



DEH-583 Instruction Guide

# Zone-Selective Interlocking Field Testing and Commissioning

For EntelliGuard\* and microEntelliGuard\* Trip Units



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This document describes a zone-selective interlock (ZSI) test procedure that confirms ZSI wiring for all modes and demonstrates proper restrained and unrestrained protection response based on ZSI signaling for short time and ground fault ZSI (GF-ZSI).

# 1. Overview

Zone-selective interlocking allows each circuit breaker tier to protect at a fast unrestrained delay for faults in their respective zones of protection while restraining upstream tiers of circuit breakers to operate at longer delays so they can provide selective backup protection without sacrificing selectivity.

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## SIMPLIFIED ZSI SCHEMATIC DRAWING

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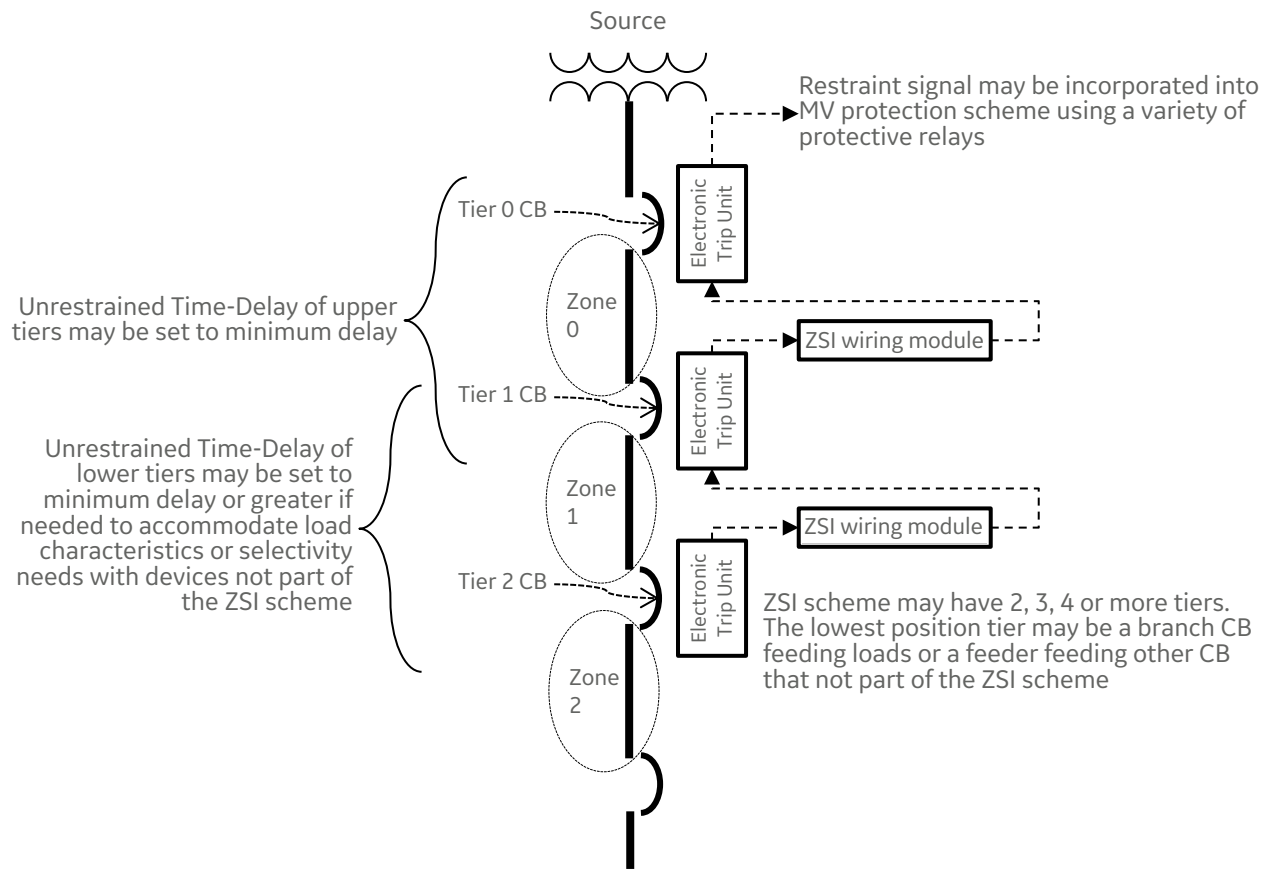


