GE

Zone Selective Interlock Module

For GE Circuit Breakers

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1. Introduction

What is Zone-Selective Interlocking (ZSI)?

ZSI is an optional feature of various GE trip units which allow enhancing protection without sacrificing selectivity between circuit breakers. ZSI adds the capability of sending information from one load-side circuit breaker tier to one or more line-side tiers of circuit breakers so that selectivity is achieved with logic in addition to nested time delays and overcurrent thresholds.

Circuit breakers that employ ZSI can respond to faults within their immediate zone of protection with minimum delay, while providing appropriately delayed backup protection to zones further downstream from the zones to which they are dedicated. This allows fast protection reducing system stress and arc flash hazard while maintaining the same selectivity that a fully nested and delayed system would have achieved.

The traditional means of obtaining selectivity between main circuit breaker and feeder circuit breakers is to set the furthest load side device with the lowest time delays, and increase line side time delays and thresholds. Consequently, the line side portions of the system must withstand high fault current for longer periods of time.

For further details on ZSI feature and ZSI application please refer DET-1001 Application and Technical Guide; Zone-Selective Interlocking for GE Circuit Breaker and Power Switch Trip Units.

This document provides information about Zone-Selective Interlock Module to implement ZSI wiring and connections.

What is a Zone-Selective Interlock Module?

The zone-selective interlock module is an intermediate control device used between line side (upper tier) and load side (lower tier) circuit breakers to control and distribute the communication signal between the tiers of devices.

Figure 1: Zone Selective Interlock (ZS) Module

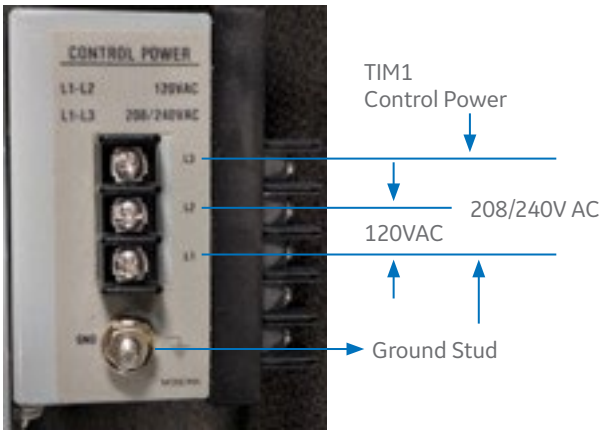


Figure 2: Control Power for Module is Applied from the Left Side of the Enclosure

2. Description

General

The ZSI module receives a signal from a load side trip (lower tier) unit which causes the module to transmit a low-level interlock signal to line side trip units (upper tier). The received interlock signal activates the LED portion of an LED-transistor opto-isolator in the line side trip unit causing its ZSI enabled protection to shift from unrestrained mode of operation ("unrestrained "time delay) to restrained mode of operation ("restrained" time delay). In the case of short time and ground fault protection unrestrained protection should be a shorter time delay band and restrained protection should be a greater delay band. If the receiving trip unit is enabled with Instantaneous ZSI (I-ZSI) the trip unit's instantaneous function will shift from its instantaneous algorithm to an algorithm akin to a fast short-time band. The exact shift of the instantaneous is different based on the circuit breaker platform within which the receiving trip unit is installed. If a trip unit is enabled with threshold ZSI (T-ZSI) the upper tier overcurrent threshold for various protective functions may also shift to a larger threshold. For more detailed information on the application of GE ZSI functions see GE publication DET-1001.

Line Side (Upstream) and Load Side (Downstream) Connections

Terminals are provided to connect signals from load-side and line-side circuit breakers. Carefully note the polarity and instructions on the label of the ZSI module. See also Section 4, "Installing and Connecting the ZSI Module".

Control Power

Control power for the module is applied via the terminals on the left side of the enclosure. See Figure 2.

Energy Storage Feature

If a fault occurs, the possibility exists control power may be lost. To ensure the integrity of the signal transmitted to the line -side circuit breakers and to ensure that coordination is not lost, the ZSI module has an energy storage feature that permits follow-through of the interlocking functions if control power is lost.

Test Capabilities

The ZSI module is provided with an integral test means which will provide an indication of:

- Simple module functionality;
- Shorted or reverse polarity of the downstream wiring;
- A proper upstream circuit.

Use of the module test means is described in Section 3 (Dielectric Testing).

Additional test capabilities are possible with the trip unit and the GE Trip Unit tool kit. For further information on fully testing a ZSI scheme see GE publication DEH-583, "Zone-Selective Interlocking Field Testing and Commissioning".

3. Application Information

Control Power Requirements

Cat. No. TIM-1:

- 120/208/240 V ac 50/60 Hz
- 15 VA maximum
- Input voltage tolerance: +10%, -15%

Note: ZSI Input /Output signal requirement :24VDC, 20ma. tolerance ¬+ 10%. (28VDC max)

Max Ambient Temperature

The ambient temperature surrounding the module should not exceed 85°C.

