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Siemens Dynamic Arc Flash Reduction System and its application in low voltage switchboards

White Paper

The risk of Arc Flash is a growing concern within the electrical equipment community and among both designers and workers. Current research shows that up to 80% of reported electrical injuries are caused by an electrical arc¹. This fact has spawned new requirements and standards in governing documents, such as in NFPA 70E and the NEC. These documents address the safety of workers on and around energized electrical equipment. In response to safety needs and to fulfill these standards, Siemens has developed new technologies to address the issue of arc flash, and help mitigate its risk. This paper will explore the capabilities of the Dynamic Arc Flash Sentry (DAS), investigate an example case, and show the benefits of this technology in switchboards.

Siemens strongly recommends that all systems be de-energized when personnel are working on electrical equipment. In some circumstances qualified professionals may need to access and work near energized equipment. Testing, troubleshooting, diagnostics and a continuous process segment require that power remain on to complete the task when de-energizing would introduce an additional or increased hazard or is infeasible. This is where many accidents occur and the risks and effects of an arc flash are the greatest. The Dynamic Arc Flash Sentry system is designed to greatly reduce the risk and level of arc flash while the equipment is energized. Siemens Dynamic Arc Flash Sentry Technology uses a dual function setting of the ETU776 electronic trip unit in the Siemens WL power circuit breaker. The trip unit has two parameters (A and B), that allow the operator to switch back and forth from a normal operating mode to a maintenance mode. The maintenance mode (Parameter B) has a reduced instantaneous trip setting in the WL main breaker. By reducing the instantaneous region, the trip timing of the system is accelerated. This reduction clears a fault much sooner than the original operating time. This decreases the amount of energy available for an arc flash and reduces the danger zone, known as the arc flash boundary (AFB).

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Let’s look at an example of how the DAS can function to increase safety and help mitigate the risks associated with arc flash. We will use a sample system that is based on an actual application in the field. This example was set up with aid from ESA and their EasyPower software² tool to help create the switchboard layout and calculate the associated arc flash energies. Figure 1 shows a typical switchboard with a Siemens WL as a main breaker and numerous feeder breakers supplying power to different loads.

switchboard with the main breaker upstream, it is appropriate to analyze the time current curve (TCC) to see the trip parameters for long time, short time, and instantaneous trips. Typically in a switchboard, as with MSB1 in Figure 1, there are numerous operating devices present. The resulting TCC for this switchboard would be cluttered and virtually unreadable. For this example, we selected the three most relevant devices to display, that will affect the coordination of the upstream breaker. Figure 2 shows the TCCs of 4 devices: the main device a 1600A Siemens WL1600S, a 600A Siemens LXD6 feeder circuit breaker, a 225A Siemens HFD6 feeder circuit breaker, and an 800A Siemens WL800S feeder breaker. The other two breakers are left off of this figure for clarity sake.

This switchboard configuration will serve as the basis for this example. To properly coordinate the breakers in the

