Industrial Solutions

DET1001 Application and Technical Guide

Zone-Selective Interlocking

For ABB Circuit Breakerand Power Switch Trip Units

by ABB

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A brief description of the terms used to describe ZSI functions and applications within this guide.

Restraint Signal

Also referred as blocking signal or ZSI signal. A logic signal transmitted from one overcurrent device to another to alter the protective behavior of a circuit breaker or protective relay. In the context of ZSI systems, the device that receives a restraint signal assumes a different, typically longer, preset tripping time delay for backup purposes. The term blocking signal is also used in relay applications and may include signals used to inhibit relay operation.

Restrained

A condition of the trip unit logic when the trip unit has received and processed a restraint signal and is, hence, operating in its restrained, backup, mode of protection.

Unrestrained

A condition of the trip unit logic when no restraint signal is present. The trip unit should then be operating at its most protective.

Zone-of-Protection

Refers to a portion of the electrical system that an overcurrent protection device (OCPD) is expected to protect bounded by the load terminals of that OCPD and the line-side terminals off all overcurrent protective devices fed from that circuit, if any.

Zone-of-Protection Tiers

Within the context of an overcurrent protection scheme tiers refers to overcurrent devices operating in parallel or series zones of protection. Devices in the same tier are protecting circuits at a parallel level within any specific topography of the system. Devices in different tiers are operating at different levels within the topography. Upper tiers are upstream of lower tiers. Tiers may be numbered 0, 1, 2, etc. However, whether 0 is the lowermost or uppermost tier is not universally defined and may vary from discussion to discussion.

Zone-Selective Interlocking (ZSI)

A selective trip system which obtains shorter tripping times within a zone by external wiring or electronic communication between two or more circuit breakers. The upstream circuit breaker trips sooner for a fault within its respective protection zone than it does when providing selective backup protection for faults beyond the downstream circuit breaker(s).

ZSI Scheme

Refers to the system of circuit breakers, circuit breaker trip units or relays that have been interconnected to apply zone-selective interlocking techniques.

Short-Time ZSI (ST-ZSI)

Consisting of restrained and unrestrained time delay, both of which must be selected by the user in GE trip units. The ST-ZSI function allows use and change of short-time curve shape between definite time and three I2t slopes. The restraint signal can be used to toggle between different selected shapes. Protection and restraint signals are based off the same short-time protection threshold.

Instantaneous ZSI (I-ZSI)

Consisting of a normal instantaneous threshold, adjusted by the user, as well as, standard unrestrained and restrained timing which vary per circuit breaker type. The restrained mode uses the same user adjusted instantaneous threshold as the unrestrained protection but is slowed to allow one tier of devices to clear selectively.

Ground Fault ZSI (GF-ZSI)

Consisting of one threshold, a restrained and unrestrained time delay and a restrained and unrestrained shape. The delays and shapes are user selectable for the restrained and unrestrained modes of operation. The current pickup threshold is user selected only once. The restraint signal can be used to toggle between different delays and shapes similarly to the ST-ZSI function.

Threshold ZSI (T-ZSI)

This is a unique ABB function that allows the user to set overlapping protective current pickup thresholds for short-time and instantaneous protective functions adjusted by the user. The trip unit automatically selects a restrained threshold at 123% of the user set protective threshold to ensure backup selectivity. The system allows multiple tiers of devices to protect at the same current threshold but forces selectivity for devices in upstream protection zones.

Introduction

The traditional means of obtaining selectivity between main circuit breaker and feeder circuit breakers is to set the furthest downstream device with the lowest time delays, and increase upstream time delays and thresholds. Consequently, the upstream portions of the system must endure high fault current for longer periods of time. This is unnecessarily damaging to the system and equipment, as well as increasing the electrical arcflash hazard to personnel.

Circuit breakers and Power Switches equipped with EntelliGuard™ or microEntelliGuard™ trip units can help to improve the protection to zones between circuit breakers using zone-selective interlocking. As shown on Figure 1, when a downstream circuit breaker detects a fault, it signals the upstream device to shift to a preset "restrained" time delay band, allowing the downstream device to clear the fault while the upstream device provides backup protection. During a fault between two circuit breakers equipped with zone-selective interlocking, the upstream breaker can clear the fault using a preset "unrestrained" setting adjusted to the minimum delay band because it receives no interlock signal from a downstream circuit breaker. The unrestrained setting of the circuit breaker in the lowest tier of the zone interlock system may need to be adjusted to a delay higher than its minimum delay if required to coordinate with the clearing times of downstream overcurrent devices that are not in the zone interlock system.

SIMPLIFIED ZSI SCHEMATIC

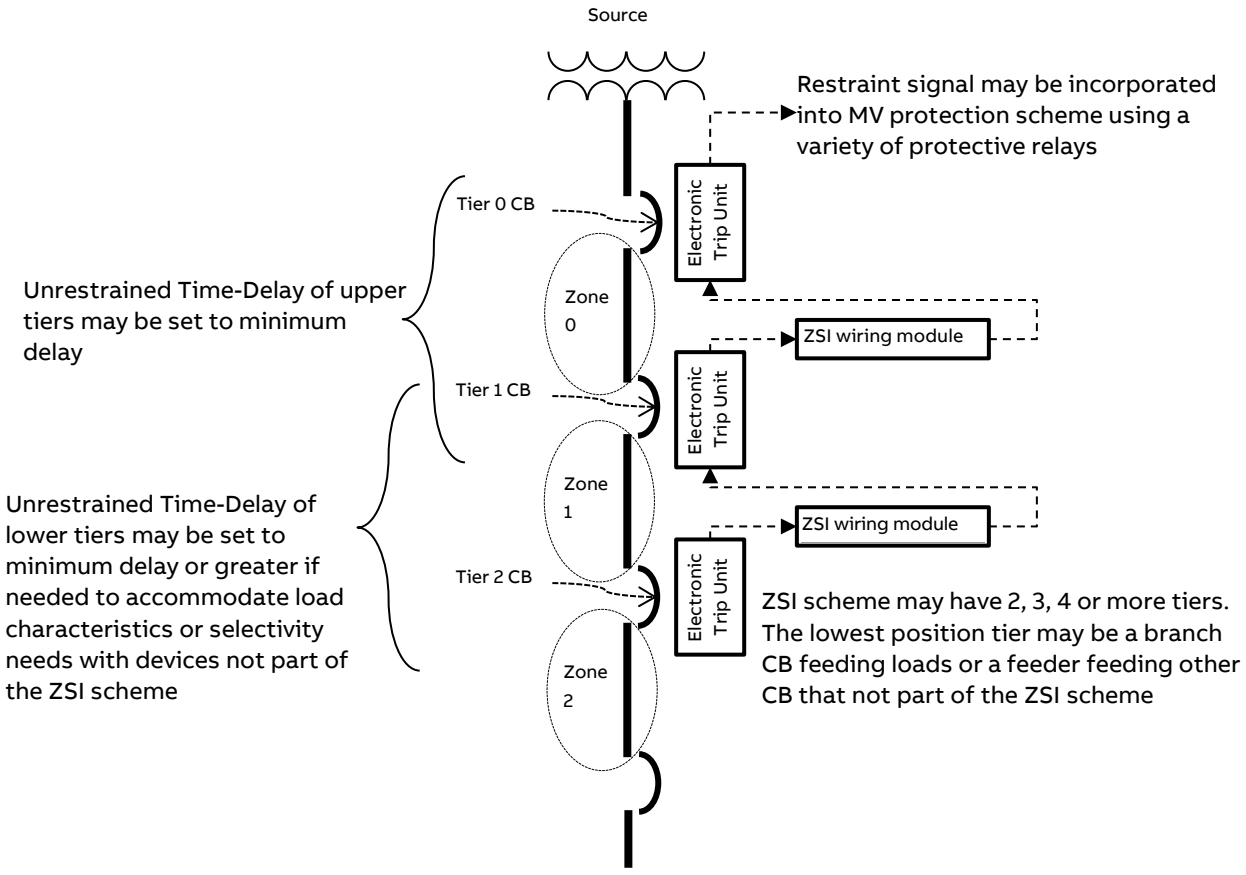

Figure 1

Zone-selective interlocking between low voltage systems using EntelliGuard and microEntelliGuard trip units and medium voltage systems using ABB Multilin relays is also possible. This can extend the instantaneous selectivity and arc flash protection of the secondary substation LV terminals and beyond. A separate application guide discussing this is available.1