Wiring

The wiring for the equipment shall be as follows:

1. Wiring from the circuit breakers to the ZSI module shall be twisted pairs—non-shielded, AWG #18-12. A minimum twist configuration of one turn per inch is recommended.
2. Maximum recommended line length (distance between a circuit breaker and the ZSI module) is 1000 feet.
3. Note that downstream/upstream connections require proper observance of polarity. For downstream/upstream connections (signal) use RED for plus. WHITE for minus.
4. The signals being conducted via the downstream/ upstream wiring are low-level signals (dry circuits). It is important, therefore, to ensure that splices are soldered connections (or other approved connections for low power dry circuits); also, if connectors are used, they should be gold-plated terminations. Standard terminal blocks can be used for intermediate connections do not require gold plating.

Connections

Downstream (Load Side) Connections

A maximum of 30 zone selective “OUTPUTS” from lower tier circuit breakers may be connected in parallel provided that:

- No more than six parallel “OUTPUTS” are used per downstream terminal set at the ZSI module (e.g. D1; D2; D3; etc.) See Figure 3.
- Paralleling is done so that only one set of wires (one twisted pair) is connected to each downstream terminal set at the ZSI module.
- Wiring is per Section 3 (Wiring) and Figure 3.

See “Downstream Connections” portion of Section 3 (Test Feature – How to Apply It) to use the integral test means of the ZSI module as an aid in checking downstream wiring.

Upstream Connections (Line Side)

In some applications, it may be desirable to interlock an upper tier circuit breaker from more than one ZSI module (e.g. it may be desirable to interlock a main circuit breaker from several separate zones). To accommodate coordination schemes that require this, up to four modules may be connected in parallel to one circuit breaker zone selective “INPUT”. Two rules that apply to upstream connections are:

1. The upstream connections for several ZSI modules (up to four) may be connected in parallel provided they are terminated in the zone selective “INPUT” of only one circuit breaker, means this is valid if and only if one upstream breaker is connected as shown in Figure 4.
2. Never parallel the ZSI “INPUT” connections of circuit breakers provided upstream terminal pair connections must ALWAYS be terminated in the ZSI “INPUT” of only one trip unit (means one to one mapping or one upstream terminal pair set connection to one trip unit only). See Figure 5.

Energy Storage Feature

The ZSI module has an energy storage feature which enables it to follow-through with full interlock power should control power to the module be lost simultaneously with the initiation of an interlock signal.

Although the module can operate immediately upon application of control power, the energy stored Is not sufficient to fully operate the module unless the module has been energized for one minute prior to the loss of control power. This is applicable whenever control power is removed and then reapplied.

Therefore, if there is a possibility that control power could be lost during the closing of a circuit breaker and coordination of upstream breakers is important during that interval, the control power for the module should be either (1) derived from an independent source, or (2) derived from the line side of an upstream circuit breaker in such a manner that operation of the circuit breakers is delayed by one-minute post control power being available on the line side.