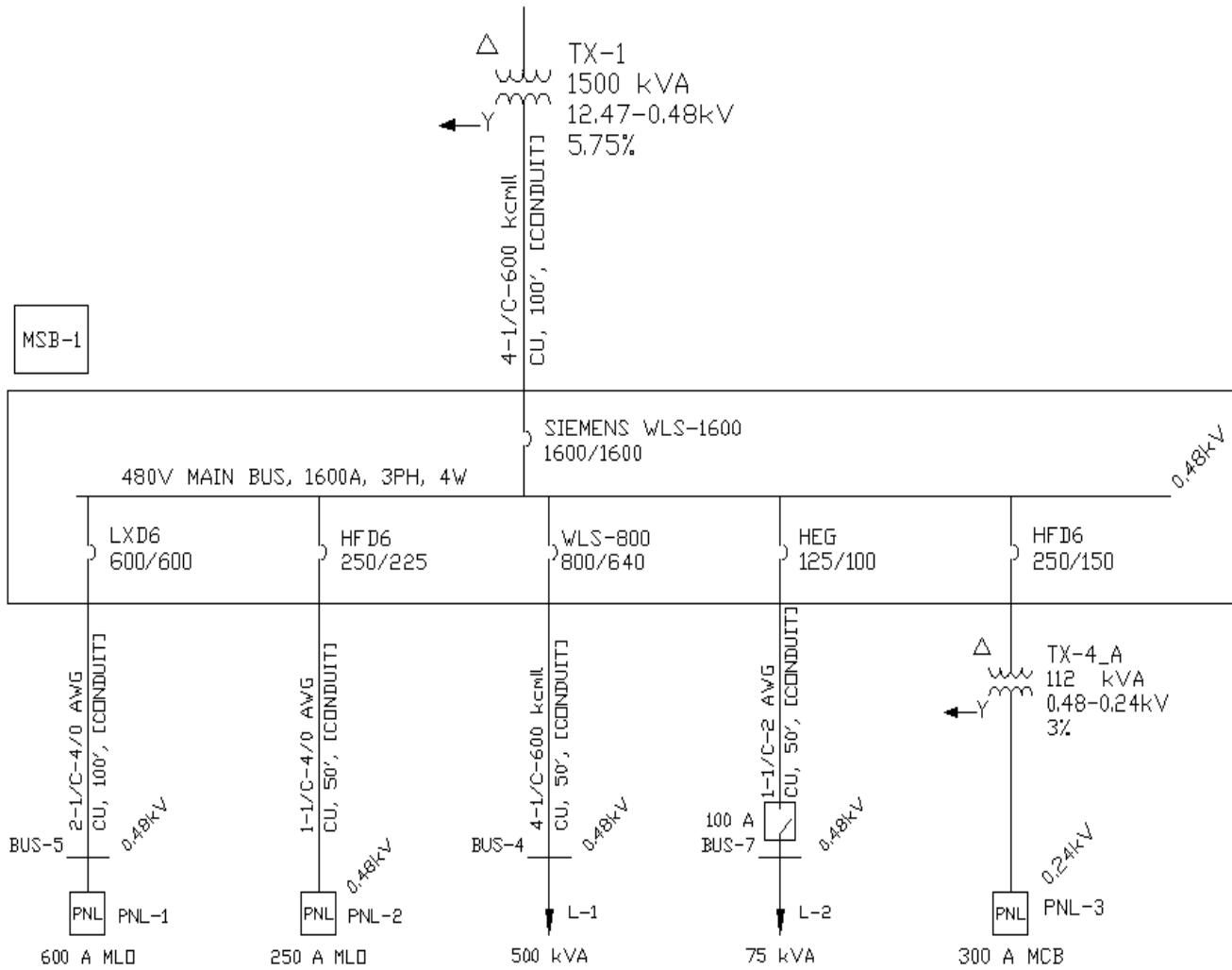


Figure 1 – Switchboard example one-line diagram

As you can see in Figure 2, the 1600A WL breaker is coordinated with each of the devices downstream from it. The WL main has a typical instantaneous trip time of approximately 0.32 to 0.41 seconds at 7kA or greater. The next step is to run an arc flash hazard analysis across the

system to determine the calculated risk of working on this switchboard. The arc flash boundary, the incident energy, and proper personal protective equipment (PPE) can be calculated based on IEEE 1584³ and NFPA 70E⁴.