Figure 1

Various aspects of the functionality can be efficiently tested with the procedures described in this document. The test procedures require following:

- 24 VDC control power. This is supplied externally via the circuit breaker's secondary disconnect or from the EntelliGuard test kit, Cat#GTUTK20.
- The circuit breaker should not carry load current (No load) during the test procedure.
- Testing of wiring integrity between trip units may be done directly from the trip unit built in display and control pad. Testing of trip unit response and protection timing will require the EntelliGuard test kit , Cat#GTUTK20, trip unit software package available from the following link, <http://www.geindustrial.com/products/conversion-kits-and-trip-units/trip-unit-toolkit>

The testing methods described in this document apply to the following trip units and related products:

- EntelliGuard TU trip units in EntelliGuard G IEC, UL489 and UL1066 air, Insulated Case and Low Voltage Power circuit breakers
- EntelliGuard TU Trip units in PowerBreak II Insulated Case Circuit breakers (UL 489)
- microEntelliGuard trip units in molded case Spectra K and Spectra G circuit breakers (UL489)
- High Pressure Contact (HPC) switch control relays

## 2. ZSI Functions in EntelliGuard Trip Units

**Ground Fault (GF) ZSI:** Arbitrates the delay and shape of the GF protection function based on the presence or absence of a ZSI restraint signal at the trip unit. Does not affect the GF pickup current threshold.

**Short Time (ST) ZSI:** Arbitrates the delay and shape of the ST protection function based on the presence or absence of a ZSI restraint signal at the trip unit. Does not affect the ST pickup current threshold.

**Instantaneous (I) ZSI:** Arbitrates the timing of the Adjustable- Selective-Instantaneous protection function based on the presence or absence of a ZSI restraint signal at the trip unit. Does not affect the Instantaneous pickup current threshold. The only user setting is enabling the I-ZSI function, or not. The procedures below will not test I-ZSI timing however they do test the associated signaling capability.

**Threshold (T) ZSI:** Arbitrates the pickup current threshold for the ST and Adjustable-Selective-Instantaneous function when T-ZSI is enabled. The only user setting is enabling the T-ZSI function, or not.

With Threshold ZSI enabled it is possible to set the Short Time and Instantaneous protection of multiple breaker tiers at the same pickup thresholds, **maximizing in-zone sensitivity** for unrestrained operation. Without this feature in-zone pickup thresholds must be nested from feeder to main to maintain selectivity.

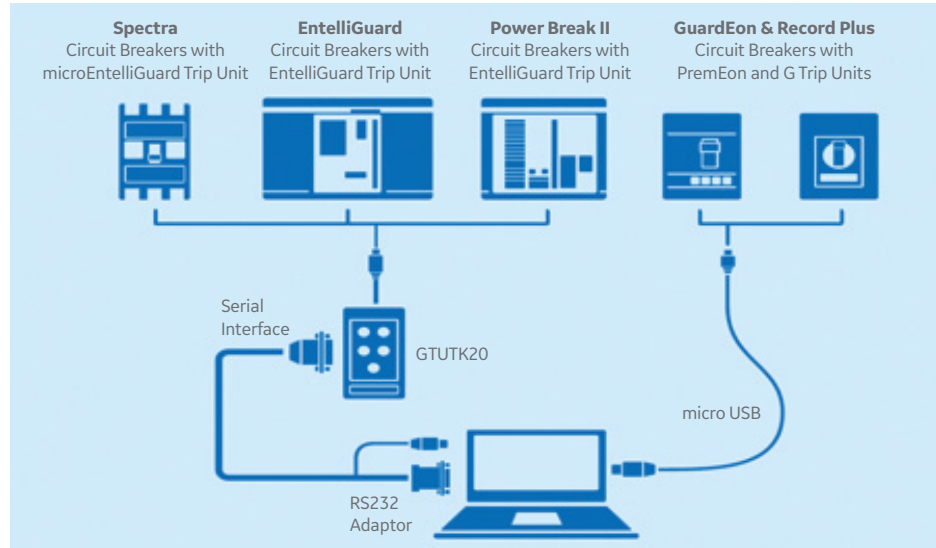
With Threshold ZSI engaged the lowest tier breaker to enter pickup will issue a ZSI Output signal when the fault current exceeds 81% of the user-set threshold. On receipt of a downstream ZSI signal an upstream breaker with T-ZSI enabled will do two things – it will engage the restrained (slower and selective) delay settings as set by the user, and it will increase its pickup threshold to 123% of the nominal user setting.