Zone-selective interlocking is available on some ABB circuit breakers for either:

- Ground fault and short-time only, each may be enabled or disabled by the user, or
- Ground-fault, short-time, instantaneous and threshold functions. Each may be enabled or disabled by the user

Instantaneous zone-selective interlocking is limited to systems that use EntelliGuard trip units in EntelliGuard G circuit breaker or as upgrade trip kits in ANSI low voltage power circuit breakers for overcurrent devices in the upper tiers. Almost any circuit breaker equipped with EntelliGuard or microEntelliGuard trip units can be applied on the lowest tier of an I-ZSI system, including ABB High Pressure Contact (HPC) power switches. Such devices include:

- EntelliGuard G™ Insulated case CB and Low Voltage CB
- Powerbreak II™ Insulated case CB
- Spectra™ Molded Case CB with microEntelliGuard™
- HPC Fusible power switch

A unique optional enhancement of zone interlocking is threshold zone-selective interlocking. T-SZI adjusts the pickup characteristics of short-time and instantaneous functions to allow the pickup setting of circuit breakers at lower tiers to be identical as opposed to increasing the pickup setting for each upper tier device to account for current measurement tolerances.

I-ZSI must be used with ST-ZSI if Short-Time protection is used. Threshold ZSI function must be used simultaneously on ST-ZSI and I-ZSI if both are enabled.

The zone interlocking feature requires a zone-selective interlock module between each zone. The module is an intermediate control device used between upstream and downstream circuit breakers to communicate between circuit breakers. The ZSI wiring module, Cat. No. TIM1, requires 120/208/240Vac control power, 15VA minimum. The module can communicate with up to 30 downstream circuit breakers and up to 6 upstream circuit breakers provided all circuit breakers share the same zone. Circuit breaker trips may operate without control power for ST-ZSI but must have control power for ground fault, T-ZSI and I-ZSI implementations. The details of ABB solutions on traditional zone-selective interlocking will be discussed in this application guide.

The ABB ZSI functions may be field tested using the tool kit and field testing module. SE ABB publication DEH583 for directions on how to test ZSI in ABB circuit breaker in the field.

Zone-Selective Interlocking System Design

The following examples discuss the signals and control for a simple zone-selective interlocking scheme in a radial system and a more complex zone-selective interlocking scheme for a double ended substation wired to provide a selective tie when the tie is closed.

Figure 2 shows a simple system with two tiers of circuit breakers, overcurrent protection scheme tiers refers to overcurrent devices operating in parallel or series zones of protection. Devices in the same tier are protecting circuits at a parallel level within any specific topography of the system. Devices in different tiers are operating at different levels within the topography. Upper tiers are upstream of lower tiers and tiers may be numbered 0, 1, 2, etc. However, whether 0 is the lowermost or uppermost tier is not universally defined and may vary from discussion to discussion.

OUTLINE DRAWING

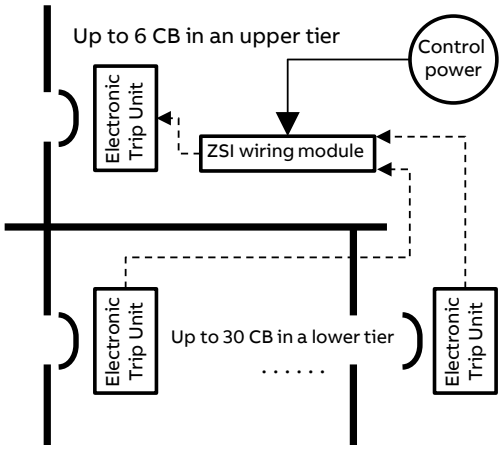

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Figure 2

In this case, the lower-most tier is composed of the two feeder circuit breakers. When a fault downstream exceeds the pickup setting that has ZSI enabled (i.e. short-time, instantaneous or ground fault) the circuit breaker trip device sends a restraint signal to the upstream-tier circuit breaker. The restraint signal causes the upstream tier circuit breaker to alter its protective characteristics assuming a longer time delay than the circuit breaker at the lower tier that issued the restraint signal. The altered protection characteristic of the restrained device should delay sufficiently to allow the lower tier device that originally issued the restraint signal to clear the fault. The larger delay allows the upstream circuit breaker to provide backup protection should the lower tier circuit breaker fail to clear the fault.

Figure 3 and 4 show the time-current curves (TCC) for one feeder and main circuit breakers with unrestrained and restrained mode of operations respectively. Note that the two trip units have overlapping short-time, not thresholds, and override instantaneous functions. The instantaneous override is an instantaneous protection function found in some large circuit breakers which is generally fixed. During the restrained mode of operation, the restraint signal alters the short-time protection timing for the upper tier circuit breaker allowing the lower level tier circuit breaker to clear the fault.

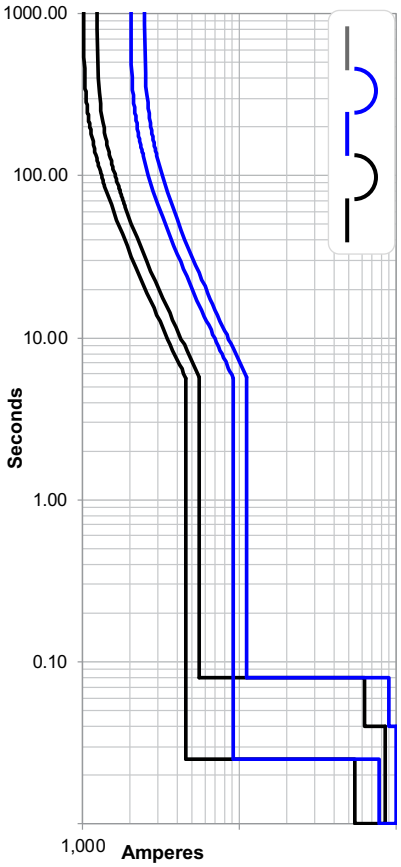

Figure 3. Two circuit breakers, unrestrained

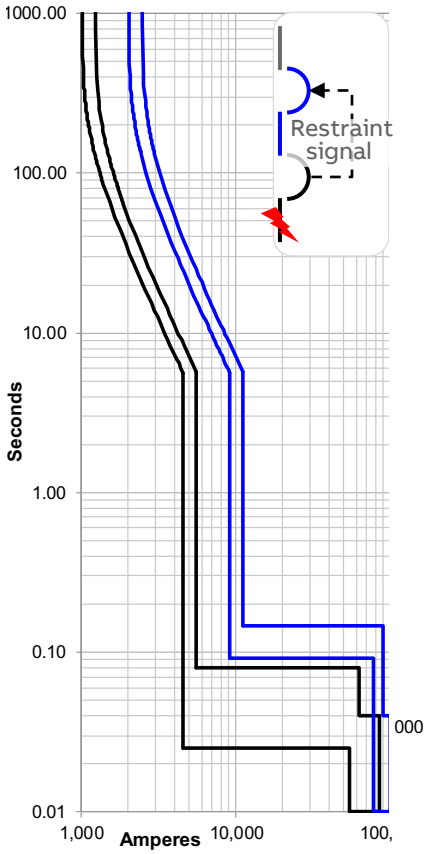

Figure 4. Two circuit breakers , ST upstream restrained

Figure 5 shows a system for a double ended substation configured to maintain selectivity at the tie circuit breaker. In other words, the tie is set up to be selective with the feeder and main circuit breakers.

The feeder circuit breaker upstream to the fault location issues a restraint signal to the first ZSI wiring module. The first ZSI wiring module sends the restraint signal directly to the tie and both main circuit breakers, as well as to the second ZSI wiring module. The second ZSI wiring module routes a redundant restraint signal to both main circuit breakers as well.