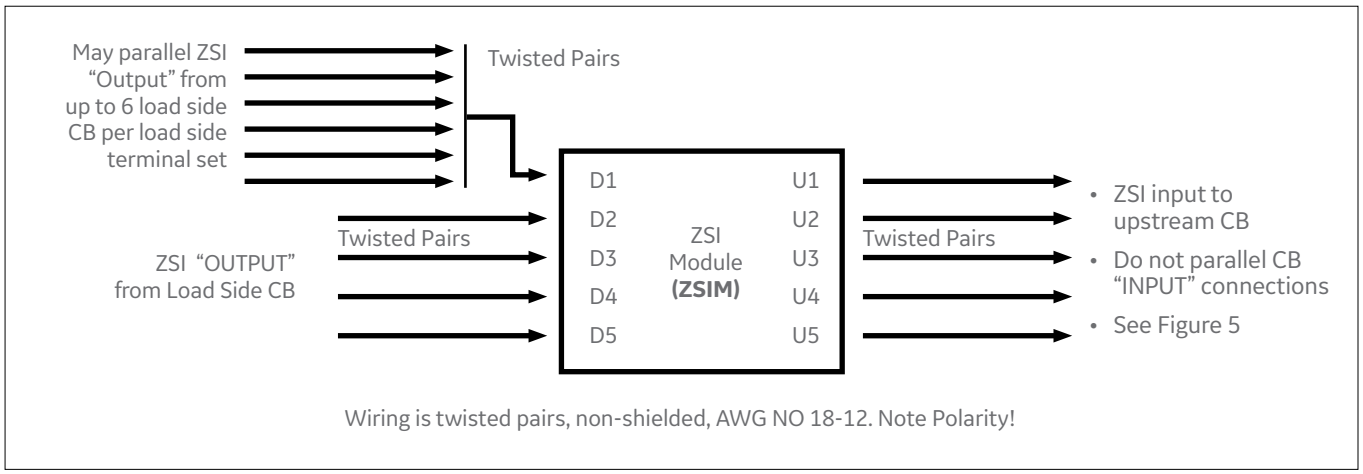


Figure 3: Wiring Diagram Showing "Upstream" and "Downstream" Connections

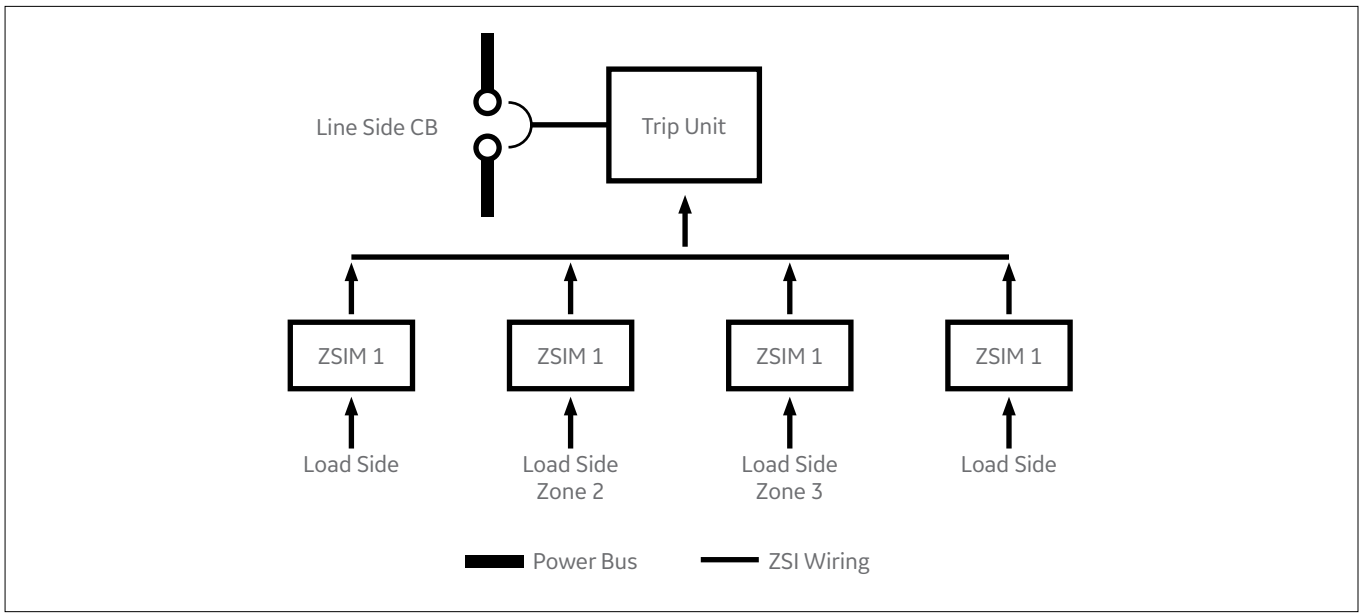


Figure 4: Interlocking One "Upstream" Circuit Breaker from Several Separate Zones

Test Feature – How to Apply It

Note: To use within TIM test feature, control power must be applied to the module.

Module Functionality

The “MODULE FUNCTIONAL” light will illuminate whenever there is an interlock signal at the “DOWNSTREAM CONNECTIONS” terminals. This can be simulated manually by pushing the “PUSH TO TEST” button in the center of the module, thereby proving basic module functionality.

Downstream Connections

If the “MODULE FUNCTIONAL” light is illuminated continuously (without pushing the “PUSH TO TEST” button), one or more of the following problems exist with the downstream circuits:

1. At least one set of wires connected to the “DOWNSTREAM CONNECTIONS” terminals, D1 through D5 are connected in reversed polarity.
2. Load side wiring is shorted.
3. A trip unit in a load side circuit breaker is defective.

To isolate the problem, remove the wires from the “DOWNSTREAM CONNECTIONS” terminals one at a time, noting when the “MODULE FUNCTIONAL” light goes out. This will identify the problem circuit. The following checks may be useful in identifying the specific problem:

- Check for reversed polarity by simply reversing the lead connections from what they were originally and observing whether the “MODULE FUNCTIONAL” light goes out.
- Check for shorted downstream wiring by checking between the disconnected wires with an ohmmeter.
- The Zone Selective Interlock “OUTPUT” circuit from GE electronic trip unit is essentially an NPN transistor with a reverse diode connected from collector to emitter. To check this circuit for a shorted transistor, check for the forward/reverse characteristic of the diode with an ohmmeter.

IMPORTANT

The open circuit output voltage of the ohmmeter must be less than 15 Vdc if the load side trip unit is connected.