This feature eliminates concerns about trip system current measurement tolerance interfering with selectivity while providing maximum sensitivity.

For further details on ZSI application see publication DET1001, Zone-Selective Interlocking Application Guide. Available at [www.library.abb.com](http://www.library.abb.com)

### 3. Trip Unit Toolkit Software

The Trip Unit Toolkit is a software package available from for trip units to manage, monitor, test and customize various user-adjustable trip unit operating parameters. This tools aids in startup, commissioning, maintenance, diagnostics and testing of various ABB trip units directly on your personal computer or laptop.



The software, instructions and other information can be found in the link below:  
[www.library.abb.com](http://www.library.abb.com) - search Toolkit

Trip unit tool kit software requires Modbus serial communications through the circuit breaker's secondary disconnect or via the EntelliGuard test kit, Cat#GTUTK20.

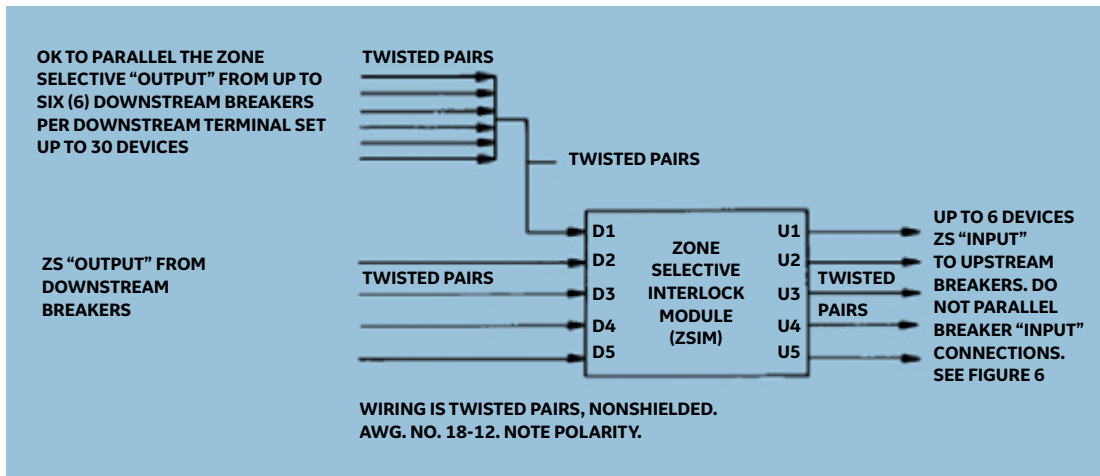
### 4. ZSI Wiring Basics

ZSI interconnection wiring is achieved with the use of the ZSI module (TIM1) or an equivalent ABB recommended device. Each circuitbreaker includes a set of ZSI output (ZSI-OUT) & ZSI input (ZSI-IN) terminals on its secondary disconnect which are wired internally to the EntelliGuard trip unit control logic. The TMI1 device provides signal isolation and routing functions for the ZSI system. The

device requires constant 24V. It should be noted that the trip unit does not require control voltage for ST-ZSI and GF-ZSI but does require it for reliable operation of the T-ZSI and I-ZSI functions.