OUTLINE DRAWING - TWO PARALLEL SOURCES & FEEDER FAULT

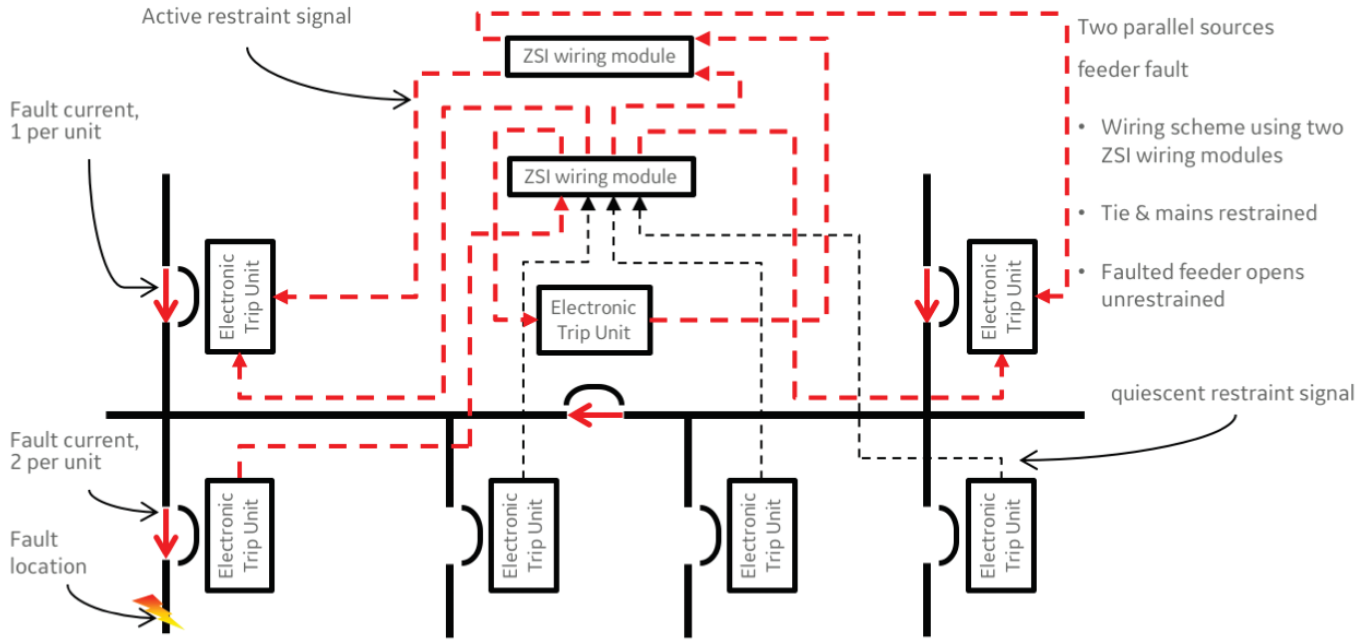

Figure 5

Figure 6 shows the fault on the main bus fed by the tie and the left main circuit breaker. The right main circuit breaker also feeds the fault but does it through the tie circuit breaker. In this situation, the first ZSI wiring module is completely isolated the from restraint signal because all the feeder circuit breakers are downstream from the fault location. The tie receives no restraint signal and hence can operate at its unrestrained setting. The tie circuit breaker issues a restraint signal which is routed to both mains via the second ZSI wiring module.

The ZSI logic allows the tie circuit breaker to work with minimum delay to separate the two buses which should reduce the fault current at the fault by half. The left main circuit breaker continues to feed fault current and should operate at its backup delay after the tie circuit breaker opens, while the right main circuit breaker remains closed. This scheme maintains the right bus energized through the fault clearing process.

OUTLINE DRAWING - TWO PARALLEL SOURCES & BUS FAULT

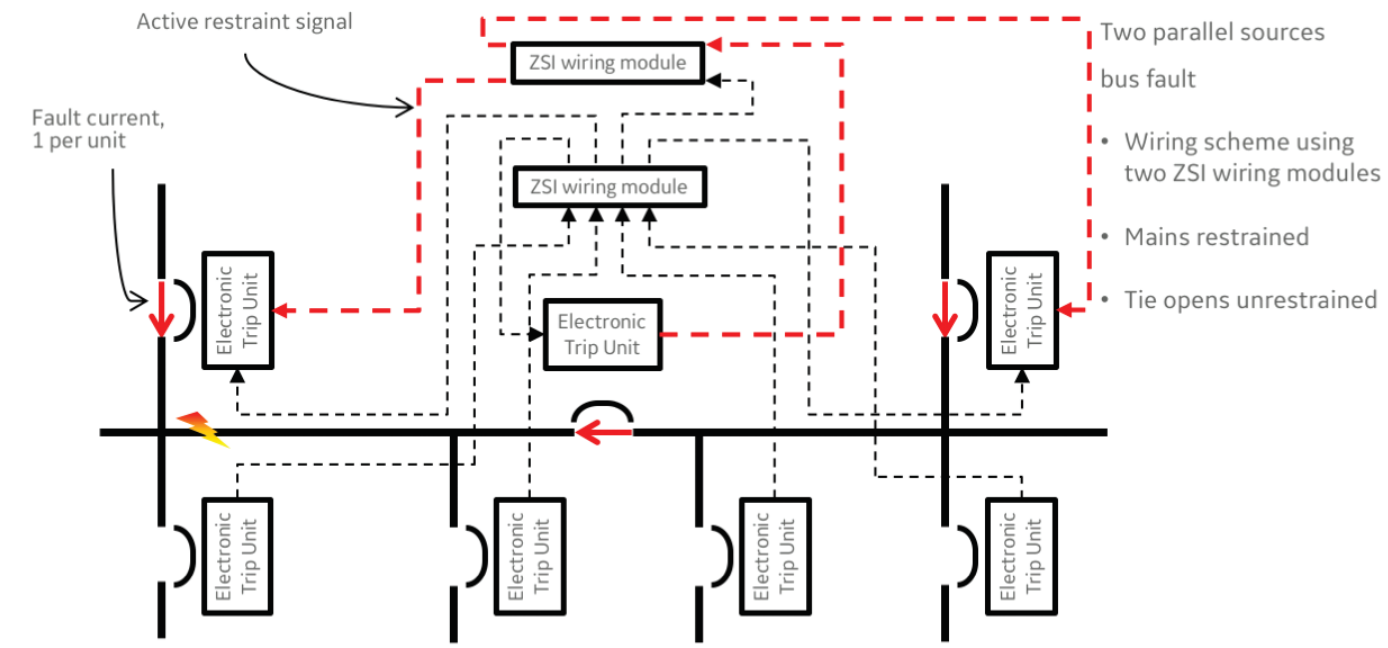

Figure 6

Figure 7 shows the tie circuit breaker is open so it does not carry fault current at any time. Only the left main circuit breaker carries fault current. No ZSI restraint signals are issued or processed. The left main operates at its unrestrained protection logic and timing able to provide fast protection for bus fault while maintaining selectivityfor all the other fault scenarios described.