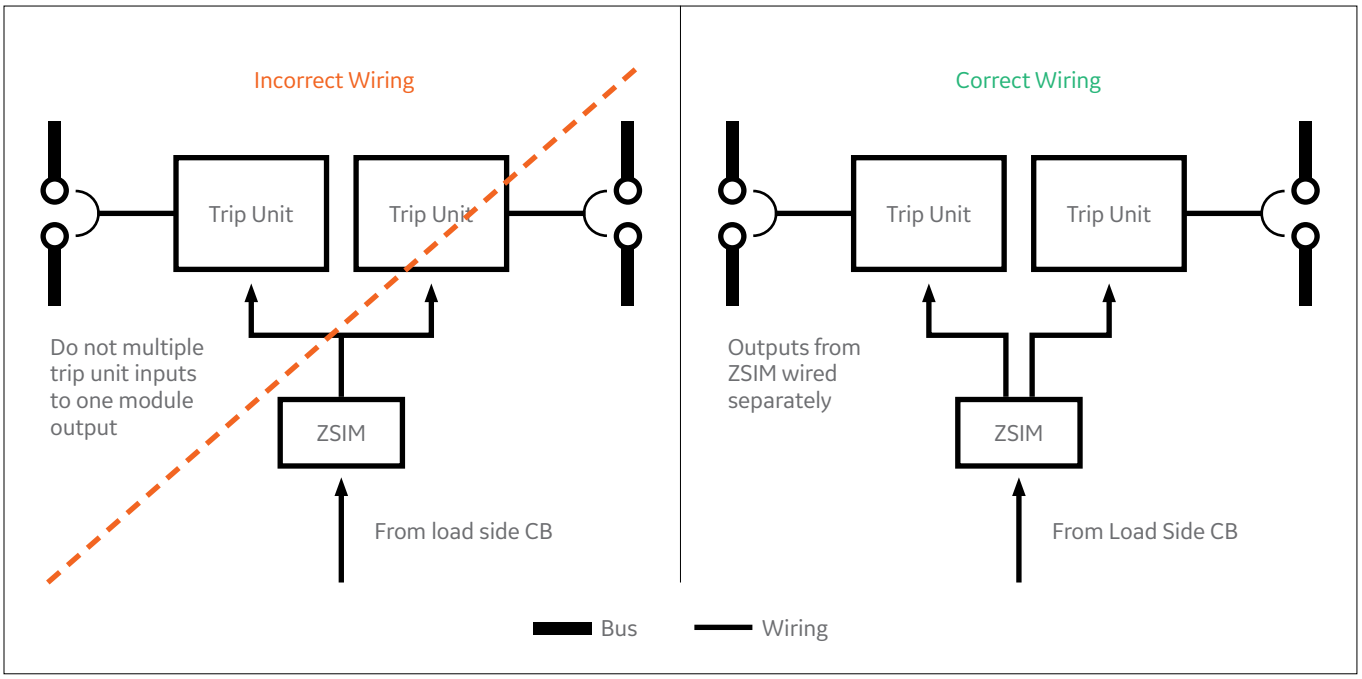


Figure 5: Do Not Parallel Circuit Breaker Zone Selective Interlock “Inputs”

Upstream Connections

You will note that for each set of upstream terminals (U1-U5), an LED is provided between them.

When the "PUSH TO TEST" button is pressed, these LEDs will light if the voltage developed across the upstream circuit is within an acceptable range. Failure of a LED to light is an indication of one or more of the following upstream conditions:

1. Reverse polarity
2. Open circuit
3. Shorted upstream wiring
4. Improper resistivity of the upstream circuit

The following checks may be considered for isolating the problem area:

- Check for reversed polarity by simply reversing the lead connections from what they were originally and observing for the appropriated upstream LED "light" when the "PUSH TO TEST" button is pressed.
- To check for open, shorted, or high-resistance connections in the line side wiring, disconnect the wiring at Trip Unit side from the ZSI module and check the wiring with an ohmmeter.
- The ZSI module test means may itself be tested by disconnecting the wires from the U1-U5 terminal pair sets and connect 390 Ω ±20% resistor across one of the pair set (positive & negative terminals). The appropriate LED must light when the "PUSH TO TEST" button is pressed.
- Note: If all connections to upstream terminal pair sets U1-U5 are open (not connected) the five LED indicators may light without pushing the "PUSH TO TEST" button. This is not an abnormal condition but a valid test of the upstream circuits will always be obtained when U1-U5 terminals are properly connected which means "PUSH TO TEST button is activated.

Testing the Energy Storage Feature

As described in Section 3 (Energy Storage Feature) the ZSI module has an energy storage feature that allows follow-through of the interlocking function if a fault causes a simultaneous loss of control power to the module. Energy storage is achieved via an electrolytic capacitor which will may lose capacitance over an extended period of time. Thus, it is advisable to perform the following in-service check every 6-12 months and whenever additional upstream circuits are connected (added) to terminals U1-U5.

- Allow the module to be energized with rated control power for a minimum of one minute.
- Interrupt control power and immediately push the "PUSH TO TEST" button. The MODULE FUNCTIONAL" light must come on for at least one-third of a second (a long blink). Allow at least one-minute charge time before repeating the test.
- Failure to achieve the above noticeable time delay will require the energy storage capacitor be replaced.

Dielectric Testing

CAUTION

Indicates that if the hazard is not avoided could result in minor or moderate injury.

The ZSI module may be tested at 1500 Vac for one minute or 1650 Vac for one second, between all upstream, all downstream, all control power terminals shorted together (inclusively), and the ground stud. In other words, every terminal on the ZSI module (except the ground stud) shall be shorted together and the potential applied between that point and the ground stud. Under the above test conditions, the test current should not exceed 500 micro-amperes.