The ZSI-OUT terminals from the downstream circuit breaker secondary disconnect are wired to the downstream input on the TIM1 module. The ZSI-IN terminals on the upstream circuit breaker secondary disconnect are wired to the upstream input on the TIM1 module.

Refer to publication GEK-64467A for the ZSI Module installation and configuration instructions.



## 5. ZSI Wiring Integrity Test Using Trip Unit Display & Key Pad

The ZSI test and a ZSI status display functionality can be used during ZSI setup, commissioning, and periodic maintenance checks. Neither the Trip Unit Toolkit software, nor the GTUTK20 test is needed for this test.



**NO** means the specific ZSI **functionality** in this Trip Unit is not enabled. **YES** means it is enabled.

**OFF** means the ZSI functionality in this Trip Unit is not enabled. Any other selection means it is enabled on selected protections. This is a user selection.

ZSI Test Option in Setup Menu



**OFF** means the ZSI-IN signal has not been received. **ON** would mean it has been received.

**OFF** means the ZSI-IN signal has not been sent out to upstream, **ON** would mean it has been sent out.

ZSI Status Screen in Status Menu

From the downstream circuit breaker, you can use the **ZSI test** function available on zone-selective interlock screen in the setup menu to cause the ZSI-OUT signal, that upstream circuit breaker shall receive as ZSI-IN signal.

The ZSI status screen in the status menu shall display the ZSI-OUT display status and ZSI-IN status. In this case, upstream circuit breakers ZSI-IN display Status and the downstream breaker's ZSI-OUT display status report status as ON in respective trip unit's screens.

The ZSI-Test function turns off after 30 seconds from initiation.

## 6. ZSI Delay Bands Test Using Trip Unit Toolkit Software

In this test, we can demonstrate the how the trip unit operates on restrained or unrestrained settings based on ZSI-IN status.

The EntelliGuard trip unit must be setup to communicate with the trip unit toolkit software installed in a laptop or PC. Using the trip unit toolkit, you can digitally test a circuit breaker for diagnostics without requiring an actual fault condition. The Test tab on the user interface of the software provides the flexibility to create overcurrent and ground fault conditions and monitor trip time response from the unit.

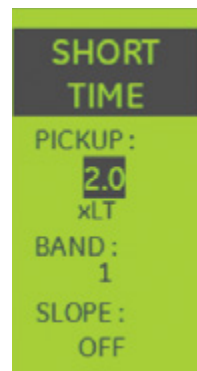
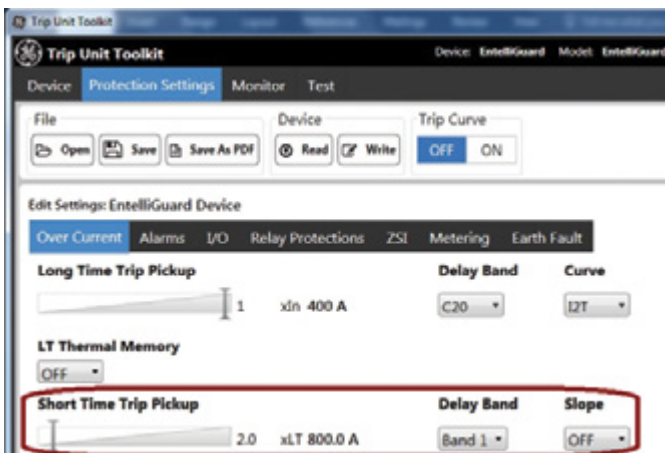
The ZSI test is demonstrated with short-time protection function in this section. There are two set points for ST protection referred as unrestrained settings & restrained settings in the software. In the EntelliGuard and microEntelliGuard trip units the first setting is the unrestrained setting, the ZSI associated setting is the restrained setting.

### 6.1 Configuration Settings

If the trip unit does not have ST-ZSI enabled, the user sets a ST pickup, shape and time delay. 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 remains the same for both the restrained and unrestrained response.

The same is applicable for GF-ZSI as well.