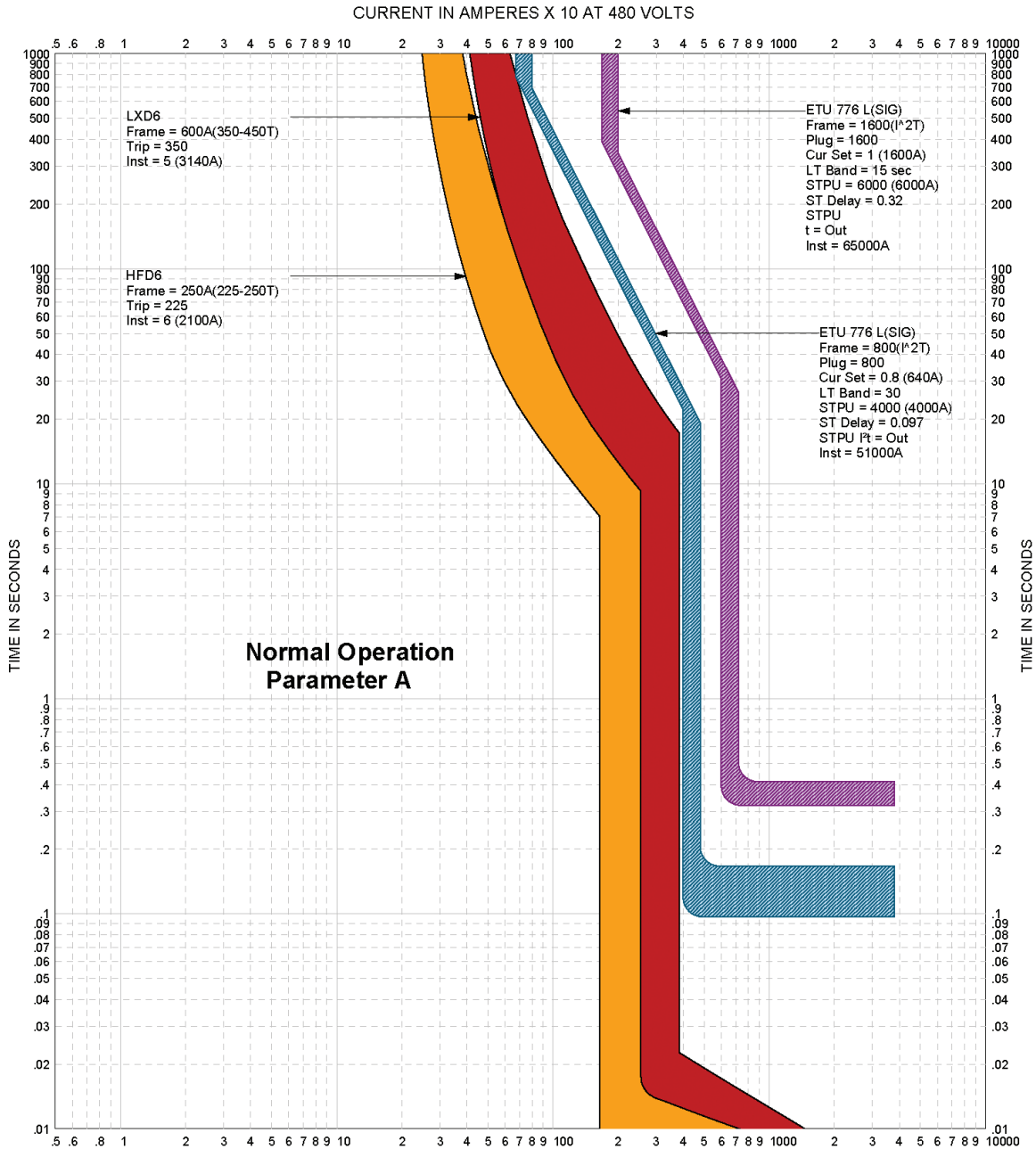


Figure 2 – TCC of Parameter A – Normal Operating Mode

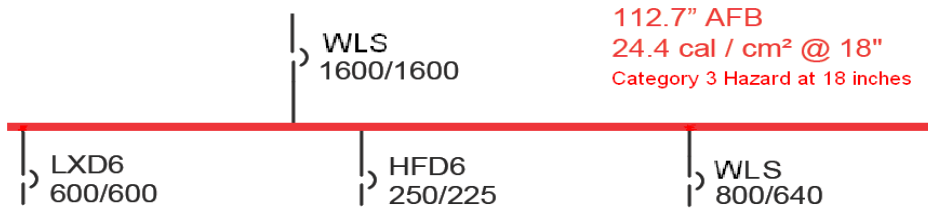


Figure 3 – Arc Flash in Parameter A

Figure 3 shows the conditions that appear at the switchboard when a fault occurs on the bus in MSB1. The incident energy is calculated to be 24.4 cal/cm² and a PPE level #3 clothing at 18 inches. This level of PPE would require the qualified personnel to wear flame resistant shirt, pants and coverall plus cotton underwear per NEPA 70E and Table 1 below. All of this equipment will need a minimum arc rating of 25. As the PPE level increases, the material can become increasingly bulky and hot, leading to uncomfortable work conditions for any personnel. This figure also shows that the arc flash boundary (AFB) is 112.7 inches away from the switchboard in every direction. To have personnel working on or around this electrical equipment can be extremely hazardous.