CAUTION

1. Do not test between individual terminals and ground
2. Do not test between downstream/upstream terminals
3. All terminals must be shorted together!

Fusing

Recommended control power input fusing is 0.5 amperes, 250v (Littlefuse 312.500) or equivalent.

4. Installing and Connecting the ZSI Module

To Install and connect the ZSI module, proceed as follows:

- Read the application information (Section 3).
- Wire the module in accordance with Section 3 (Wiring) and Figure 3.
- Torque terminals to 20 in-lbs.
- Connect control power. See label on the left side of the ZSI module. Refer also to Figure 2. For dc versions, note polarity. Note that filtered direct current must be used. Also, refer to Section 3 (Control Power Requirements).
- Follow the instructions on the face of the ZSI module regarding connections. Pay particular attention to the polarity and nomenclature (i.e. downstream connections go to the “OUTPUT” of the trip units; upstream connections go to the “INPUT” of the trip units).
- Use the integral test means of the ZSI module to check downstream and upstream connections. See Section 3 (Test Feature – How to Apply It).

5. System Coordination Using Zone Selective Interlocking

Zone selective interlocking can be a valuable tool in achieving efficient system protection and coordination. To apply it effectively requires a thorough understanding of what zone selective Interlocking is and the proper application to a strategic plan of system protection. As with any plan, the system is best protected when there is a thoughtful strategic plan which factors in significant variables and contingencies.

It is beyond the scope of these instructions to attempt a detailed discussion of coordination schemes. Figure 6 and 7 shown only in the interests of illustrating examples of two basic applications of ZSI module.

Figure 6 is a simple example of multiple zone interlocking. If a fault occurs, each breaker will interlock the breaker immediately upstream from it.

Figure 7 is an example of double ended substation with tie circuit breaker, feeding two banks of load side feeder circuit breakers. Note that ZSI module NO.1 interlocks both mains and the tie circuit breaker for the occurrence of a fault on the load side of the feeder circuit breaker (Zone 2).

ZSI module NO.2 is an option which provides coordination between the tie circuit breaker and the main circuit breaker (i.e., the TIE will trip first in the event of a bus fault in Zone 1. Without ZSI module NO.2, a bus fault in Zone 1 would probably cause tripping of both the tie and the main circuit breakers.