Unrestrained mode ST set points: If ZSI is enabled and there is no ZSI-IN signal, the trip unit operates on unrestrained ST delay settings. These can be configured through the LCD panel in the trip unit or the trip unit test kit (TUTK) interface in the software once ZSI is enabled. Both are shown below.



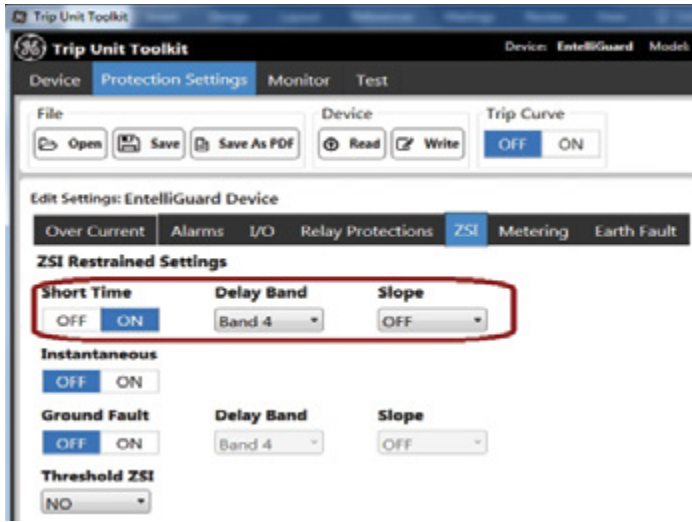
Trip Unit Toolkit Protection Settings Tab & LCD screen for configuring ST Unrestrained Settings



**Restrained settings:** If ZSI is enabled and the ZSI-IN signal is present, the trip unit operates on restrained ST delay settings. These can be configured through either interface as shown below.

This setting is usually intended to provide selectivity with the faulted circuit breaker, so it will typically be set with a longer delay to allow the downstream circuit breaker time to clear the fault. Note that the Short Time ZSI Pickup value (current) is not a separate adjustment.

Note: The restrained ST delay setting is called “ZSI ST” delay in EntelliGuard and microEntelliGuard trip units. The default delay if ZSI is disabled is the unrestrained more protective timing.



Note that there is no current pickup adjustment associated with the ZSI function. The current pickup adjustment is only made once.

Trip Unit Toolkit Protection Settings Tab & LCD screen for configuring ST Restraint Settings

The delay band configuration can either be performed through the trip unit mounted LCD-KeyPad interface or through the TUTK software tool as required for the test procedure described below. The test procedure in the example below can be generalized to other settings with response as per the settings configured.

## 6.2 Generating ZSI-IN Signal

This ZSI-IN signal to upstream breaker can be provided by ZSI test functionality from downstream Trip Unit or through **Push to Test** button on TIM1 module for evaluation during this test procedure.

### Example

CONFIGURATION	
Sensor Rating	400A
Rating Plug	400A
Frequency	60Hz
Agency	UL
LT Pickup	400A
LT band	C20
LT Curve	I <sup>2</sup> T

CONFIGURATION (CONT.)	
ST Pickup	2x LT
ST Band	1 (25ms-80msec)
ST Slope	OFF- (Unrestrained Settings)
ZSI Settings	ZSIST
Threshold ZSI	OFF
ZSI ST Band	4 (58ms to 110 m sec)
ZSI ST Slope	OFF - (Restrained Settings)

- The test is performed by injecting a signal that exceeds ST Pickup digitally for evaluating response with & without ZSI-IN signal.
- The ZSI input is provided by TIM1 module (PUSH to ON). The circuit breaker's ZSI-IN is assumed to be connected to upstream breaker terminal of TIM1 module for the test. As long as button is pressed the ZSI-IN signal will be available.
- EMTK settings Test settings options in the EMTK Software → Test tab → *Select Sequence Execution*. Test Setting Tab select Over Current → Select Phase current as 840A.
- For detailed instructions on using this section refer DEE-689A TUTK User Guide. Available at [geindustrial.com](http://geindustrial.com).