OUTLINE DRAWING - OPEN TIE & BUS FAULT

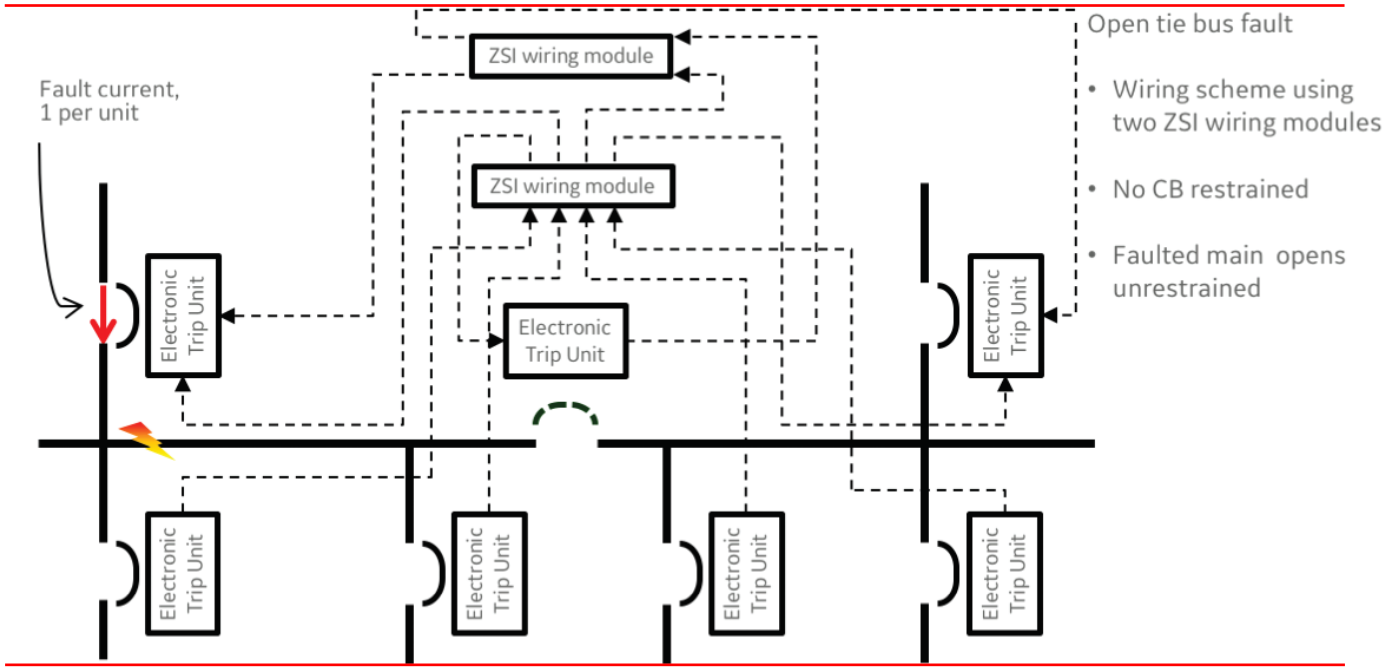

Figure 7

In an alternate scheme, the second ZSI wiring module is completely omitted and the tie and mains can only be restrained by feeders. If there is a fault on either one of the main buses the closed tie and closed mains would all react at their unrestrained protection logic and timing simultaneously. Both buses would be cleared simultaneously regardless if faulted or not if the tie is closed.

Adjusting ZSI Settings

The EntelliGuard and microEntelliGuard trip units has built-in display and keypad to allow access to the setting menu and enable or disable zone interlocking and adjust all associated restrained settings. The setting menus can also be accessed via optional serial communication (RS-485/Modbus RTU) or connecting a PC to the trip unit and running the ABB Trip Unit Toolkit software as shown on Figure 8. When selecting time delays and shape for short-time and ground fault, it is important to realize if the settings are for the restrained or unrestrained response.

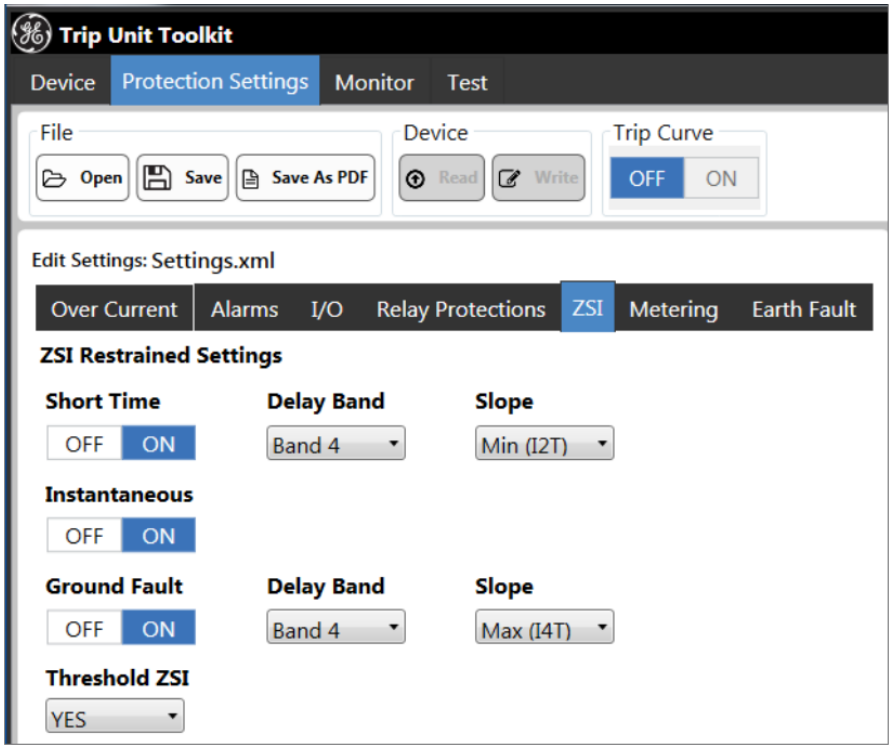

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Figure 8. Partial screen from the GE EntelliGuard tool kit circuit breaker setting and diagnostic software

For both, the restrained and unrestrained protection functions all shapes and delays are available for user selection. Only one current pickup threshold is set for each circuit breaker per protective function, but the restrained time delay setting on the upper tiers or upstream circuit breakers upstream must be set at a greater (slower) delay than the lowermost tier or downstream circuit breakers.

For detailed instructions on the ABB EntelliGuard trip units please see publication DEH4567 and for microEntelliGuard trip units please see publication GEH703.

Short-Time ZSI

If the trip unit does not have ST-ZSI enabled, the user sets a Short-Time pickup, shape and time delay to meet coordination study requirements. If ST-ZSI becomes enabled, the time delay and shape setting becomes the protective or unrestrained setting and the user now must provide an additional backup restrained time delay setting and shape. The current pickup setting remainsthe same for both the restrained and unrestrained response.

For both, the restrained and unrestrained protection functions all shapes and delays are available for user selection at all trip units. Only one current threshold is set for each circuit breaker but the restrained time delay setting on the upper tiers must be set at a greater delay than the lowermost tier.

Only one short-time current-threshold is set per circuit breaker trip unit and the restrained TD setting on the upper tiers must be set at greater delay than the lowermost tier. A third or higher tier may be set at the same delay as a second tier or at increasing slower delays if traditional coordination orcurve nesting is desired.

Figure 9 shows three circuit breakers with ST-ZSI enabled. All three are set with the unrestrained short-time delay at minimum. When there is a feeder fault, Figure 10, the upper tiers are restrained. The middle circuit breakeris set to a mid-level delay and the upper to slower delay. This is the traditional way to set circuit breakersto be selective, even when ZSI is implemented. Note that when the fault is in the middle protection zone, Figure 11, the third circuit breaker is restrained more than required to maintain selectivity and becomes a backup protection. This may be an issue if there are too many tiers in a scheme and there are either not enough delays to make all circuit breakers selective with each other or the backup delay in upstream tiers is unacceptable long.