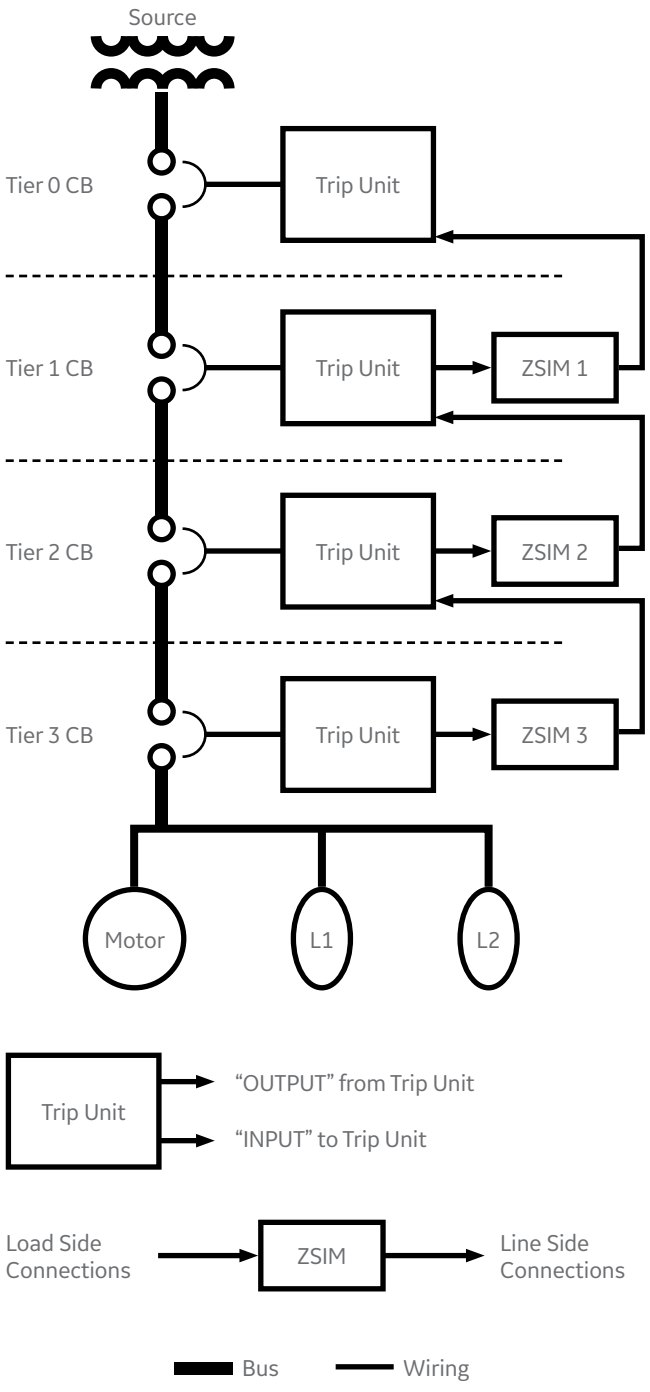


Figure 6: Multi-zone Interlocking

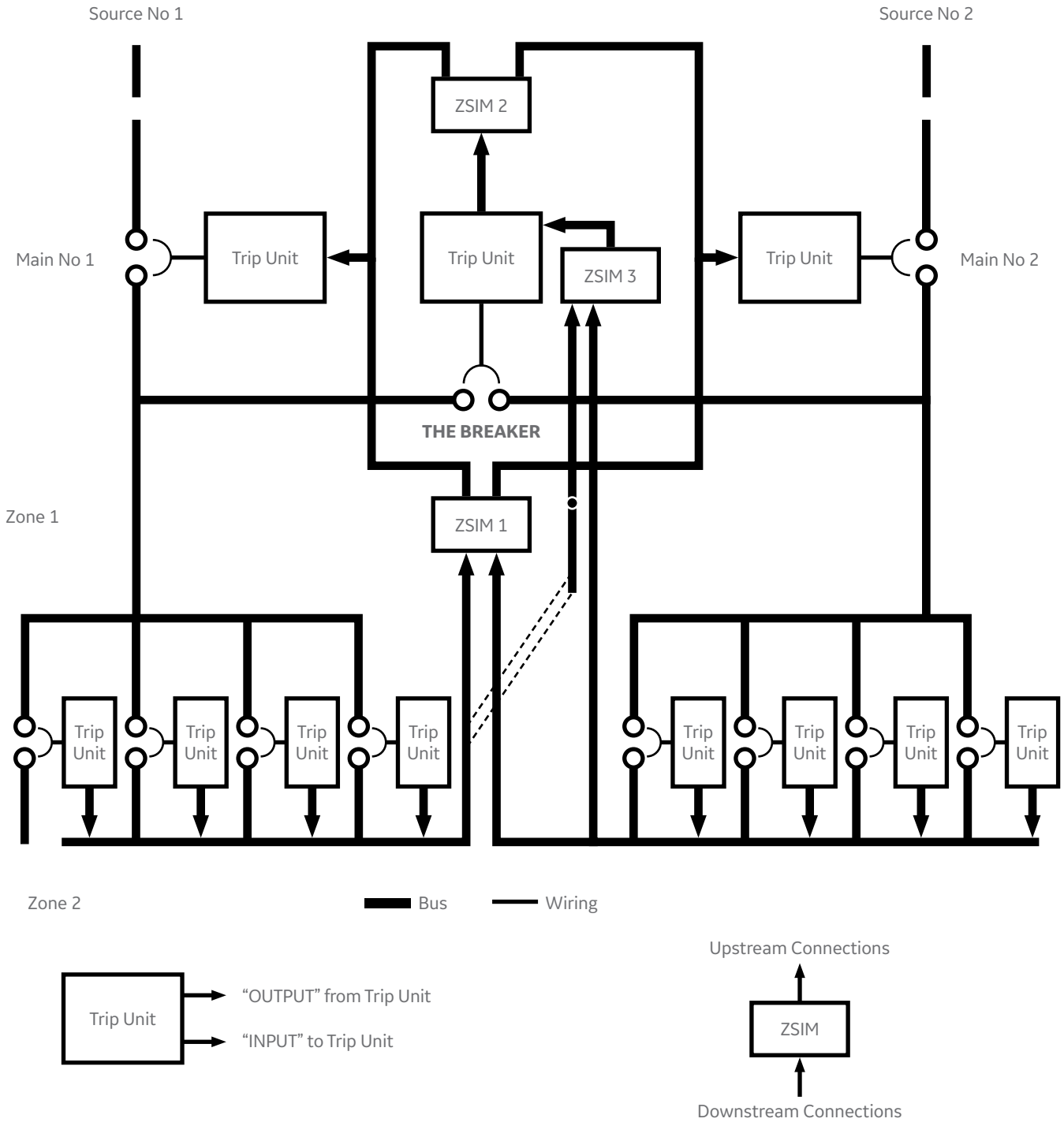


Figure 7: Zone Selective Interlocking a Double-ended Substation

6. Circuit Description

The following is a brief circuit description of the ZSI module. See Figure 8 for the circuit diagram.

The "DOWNSTREAM CONNECTIONS" consist of five separate terminal sets, each set providing a voltage reference input via a resistor divider network to a voltage comparator. This voltage reference is compared to a second internal comparator reference. When the voltage at the "DOWNSTREAM CONNECTIONS" is higher than the comparator reference there is no output at the "UPSTREAM CONNECTIONS" of the module.

When an interlock signal (Logic O) is received at any of the downstream terminals, the comparator will go "high". This actuates the electronic switch and provides and output voltage at all "UPSTREAM CONNECTIONS;" the output from the electronic switch will also illuminate the "MODULE FUNCTIONAL" LED.