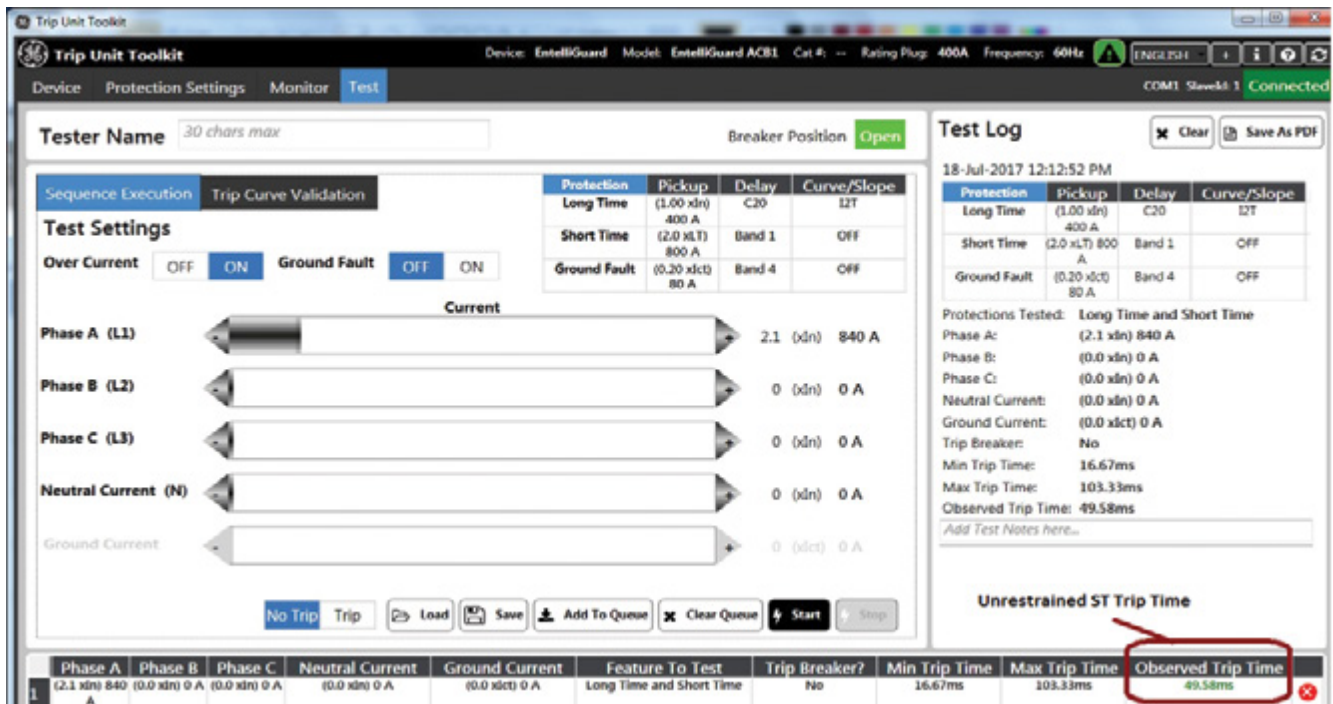
### Step 1: EntelliGuard TU Response Without ZSI-IN (Unrestrained Delay)

ZSI-IN status in ZSI Status screen should display OFF before start of test. This means no ZSI-IN signal is available. The unit without a ZSI Input should operate based on unrestrained settings. Test can be performed by clicking on the Start button after which the TUTK provides a current signal into the trip unit. Expected Trip time as per above example setting should be delay band1 observed Trip time: 49.58 msec, that is within delay Band1 range.



The status of ZSI can also be observed on the Monitor tab of the TUTK software.

STATUS			
<b>Breaker</b>	<b>RELT</b>	<b>ZSI IN</b>	<b>ZSI OUT</b>
OPEN	OFF	OFF	OFF



TUTK Test tab after performing ST digital injection test with ZSI-IN as OFF

## Step 2: EntelliGuard TU Response with ZSI-IN (Restrained Delay)



Provide a ZSI-IN signal by the PUSH to ON switch located on the TIM1 module or through a ZSI test function available on a downstream EntelliGuard trip unit. Confirm the status on ZSI Status screen.