So how can we resolve this problem? The goal would be to reduce the arc flash risk by lowering the amount of incident energy of the system. This is done by reducing the clearing time of the fault, which then makes a safer work

environment. This solution lies in Dynamic Arc Flash Sentry Technology.

Instead of working under these conditions, the DAS allows the flexibility for the worker to switch from the normal operating settings of Parameter A, to the lower arc flash energy settings of Parameter B. The goal is that when any qualified person is working on or near this equipment, the system will be set to Parameter B. This is made possible by the dual protection capability of the ETU776 trip unit. Lowering the instantaneous trip settings of the WL breaker ensures that the time it takes for an electric fault to clear will be decreased, providing a safer working environment. Additionally, the WL breaker adjusts by ramping up or down to the programmed level. On some other breakers, when adjusting settings while energized, the breaker will default to a minimum when the dial is turned. This could cause a nuisance tripping turning off power to the entire facility.

Hazard/Risk Category	Clothing Description	Required minimum arc rating of PPE {cal/cm ² }
0	Nonmelting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd ²	N/A
1	Arc-rated FR shirt and FR pants or FR coverall	4
2	Arc-rated FR shirt and FR pants or FR coverall	8
3	Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	25
4	Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	40

Table 1 – Protective Clothing Characteristics from Table 130.7(C)(11), NFPA 70E, 2009

Let's look at the second part of the example.