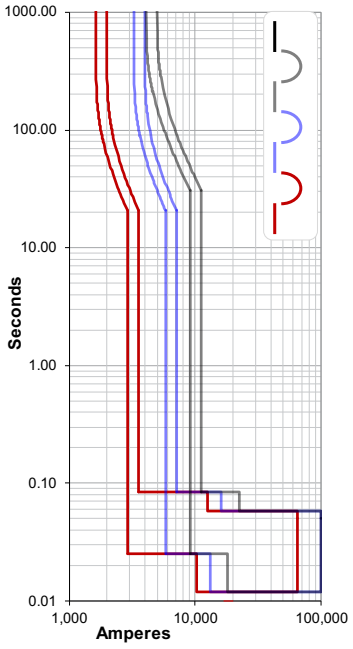

Figure 9. All trips showing protection response unrestrained

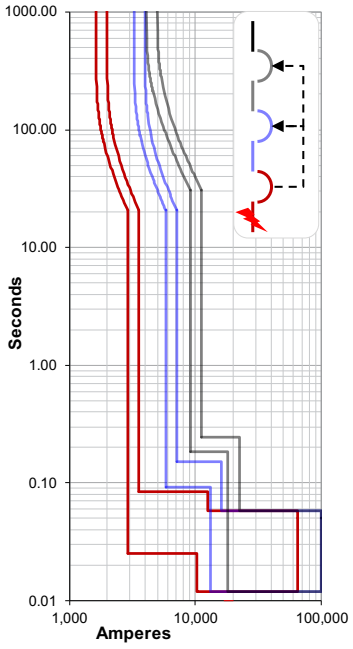

Figure 10. Upper tiers restrained by bottom tier. Selective with each other

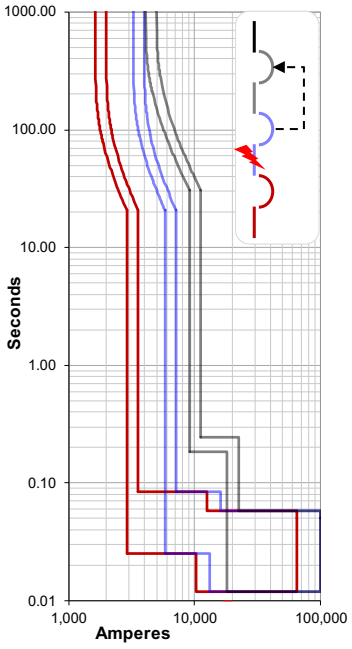

Figure 11. Upper tier restrained by middle tier, selective but slow backup

Example described in Figures 12-14 show an alternate way to set time delays if faster backup protection is desired. This may be particularly important to consider if there are many tiers of devices in series.

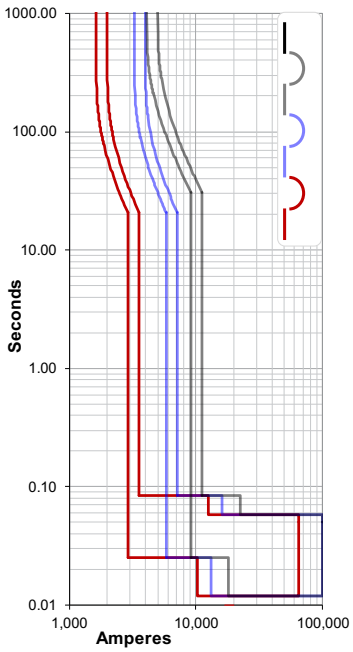

Figure 12. All trips showing protection response unrestrained

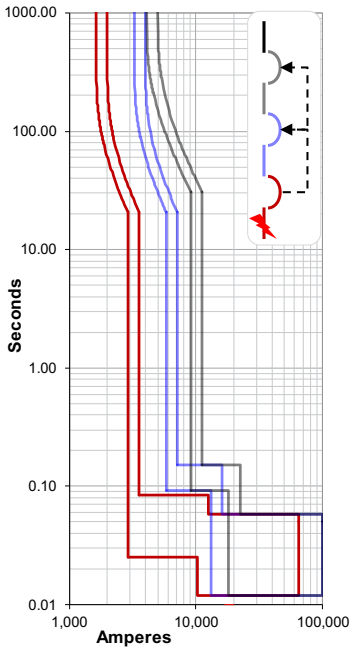

Figure 13. Upper tiers restrained by bottom tier. Upper tiers only selective with protecting CB

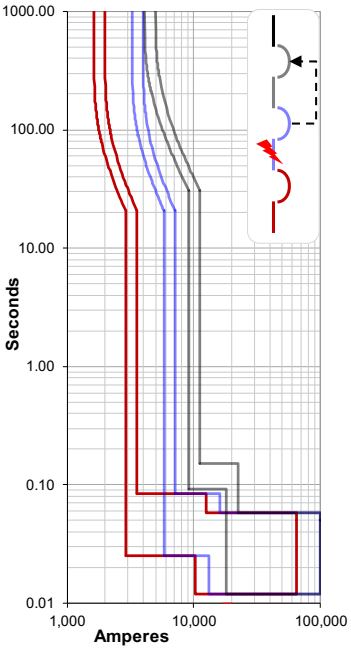

Figure 14. Upper tier restrained. Selective & fast backup

Figure 12 represents the same topology as Figure 9. However, in this case the restrained delay in the upper tier circuit breaker are set the same. When there is a feeder fault, Figure 13, the middle and top circuit breakers are restrained but they are not selective with each other, however, they both are selective with the faulted feeder circuit breaker. When the fault occurs in the middle protection zone, Figure 14, the upper tier circuit breaker is restrained and is selective with the second circuit breaker. However, the backup protection is faster than that shown in Figure 11.

This setting scheme allows for selectivity in the various fault scenarios but provide faster back up protection in case of a circuit breaker failure. If the fault is at the lowest level and the feeder fails to clear the fault, then there is a lack of selectivity in the back up protection as both the second and third circuit breaker may trip together.

This would only happen if the first circuit breaker fails to clear the fault which should be a rare event and if it happens then achieving faster backup protection may be more important than maintaining multiple levels of selective backup protection. Either way to set upper tier delays will work. This second way of setting retrained delays may be particularly valuable in large ZSI schemes with many tiers where top level tier backup delays may, otherwise, be very long and to ensure arc flash incident energy does not increase too much if a backup circuit breaker must provide the protection.

Example in Figures 15-17 describe the 4 shapes within short-time including three different I^2t slopes and one definite time shape. All of them are available for restrained and unrestrained protection. If the fuse shaped long time curve is selected, the I2t slopes for short-time are disabled and only the definite time shape is available.

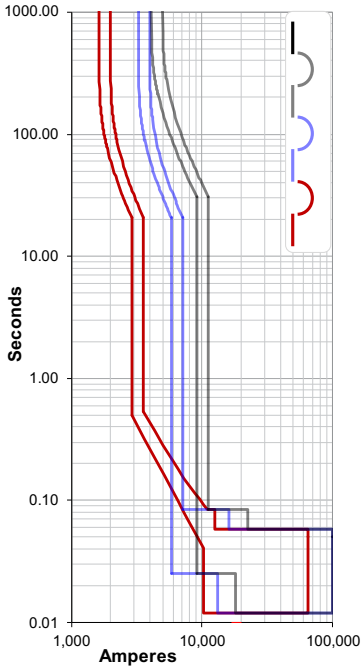

Figure 15. All CB unrestrained. Bottom CB has I^2t slope

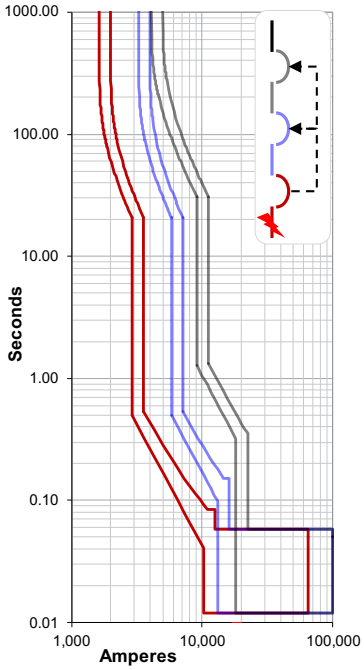

Figure 16. Upper 2 CBs are restrained by bottom tier. Restrained response adds slopes

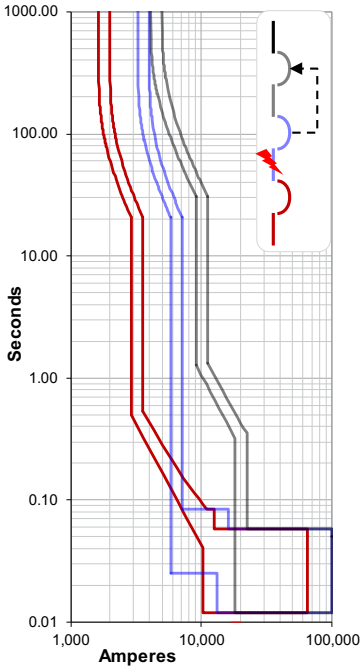

Figure 17. Middle tier projects without slope and restrains upper tier which adds slope

Figure 15 shows the same three circuit breakers from the previous two examples but now the feeder has an I^2t slope enabled. Note that the upper two circuit breakers do not have a slope enabled and operate using only a definite time function. For part of the fault range the upper two circuit breakers are faster and more sensitive than the feeder, yet they remain selective. Figure 16 shows what happens if the there is a fault at the feeder. The upper two circuit breakers receive a restraint signal and implement slower short-time delays and I2t slopes. In this case, the middle circuit breaker implemented a minimum slope and the upper most circuit breaker implements a mid-level slope. When the middle circuit breaker is faulted, it responds using the faster and more sensitive definite time response, Figure 17. In all three fault scenarios, the circuit breakers provide the fastest possible protection and maintain selectivity.