Perform the test with same settings as Step1 but with ZSI-IN signal as ON.

Expected Trip time as per above example setting should be delay band 4 observed Trip time: 87.5 msec, that is within delay Band 4 range.

**Observation:** Trip unit trips as per Unrestrained ST band when ZSI-IN is OFF.

**Observation:** Trip unit trips as per ST-ZSI Restrained delay when ZSI-IN is available with acceptable tolerance.

Note: Ignore the limits of Min Trip Time and Max Trip Time displayed on TUTK, in this case, as TUTK continues to display the unrestrained limits in this case.

Trip Unit Toolkit

Device: IntelliGuard Model: IntelliGuard ACB1 Cat #: -- Rating Plug: 400A Frequency: 60Hz

COM1 SlaveId: 1 Connect

Tester Name: 30 chars max Breaker Position: Open

**ZSI IN**

Test Log

Min Trip Time: 16.67ms  
Max Trip Time: 103.33ms  
Observed Trip Time: 49.58ms

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Protection	Pickup	Delay	Curve/Slope
Long Time	(1.00 xIn) 400 A	C20	I2T
Short Time	(2.0 xLT) 800 A	Band 1	OFF
Ground Fault	(0.20 xICT) 80 A	Band 4	OFF

Protections Tested: Long Time and Short Time  
Phase A: (2.1 xIn) 840 A  
Phase B: (0.0 xIn) 0 A  
Phase C: (0.0 xIn) 0 A  
Neutral Current: (0.0 xIn) 0 A  
Ground Current: (0.0 xICT) 0 A  
Trip Breaker: No  
Min Trip Time: 16.67ms  
Max Trip Time: 103.33ms  
Observed Trip Time: 87.50ms

Test Settings

Over Current: OFF ON Ground Fault: OFF ON

Phase A (L1): 2.1 (xIn) 840 A  
Phase B (L2): 0 (xIn) 0 A  
Phase C (L3): 0 (xIn) 0 A  
Neutral Current (N): 0 (xIn) 0 A  
Ground Current: 0 (xIn) 0 A

Ignore Limits

Restrained ST Trip Time

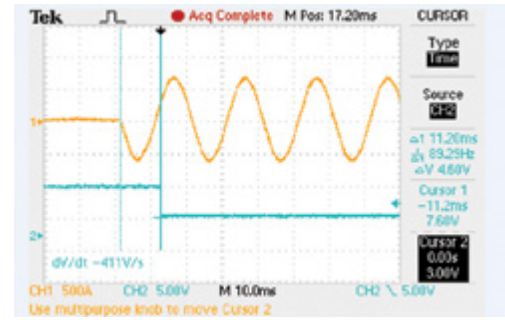
Phase A	Phase B	Phase C	Neutral Current	Ground Current	Feature To Test	Trip Breaker?	Min Trip Time	Max Trip Time	Observed Trip Time
(2.1 xIn) 840 A	(0.0 xIn) 0 A	(0.0 xIn) 0 A	(0.0 xIn) 0 A	(0.0 xICT) 0 A	Long Time and Short Time	No	16.67ms	103.33ms	87.50ms