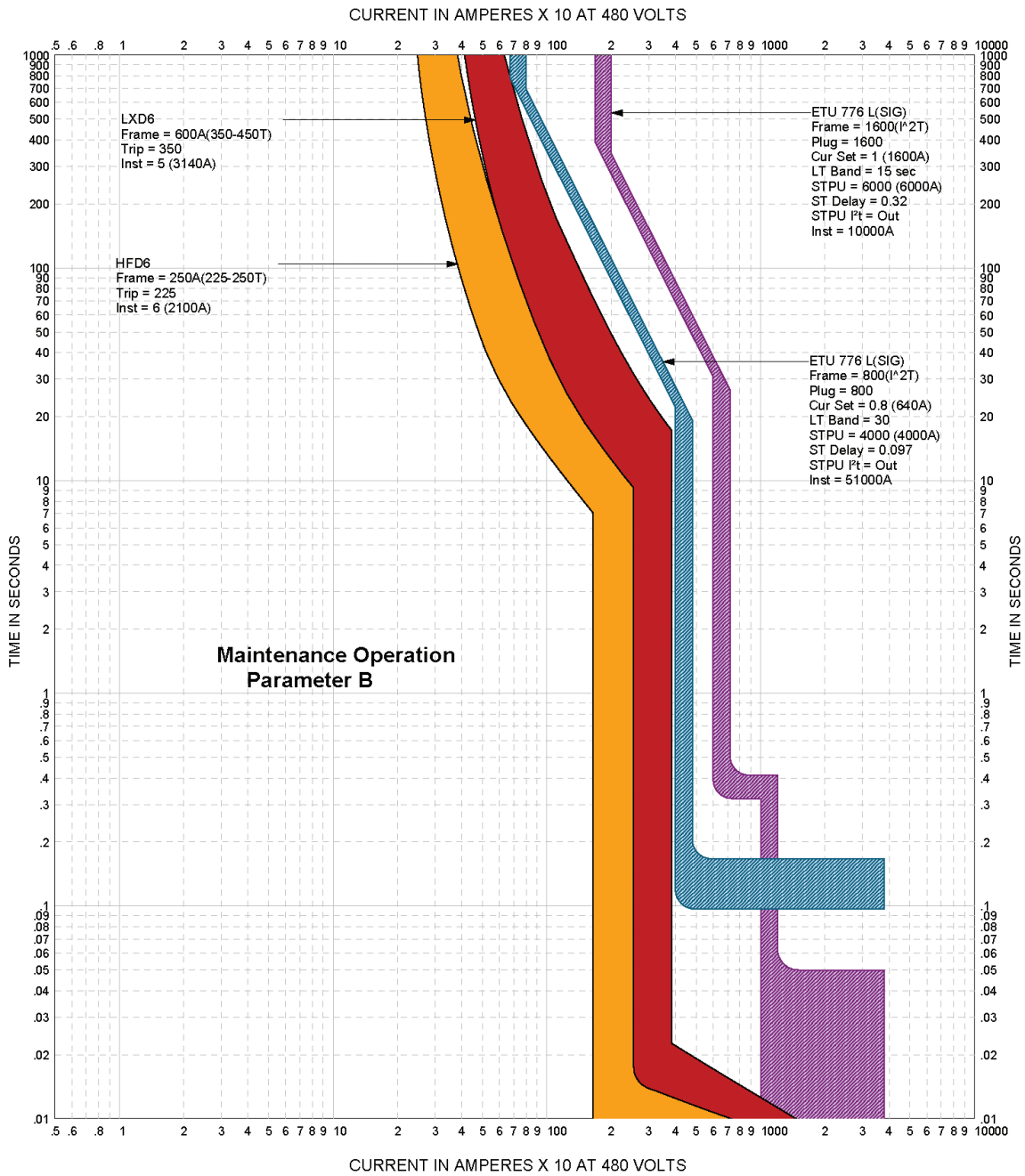


Figure 4 – TCC of Parameter B – Enhanced Safety Mode

When switching from Parameter A to Parameter B, each of the settings is kept the same in the switchboard, except the instantaneous trip setting of the WL main breaker. The TCC for Parameter B is displayed in Figure 4. As can be seen, the WL main overlaps the WL feeder breaker in the instantaneous region, which was lowered to 10kA, while the other regions remain coordinated appropriately. This provides another example of the flexibility of the ETU 776 trip unit in the Dynamic Arc Flash system. This system allows the user to alter the trip delay settings, as well as long time, short time,

and instantaneous pickup of the ETU 776 trip unit. However, these changes are not required and can be kept the same for simplicity reasons. In this example, only the instantaneous pickup was reduced between Parameter A and B, keeping all other trip unit and main breaker settings the same. When an electrical fault is applied to the MSB1 bus in Parameter B, the difference can be seen. When we look at Figure 5, we see a dramatic reduction in the Arc Flash boundary, incident energy and category of PPE required.

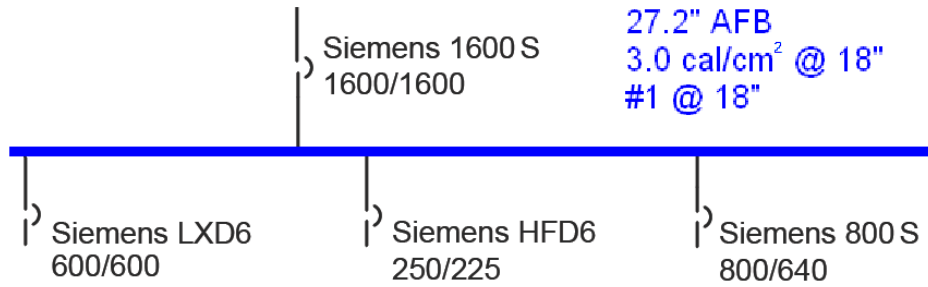


Figure 5 – Arc Flash in Parameter B

Now let's compare the TCCs from Parameter A and B when they are side by side, as shown in Figure 6. This clearly shows that the only parameter that is changed is the main WL breaker, with the instantaneous pickup being reduced.

By switching from Parameter A to B, the DAS allows a temporary overlapping of the main breaker with a feeder breaker. However, to fully understand this situation, there are two main points to consider. First, to maintain a reliable system and avoid nuisance tripping due to normal operating currents in Parameter B, inrush currents must be taken into account. In this example, a 1500kVA transformer with a 480V secondary side and 5.75% impedance has a typical full load current of 1805 amps. If the system has a 300 HP motor, then when running the motor's full load amperage is 361 amps. This would give a typical inrush current of around 4700 amps⁵. With a peak inrush current lasting less than 1 second, this value is still well below the instantaneous pickup of the main circuit breaker at 10kA. Even with multiple devices and other loads running, a very high current spike would need to exist in order to trip the main. The reality is that if the system is designed correctly, it will coordinate and nuisance tripping should be avoided. In addition, the safety benefits are enhanced to the qualified electrician who is standing near an

energized switchboard. This leads to the second and more realistic point of understanding the temporary overlap of the main breaker with a feeder. Parameter B does present an overlap of coordination; however the intent of this system is to create a significantly safer environment when the equipment is energized. Safety should be the primary concern when the equipment can not be de-energized. To lessen the arc flash level, the DAS provides the flexibility of the full range of settings to create a safer environment for workers. In this way, the DAS system provides a unique solution for the industry.

