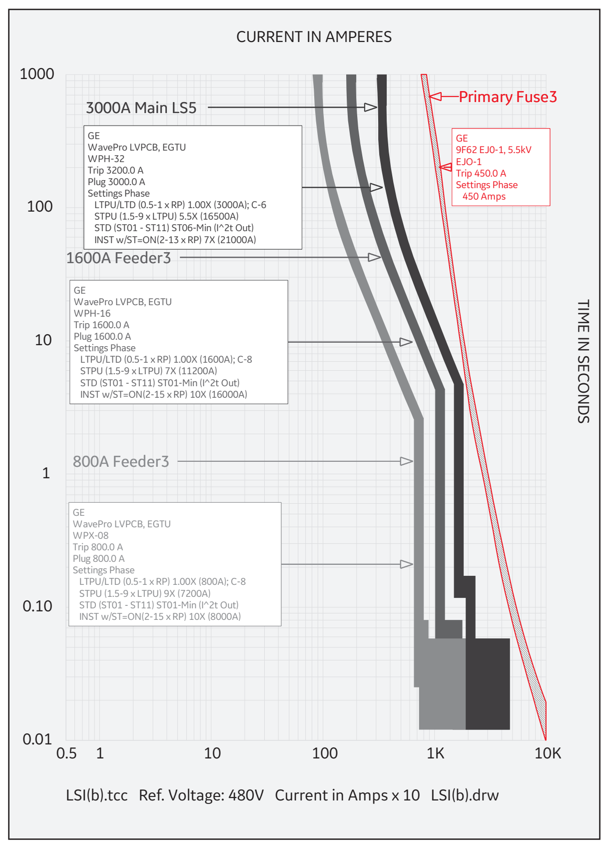

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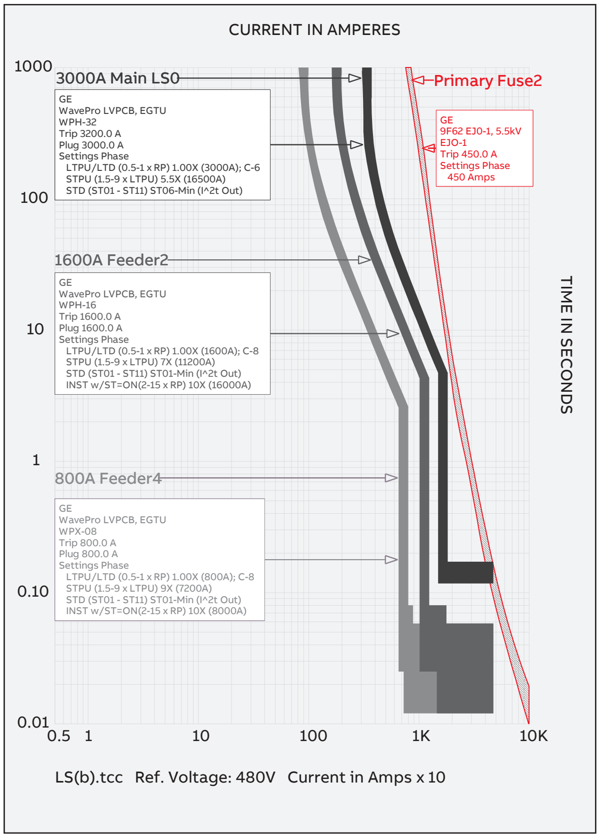
03 This third TCC shows the main breaker with the RELT mode activated for downstream personnel protection. Note that all levels of selective coordination have been compromised up to the 10 sec time frame. As mentioned previously, the incident energy level to which the maintenance personnel are exposed to has been reduced, but the level of selective coordination has been severely impacted. The design engineer should be well aware of this impact and use prudence when applying this scheme for certain distribution systems.



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Another scenario which is often overlooked and of which the design engineer should be aware of is the style of equipment in which the RELT is implemented. If RELT is applied to a main breaker in a switchboard, the design engineer and end user should be aware that the incoming point of connection to that main breaker still has the high incident energy level. This can be seen on the previous one-lines at the point noted as XFMR secondary. For every scenario, the secondary main does not have any effect for the incident energy at this point and for this scenario it is 177.22 Cal/cm^2 which is an extremely dangerous level. If there is no barrier between the main breaker compartment and the distribution sections that is suitable and tested as an arc flash barrier, this high level of incident energy is present in the open space of the distribution equipment. Even though the RELT applied to the main circuit breaker might reduce the incident energy level at any point on the load side of that breaker, the equipment will still indicate the available incident energy level available at the primary of the main breaker. End users and maintenance personnel would typically then be required to adhere to the “dangerous” label and would not be able to work on the live equipment. The design engineer can overcome this scenario by utilizing switchgear which as a suitable barrier between the main and the feeder breakers or can simply design a system which will separate the main from the feeder sections. For the scenario discussed in this paper, the main could be close coupled to the transformer secondary and then cable or bus connected to the distribution breakers. Activating the RELT function for the main would then effectively lower the incident energy level for the feeder sections without the danger of the high energy levels being present in the equipment while in the RELT mode.

While this paper is focused on the RELT function for a specific scenario, there are alternative design scenarios which can be implemented to circumvent this condition. Schemes involving the interlocking of the secondary main with a primary circuit breaker has been designed which effectively reduce the incident energy level at the primary terminals of the secondary main. Other schemes involving zone interlocking and more importantly instantaneous zone interlocking utilizing waveform recognition could also be used to add protection to the equipment and the maintenance personnel.

In conclusion, Reduced Energy Let Thru (RELT) is a valuable feature which can be effectively specified and implemented to reduce incident energy levels at electrical equipment. However the electrical design professional should be aware of how the system functions, effective schemes to implement it and the potential drawbacks which can occur when implemented for certain systems. The design engineer should also become familiar with NFPA 70E, Standard for Electrical Safety in the Workplace -2012, to become thoroughly familiar with all of the terms associated with arc flash hazards. There have been numerous changes from previous editions of the standards and the reader should understand the requirements from the latest standards.

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