TUTK Test tab after performing ST digital injection test with ZSI-IN as ON

# 7. ZSI-OUT Signal Timing

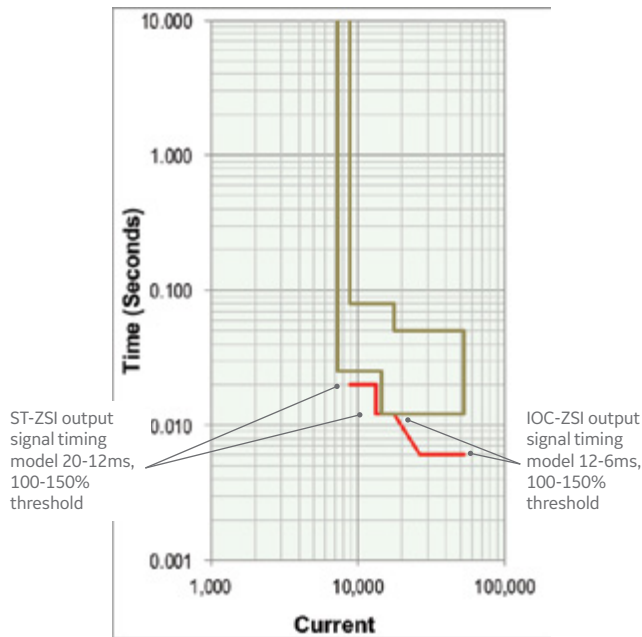
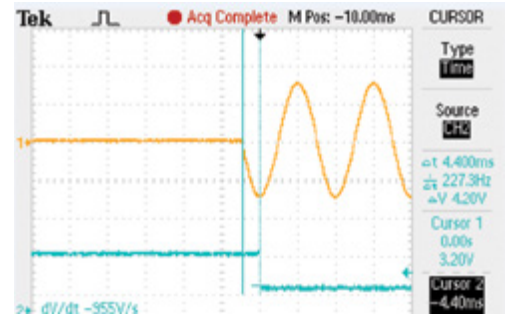
## 7.1 ST-ZSI-OUT and GF-ZSI-OUT Signal Timing

The ST-ZSI-OUT and GF-ZSI-OUT signal is issued between 0.5 and 1.5 half cycle (HC) from the instant fault is applied, depending on level of fault current. As demonstrated in attached figure the ZSI-OUT signal from downstream is issued in 11.2 ms for 50Hz. The Sinusoidal wave demonstrate the fault initiation and channel 2 captures the ZSI-OUT signal timing. An equivalent 60 cycle response would be 9.33 milliseconds.

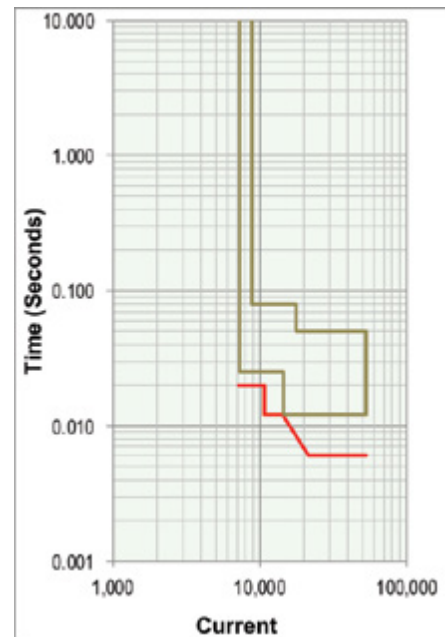


## 7.2 I-ZSI-OUT Signal Timing

The Instantaneous ZSI-OUT signal is issued between change to 12-6 milliseconds, between 100-150% of threshold, from the instant fault is applied, depending on level of fault current. As demonstrated in attached figure the ZSI-OUT signal from downstream is issued in 4.4 ms for 50Hz. The sinusoidal wave demonstrates the fault initiation and channel 2 captures the ZSI-OUT signal timing. The equivalent 60 Hz response would be 3.67 milliseconds.



ZSI output timing for CB set with 8,000A ST pickup and 16,000A IOC pickup.



Same timing model but shifted left ~20% due to use of the T-ZSI option





## For More Information Please See the Following Recommended ABB and IEEE Publications:

### Related ABB Application Notes:

- \* DEE - 689 Trip Unit Toolkit User Guide
- \* DEE - 688 Trip Unit Toolkit Installation Instructions
- \* DET - 10001 Zone-Selective Interlocking Application Guide
- \* GEK-64467A for the ZSI Module Installation and Configuration Instructions

### For Additional Product Data See:

- \* Trip Unit Toolkit  
<https://library.abb.com/>

These instructions do not cover all details or variations in equipment nor do they provide for every possible contingency that may be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise that are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Inc.

**ABB Inc.**  
305 Gregson Drive  
Cary, NC 27511.  
[electrification.us.abb.com](http://electrification.us.abb.com)

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