Ground Fault ZSI

The Ground Fault ZSI is like the phase overcurrent interlocking described in the preceding section. It consists of one threshold, restrained and unrestrained time delay, and shape; all of which are user selected. The shapes Figure 18 include:

- OFF (Definite Time)
- I^2t slope
- I^4t slope
- SGF (Selective Ground Fault)

SGF allows better selectivity with downstream circuit breaker phase protection functions and fuses than traditional ground fault curve shapes. I^4t shape is particularly useful upstream from fuses. Both restrained and unrestrained settings may include any combination of delay and shape except upper delays should be set slower and not overlapping with the lower-most delay. Multiple upper shapes may be set similarly and may overlap.

If the trip unit does not have GF-ZSI enabled, the user sets a GF pickup, shape and delay per the requirements of the coordination study. If GF-ZSI becomes enabled, that first setting group becomes the unrestrained setting and the user must now provide an additional backup restrained time delay and shape.

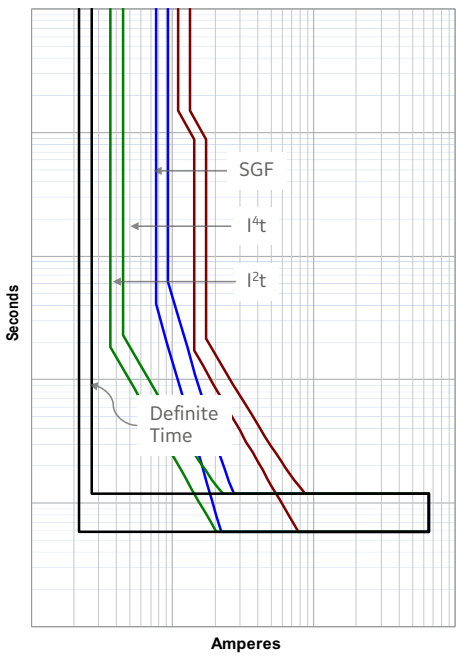

Figure 18. Ground Fault curve shapes available for restrained or unrestrained settings

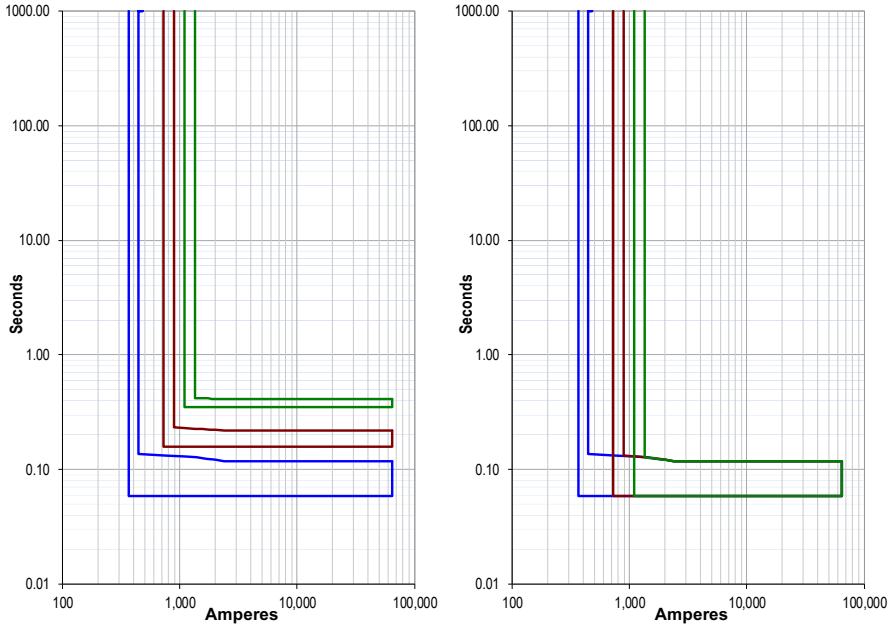

Figure 19. CB in 3 tiers shown in unrestrained protection mode in the left. Upper 2 tiers shown restrained on the right fastest possible protection & selectivity

Figure 19 is an example of how three GF functions may be set for protection and selectivity using ZSI. The left curve shows how each protects and the right curve shows the upper tiers restrained. Just like with phase protection whether the third tier is set to overlap with the second or not is a user decision. The shape used by the three circuit breakers is the definite time, or GF slope OFF shape.

Figure 20 shows three devices with the lower-most tier set with an I^2t curve. This could be used to achieve selectivity with a downstream thermal magnetic circuit breaker for example. The upper two tiers are set with the slope OFF. The restraint signal from the lower most GF function is enough to maintain selectivity regardless of the curve overlap between the unrestrained settings.

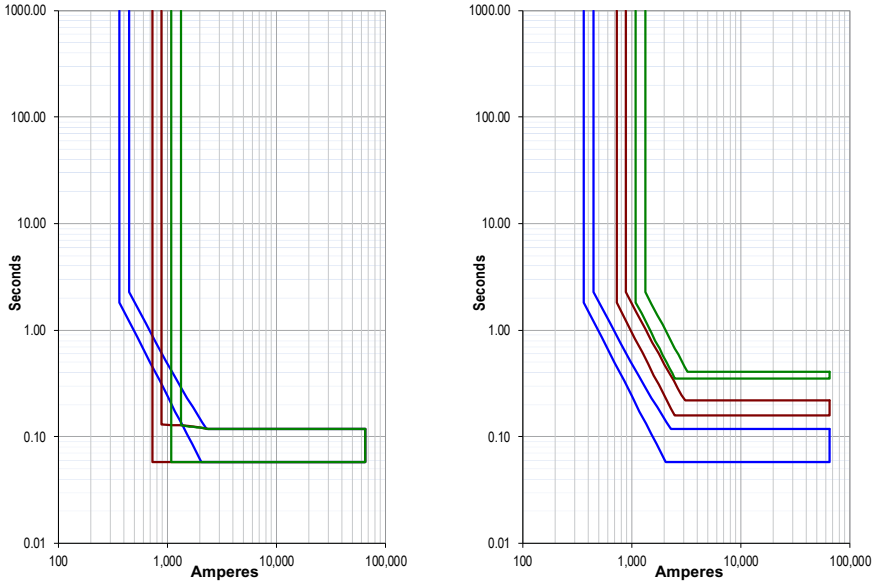

Figure 20. 3 Tiers shown in unrestrained protection mode on the left with bottom tier CB using an I^2t slope as may be needed to be selective with a smaller thermal magnetic CB downstream. Upper 2 tiers shown restrained on the right add similar slope to stay selective. Fastest possible protection & selective

Figure 21 shows two GF protective functions upstream from a phase protection function. The three devices are zone-selective interlocked. The phase protection is an 800A circuit breaker. The two GF functions are set to protect unrestrained overlapping the phase protection. When the downstream feeder protection detects a fault, it issues a restraint signal and the two GF functions are restrained to settings that allow the phase protection to selectively clear the fault first. When the fault is a ground fault in the middle protection zone, the upstream GF is restrained and made selective with the GF function from the middle circuit breaker. This is just one example of how the ABB range of GF curve shapes and zone interlocking can be used to achieve maximum ground fault protection and selectivity simultaneously.