The window detectors sense the voltage across each of the five terminal sets for "UPSTREAM CONNECTIONS" and will illuminate an LED if the voltage across its terminal set is within an acceptable voltage window. Therefore, the window detectors, (with their associated LED) serve to indication that a proper upstream circuit exists.

The "PUSH TO TEST" button is a means by which a downstream interlock signal can be simulated, thereby providing a test method for module functionally and proper upstream circuitry.

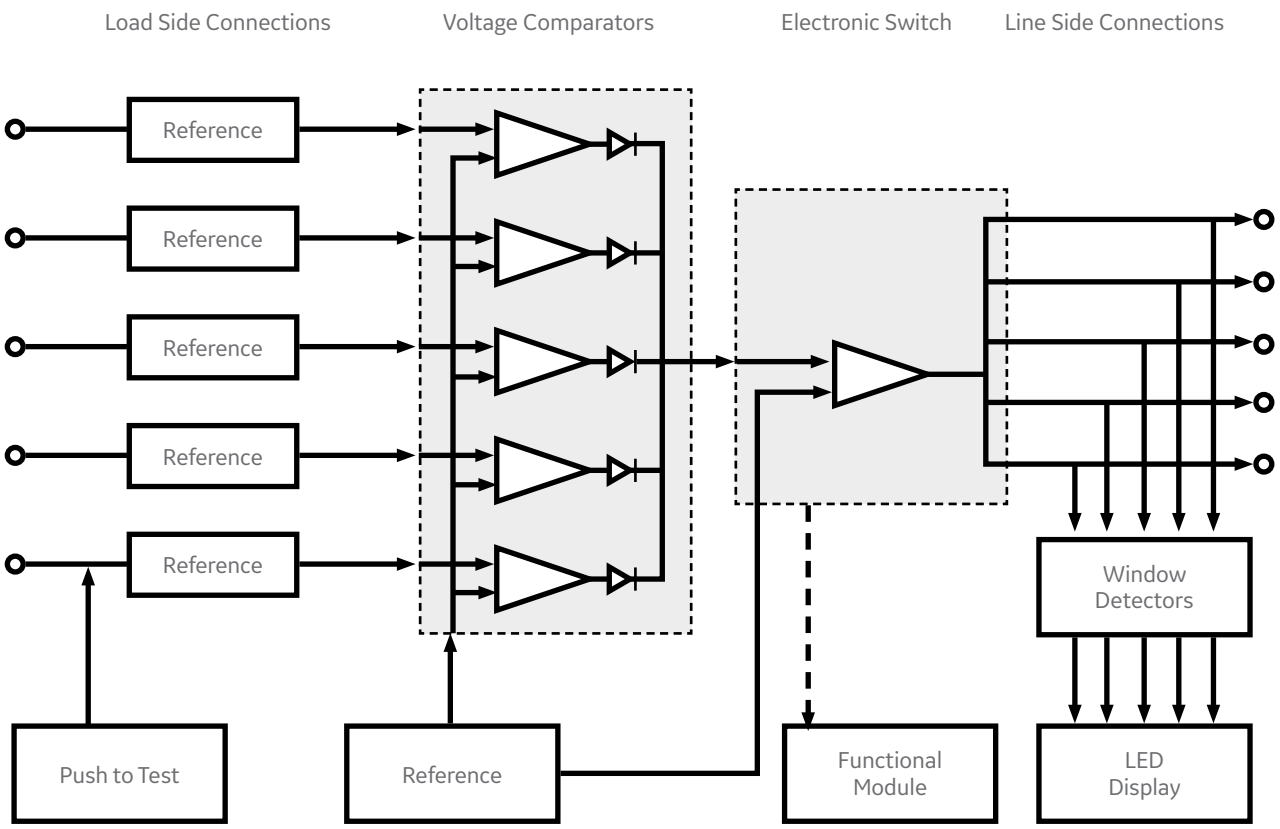
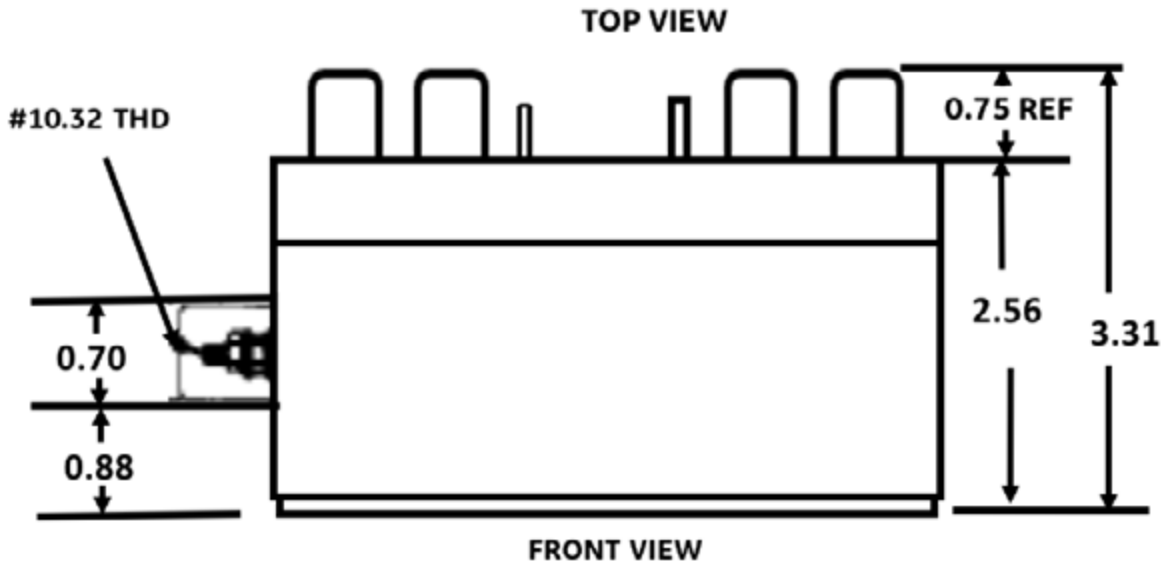
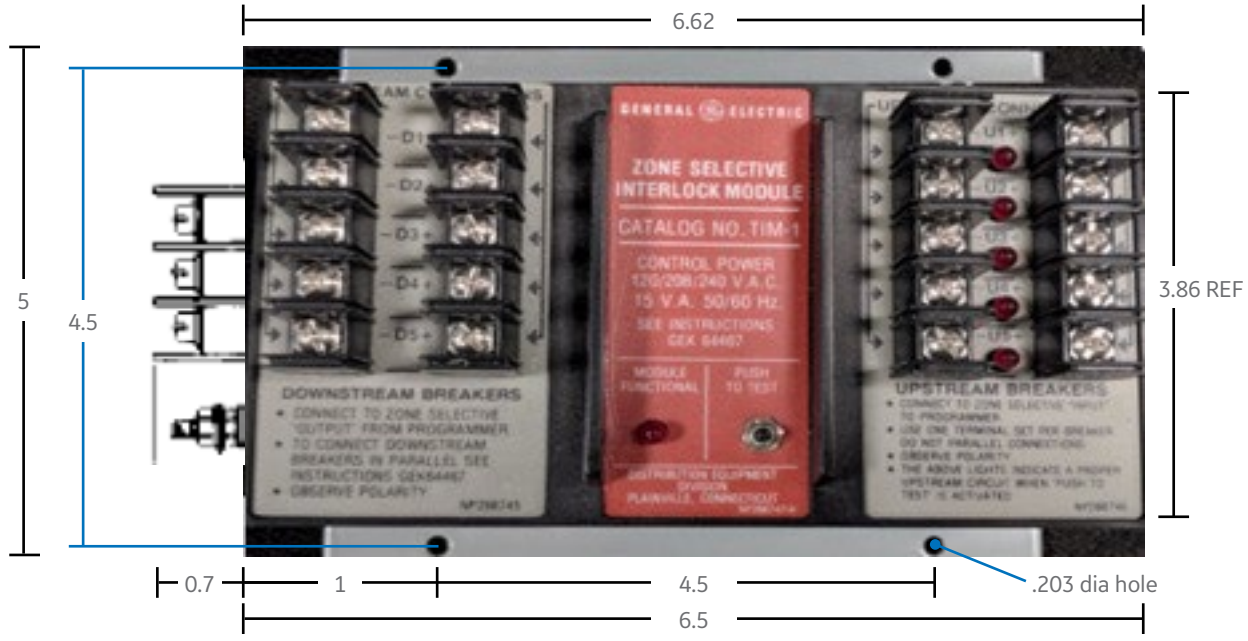