The Dynamic Arc Flash Sentry has been available from Siemens in low voltage switchboard applications for some time. It has recently become available in Siemens new Arc Sentry Motor Control Centers. This technology can be employed in Siemens switchgear as well. Siemens is listening to its customers and meeting the highest industry standards. By offering a system that has the flexibility to actually reduce the amount of arc flash incident energy without forcing customers to choose reliability over safety, the Dynamic Arc Flash System is addressing the difficult challenges related to electrical worker safety.⁶

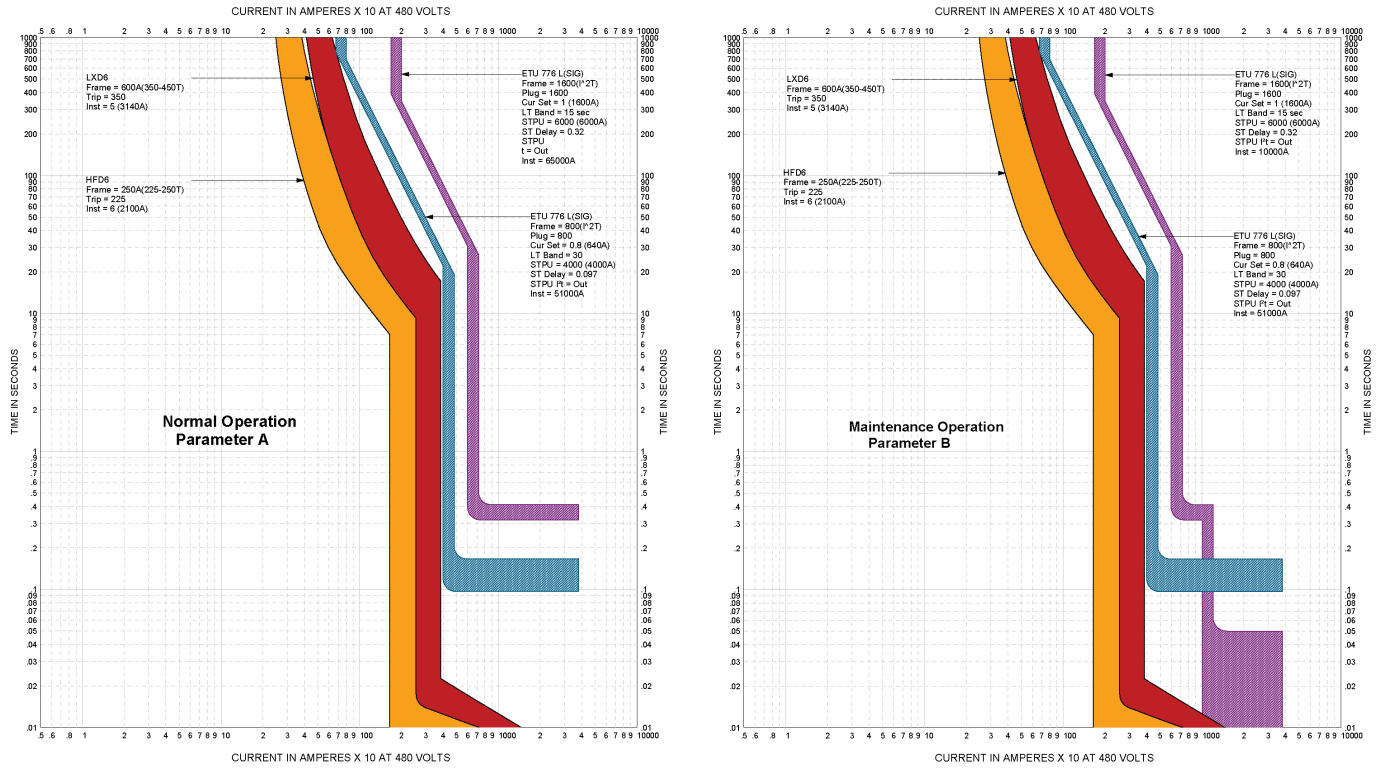


Figure 6 – Parameter A and B Comparison

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