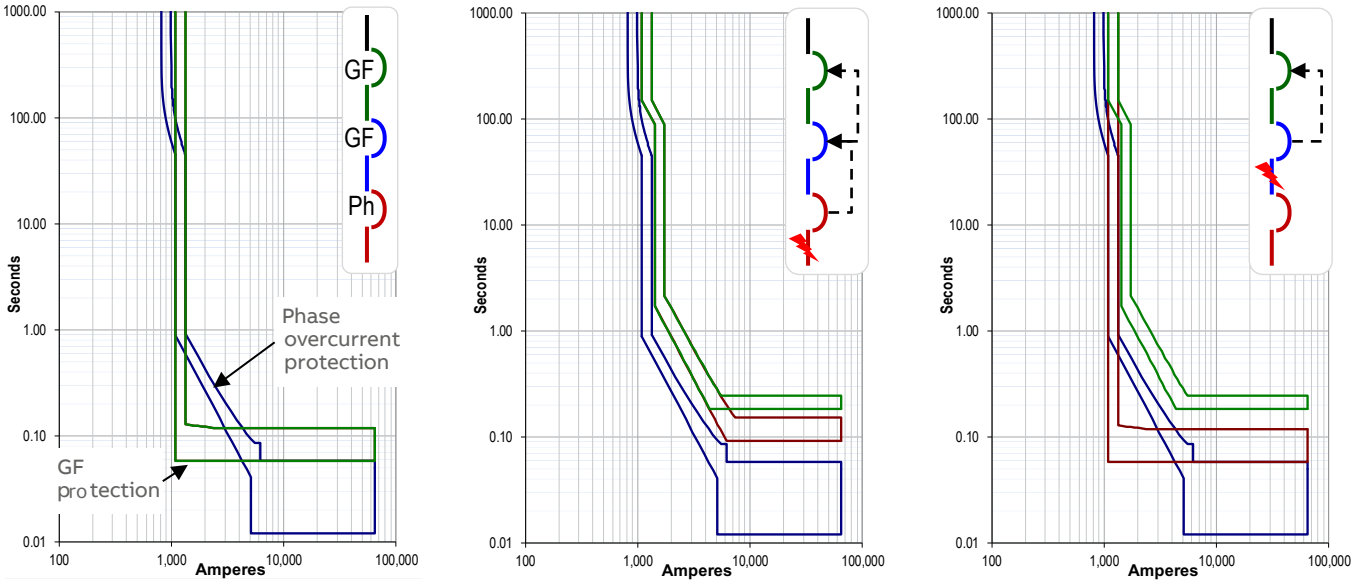

Figure 21. Three tiers zone-selection interlocked circuit breaker scheme with GF protection in the two upper tier circuit breakers set at 1200A and phase protection in the lower tier circuit breaker set at 800A.

Instantaneous ZSI

Instantaneous ZSI is an optional ZSI capability offered differently on different ABB circuit breakers. In some circuit breakers, the function is only available to issue a blocking signal based on the sensed current exceeding the adjustable selective instantaneous threshold. In other circuit breakers, it can issue a blocking signal and also shift its own instantaneous upon receipt of a blocking signal.

Figures 22 - 24 demonstrate the I-ZSI capability. Figure 22 shows three circuit breakers with unrestrained short-time and instantaneous functions which overlap in clearing time but not in current thresholds. Figure 23 shows the restrained curves for the two upper tier devices if only ST-ZSI is implemented. Figure 24 shows the restrained curves if short-time and instantaneous ZSI are both implemented. The user may select the time delay for the restrained short-time protection. However, the restrained instantaneous curve is not user adjustable. The only user setting is whether I-ZSI is enable or disabled.

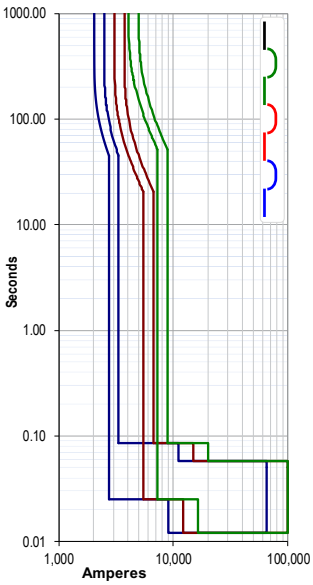

Figure 22. 3 CB with overlapping ST & instantaneous protection

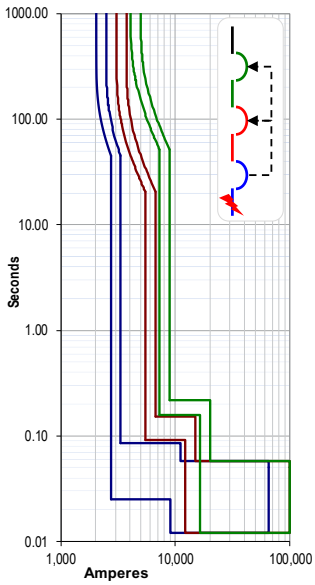

Figure 23. CB with ST-ZSI, feeder restrains upper ST protection

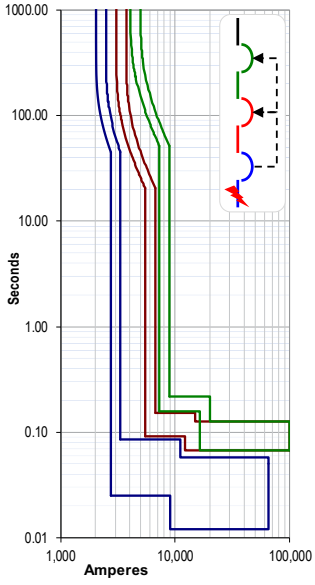

Figure 24. CB with ST -, & I-ZSI, feeder restrains upper ST & instantaneous protection

The I-ZSI function restrained delay is fixed and it depends on the circuit breaker type. When the trip unit receiving the restraint signal is installed in an older circuit breaker or retrofit kit the instantaneous shifts to a short-time function with a 3.5-4 cycle commit time. When the trip unit is implemented in a latest generation circuit breaker such as the EntelliGuard G circuit breakers, the shift isto a 3.5 cycle committime.

Please note, the I-ZSI is not fully implemented in all ABB circuit breakers. In some circuit breakers the instantaneous threshold is used to issue a restraint signal to upper tiers, but that circuit breaker type cannot have its own instantaneous restrained. The circuit breakers with the more limited implementation are suitable for application in the lower most tierof an I-ZSI scheme.

I-ZSI Characteristics For Various ABB Circuit Breakers

CIRCUIT BREAKER TYPE	AVAILABLE	RESTRAINED IOC		LIMIT BY OVERRIDE
		COMMIT	CLEAR	
Spectra G MCCB	Output Only	None	None	N/A
Spectra K MCCB	Output Only	None	None	N/A
PowerBreak Trip Retrofit	No	None	None	N/A
PowerBreak II CB	Output Only	None	None	N/A
PowerBreak II Retrofit	Output Only	None	None	N/A
WavePro LVPCB	Yes	0.067 S	0.127 S	No
EntelliGuard G	Yes	0.058 S	0.113 S	Shift Yes
ANSI Trip Retrofit	Yes	0.067 S	01.127 S	No

—

Table 1

The ABB I-ZSI function operates with its own dedicated instantaneous threshold separate from the short-time protection threshold. This provide increased coordination and protection flexibility enabling selectivity up to the withstand rating or short circuit rating of many circuit breakers types and sizes while simultaneously implementing instantaneous protectionfor low magnitude in zone arcing faults.

On circuit breakers that have an instantaneous override function and that can restrain their normal instantaneous pick up, the override instantaneous range cannot be restrained because the override is used to protect the circuit breaker. Control poweris required at eachtrip unitto properlyimplement I-ZSI.

Threshold Zone-Selective Interlocking (T-ZSI)

T-ZSI is a unique optional GE ZSI capability available for ST-ZSI and I- ZSI in which the user may enable the function given the trip unit was ordered with the optional capability. When enabled, the T-ZSI function applies to ST-ZSI and I-ZSI simultaneously. The purpose of T-SZI is to get around the nesting of thresholds required for reliable coordination due to sensing tolerance in the trip unit.