Figure 8: Zone Selective Interlock Module Circuit Diagram



Note: All dimensions are in inches

Figure 9: Outline Diagram



Note: All dimensions are in inches

Figure 10: Dimensions

For additional information on ZSI application and testing see GE publications:

- DEH-583 Instruction Guide; Zone-Selective Interlocking Field Testing and Commissioning for EntelliGuard* and microEntelliGuard* Trip Units
- DET-1001 Application and Technical Guide; Zone-Selective Interlocking for GE Circuit Breaker and Power Switch Trip Units
- DEE-689 Trip Unit Toolkit User Guide
- DEE-688 Trip Unit Toolkit Installation Instructions
- 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

For additional information on mitigating arc flash incident energy with circuit breaker protection and instantaneous selectivity see:

- DET-760D Application and Technical Guide; Guide to Instantaneous Selectivity
- DET-1002 Application and Technical Guide; 2017 National Electric Code® Updates, NEC® 240.87 Arc Energy Reduction, for Circuit Breakers & NEC® 240.67 Arc Energy Reduction, for Fusible Switches
- DET-1004 Application and Technical Guide; Energy Reducing Maintenance Switch
- Marcelo E. Valdes. Steve Hansen & Peter Sutherland; Optimized Instantaneous Protection Settings; IEEE Industry Applications Magazine, pgs. 66-73, May/June 2012.

User Manual for the EntelliGuard TU trip units:

- DEH-4567 EntelliGuard TU Trip Units Installation, Operation, and Maintenance Manual

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