Sensing tolerance in EntelliGuard and microEntelliGuard trip units is 10%. The T-ZSI function allows the user to set the curves of circuit breaker tiers with common or overlapping current pickup thresholds. The T-ZSI function shifts the restrained curves 23% to the right which makes it greater than the user-set threshold upon receipt of the restraint signal from a lower tier. The circuit breaker protects at 100% the user-set threshold and provides backup protection at 123% of the user-set threshold. The user may set the ST, or the IOC, or both thresholds partially or completely overlapping with downstream tiers. The restraining function will shift both 23% in EntelliGuard and microEntelliGuard trip units. If the trip unit is set without ST or IOC protection, then only the set protection will restrain or issue a blocking signal. The restrained threshold will not exceed the maximum threshold able to be set for the trip unit. The override protection may not be restrained in anyway.

Figure 25 shows three circuit breakers in series with the upstream two circuit breakers having overlapping short-time and instantaneous pickups. When the lower most circuit breaker senses a fault, it restrains the upper two circuit breakers as shown in figure 26. Both the short-time and the instantaneous pickup thresholds shift 23% to provide selective backup to the faulted tier. In figure 27, only the upper most circuit breaker curve is altered by the restraint signal received from the faulted middle circuit breaker. In all the fault scenarios, the system is selective and protection is achieved with minimum delay and maximum sensitivity. This function is particularly useful to increase protection sensitivity in weak systems or systems with a high number of ZSI tiers.

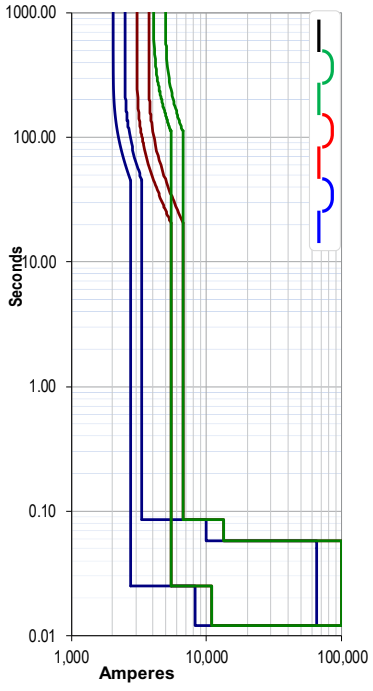

Figure 25. 3 CB with ST-, I-& T-ZSI. All at unrestrained protective settings

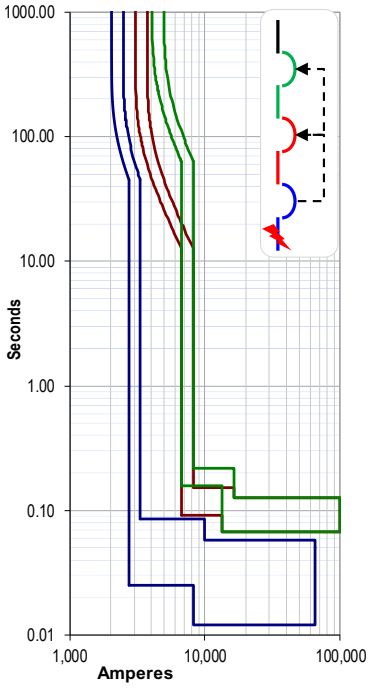

Figure 26. 3 CB with ST-, 1-& T-ZSI. Faulted CB restrains upper tiers up & to the right. Bottom tier selective

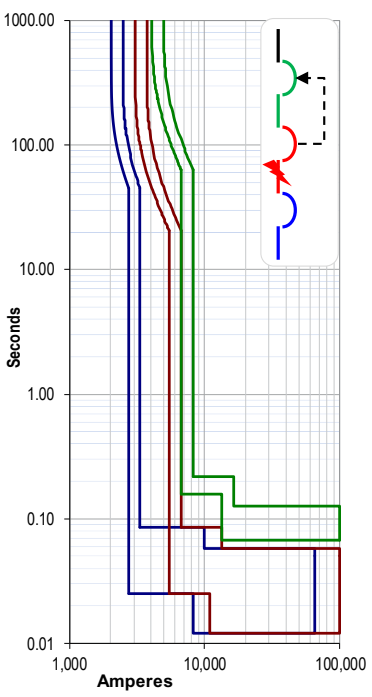

Figure 27. 3 CB with ST-, 1-& T-ZSI. Faulted CB restrains upper tier up & to the right. Mid tier selective

Table 2 identifies which ABB circuit breakers offer T-ZSI. The restrained pickup T-ZSI in a circuit breaker is automatic and need not be set by the user.

T-ZSI AvailabilityTable

CIRCUIT BREAKER TYPE	AVAILABLE	SHORT-TIME	INSTANTANEOUS
Spectra G MCCB	Yes	In & Out	Out
Spectra K MCCB	Yes	In & Out	Out
PowerBreakTrip Retrofit	No	N/A	N/A
PowerBreak II CB	Yes	In & Out	Out
PowerBreak II Trip Retrofit	Yes	In & Out	Out
WavePro LVPCB	Yes	In & Out	In & Out
EntelliGuard G	Yes	In & Out	In & Out
ANSI Trip Retrofit	Yes	In & Out	In & Out

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Table 2

In = Trip unit is ableto be restrained
Out = Trip unit is ableto issueT-ZSI retrain signal

Table 3 shows selected examples of the restrained pickup for any threshold implementing T-ZSI which is 1.23X the set protective threshold, but cannot exceed the range allowed for the user set threshold.

UNRESTRAINED PU	RESTRAINED PU	UNRESTRAINED PU	RESTRAINED PU	UNRESTRAINED PU	RESTRAINED PU	UNRESTRAINED PU	RESTRAINED PU	UNRESTRAINED PU	RESTRAINED PU
1.5	1.85	1.5	1.85	1.5	1.85	1.5	1.85	1.5	1.85
2.0	2.46	2.0	2.46	2.0	2.46	2.0	2.46	2.0	2.46
3.0	3.08	3.0	3.08	3.0	3.08	3.0	3.08	2.5	3.08
2.5	3.69	2.5	3.69	2.5	3.69	2.5	3.69	3.0	3.69
3.5	4.31	3.5	4.31	3.5	4.31	3.5	4.31	3.5	4.31
4.0	4.92	4.0	4.92	4.0	4.92	4.0	4.92	4.0	4.92
4.5	5.54	4.5	5.54	4.5	5.54	4.5	5.54	4.5	5.54
5.0	6.15	5.0	6.15	5.0	6.15	5.0	6.15	5.0	6.15
5.5	6.77	5.5	6.77	5.5	6.77	5.5	6.77	5.5	6.77
6.0	7.00	6.0	7.38	6.0	7.38	6.0	7.38	6.0	7.38
6.5	7.00	6.5	8.00	6.5	8.00	6.5	8.00	6.5	8.00
7.0	7.00	7.0	8.61	7.0	8.61	7.0	8.61	7.0	8.61
		7.5	9.00	7.5	9.23	7.5	9.23	7.5	9.23
		8.0	9.00	8.0	9.84	8.0	9.84	8.0	9.84
		8.5	9.00	8.5	10.00	8.5	10.46	8.5	10.46
		9.0	9.00	9.0	10.00	9.0	11.07	9.0	11.07
				9.5	10.00	9.5	11.69	9.5	11.69
				10.0	10.00	10.0	12.00	10.0	12.30
						10.5	12.00	10.5	12.92
						11.0	12.00	11.0	13.53
						11.5	12.00	11.5	14.15
						12.0	12.00	12.0	14.76
								12.5	15.00
								13.0	15.00
								13.5	15.00
								14.0	15.00
								14.5	15.00
								15.0	15.00

Table 3

For more information please see the following recommended ABB and IEEE publications:

Related ABB Application Notes:

- DET 760D - Guide to Instantaneous Selectivity
- DET 1002 - 240.87 & 240.67, 2017 National Electrical Code
- DET 1004 - Energy Reducing Maintenance Switch
- Marcelo E. Valdes; John J. Dougherty; *Advances in Protective Device Interlocking for Improved Protection and Selectivity*; Industry Applications, IEEE Transactions on; Vol. 50, Issue 3, Pgs. 1639-1648, yr. 2014

ABB Inc.
305 Gregson Drive
Cary, NC 27511.
electrification.us.abb.com

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