SIEMENS

White Paper

Ground Fault Application Guide

3-Pole WL Low Voltage Power Circuit Breakers

Answers for infrastructure and cities.

Contents

Ground Fault Application Guide for 3-Pole WL Low Voltage Power Circuit Breakers

Introduction

Siemens type WL Low Voltage Power Circuit Breakers, equipped with one of the members of the WL family of solid state trip units, are available with optional sensitive ground fault elements. All Siemens type WL circuit breakers, trip units, ground fault modules, and current sensors are UL listed for factory or field installation.

Need for ground fault tripping

Low voltage systems are normally solidly grounded, although ungrounded or high resistance grounded low voltage systems are sometimes used in certain continuous process applications, and only in applications where there are no line-to-neutral loads involved.

If the system is solidly grounded, then ground fault tripping should be applied because high impedance and/or arcing ground faults can be too low in magnitude to be detected by the phase overcurrent trip elements. The Siemens WL ground fault system is ideal for these types of applications.

- **Requirements from industry standards**
  There are many national, regional, and local requirements that include requirements for ground fault detection and protection. These should be researched before undertaking the addition of new electrical systems, or modifications to existing electrical systems. The following paragraphs describe some of the various requirements and recommendations from common industry standards regarding ground fault protection.

- **National Electrical Code® ①**
  The National Electrical Code (NEC) states that the purpose of system grounding is to "limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines that will stabilize the voltage to earth during normal operation" (NEC Article 250.4, ed. 2014).

The NEC provides explicit requirements for certain areas where ground fault protection is required.

NEC Articles 215.10 (ed. 2014) (feeder circuit breakers), 210.13 (ed. 2014) (branch circuit breakers), and 240.13 (ed. 2014) (main disconnecting means) detail requirements for when ground fault protection is necessary. These clauses specify that ground fault protection must be provided in accordance to the provisions in NEC article 230.95 (ed. 2014) for wye system configurations where the following conditions are met:

- The phase-to-ground greater than 150 VAC.
- The phase-to-phase voltage is 600 VAC, or less.
- The feeder circuit breaker is rated for 1000A, or greater.

NEC articles 215.10 (ed. 2014) and 240.13 (ed. 2014) contain provisions for the exception to these requirements under the following conditions:

- Ground fault protection is not required for industrial processes where the hazards are increased by shutting down the process.
- Ground fault protection is not desirable for fire pumps.
- Ground fault protection is not required on feeders where there is up-stream ground fault protection.

NEC article 517.17 (ed. 2014) details the requirements for ground fault protection within health care facilities. It is required that two levels of ground fault protection should be supplied, with protection both on the main circuit breaker, as well as the feeder circuit breaker. The devices must be coordinated to ensure that the feeder circuit breaker will trip prior to causing the main circuit breaker to trip.

NEC article 700.27 (ed. 2014) states that ground fault tripping is not required on emergency back-up systems, but it is required that there be a sensing and alarm function for ground fault.

NEC article 701.26 (ed. 2014) states that ground fault protection is not required, in any form, on legally required back-up systems. Ground fault alarm is often a preferred indication, and in some cases may be required (see NEC article 701.5(D); edition 2014).

① The National Electrical Code is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. National Electrical Code and NEC are registered trademarks of the National Fire Protection Association, Inc.

Ground Fault Detection with the Siemens WL Low Voltage Power Circuit Breaker

The Siemens WL Electronic (solid state) Trip Unit (also referred to as the WLETU) is the preferred method of providing ground fault detection, because:

1. The ground fault module is mounted within the circuit breaker and integral to the trip system, providing the same accuracy in pick-up and reliable tripping as the phase protection functions.

2. No external wiring and connections are required for 3-wire applications, and only minimal additional wiring is required for 4-wire applications, so reliability is enhanced.

3. All Siemens WL ground fault system components are UL Listed for factory or field installation. All factory installed components are subjected to additional functional component and system tests verifying reliable performance.

4. The ground fault tripping elements are self-powered, therefore separate control power is not required.

5. An LED indicates the cause of tripping. An optional LCD display provides greater insight to the source of the trip.

6. An integrated self-test function, or an optional hand-held test set, allow for easy field testing of the trip system. The hand-held test set also includes a feature to verify the proper connection of the tripping sensors.

7. Current levels and trip information may be transmitted to a supervisory system, including communication via Modbus, Profibus, TCP/IP, and to your Siemens ACCESS system.

8. Cable installations through zero sequence sensors are not required, so cable space is not restricted.

- **Ground Fault Alarm vs. Ground Fault Alarm and Trip**
The WL ground fault module can be supplied as one of two variants. The first option is an alarm only module. This device has a variable pick-up and time delay settings. After the device remains in pick-up condition for the specified time delay, an alarm signal is generated. This alarm can be viewed locally, annunciated across the connected communications network, or supervisory system.

The second variant of the WL ground fault module contains both an alarm function, and a tripping element. Like the alarm only device, after the ground fault unit remains in pick-up condition for the specified time delay, an alarm signal is generated. This alarm can be viewed locally, annunciated across the connected communications network, or supervisory system. This module also includes a ground fault trip function. The ground fault trip function can be set to a different pick-up point than the ground fault alarm (typically higher), and will trip the circuit breaker after remaining in pick-up range for the specified time delay.

- **Ground Fault Settings for Trip Unit Types WLETU727, WLETU745, and WLETU748**
There are five discrete pick-up points for the alarm and trip ground fault functions (labeled as A, B, C, D, or E). The definition of A – E varies based on frame size. The definitions are provided in Table 1, as well as on a label provided on the ground fault equipped circuit breaker.

Table 1: Ground Fault Set-Points

Set-Point	Frame Size 1	Frame Size 2	Frame Size 3
A	100 A	100 A	400 A
B	300 A	300 A	600 A
C	600 A	600 A	800 A
D	900 A	900 A	1000 A
E	1200 A	1200 A	1200 A

After reaching the set pick-up point, and if this level of current is maintained, the circuit breaker will trip at the prescribed time delay. The time delay setting may be set at one of the following discrete time delay settings: 0.1s, 0.2s, 0.3s, 0.4s, or 0.5s.

Optionally, for the trip unit models WLETU745 and WLETU748, the circuit breaker may be set to trip based on the I^2t magnitude of the ground fault current, where:

t_G = 0.1s, 0.2s, 0.3s, 0.4s, or 0.5s

Actual tripping time (seconds):

$$t_{Gmax} = \max\{ ((1.2 \times 3 \times I_G)^2 \times (t_G + 0.05)) / i^2 , t_G + 0.05 \}$$

$$t_{Gmin} = \max\{ ((3 \times I_G)2 \times t_G) / i^2 , t_G \}$$

- **Ground Fault Settings for Trip Unit Types WLETU755 and WLETU776**
  The pick-up point may be adjusted between the following ranges for both the alarm and trip functions at 10A increments, within the ranges described in Table 2.

Table 2 : Ground Fault Setting Ranges

Set-Point	Frame Size 1	Frame Size 2	Frame Size 3
Minimum	100 A	100 A	400 A
Maximum	1200 A	1200 A	1200 A

After reaching the set pick-up point, and if this level of current is maintained, the circuit breaker will trip at the prescribed time delay. The time delay setting may be set between the following time delay bounds of 100ms and 500ms, at 50ms steps.

Optionally, the circuit breaker may be set to trip based on the I^2t magnitude of the ground fault current, where:

t_G = adjustable from 100ms – 500ms, at 50ms steps

Actual tripping time (seconds):

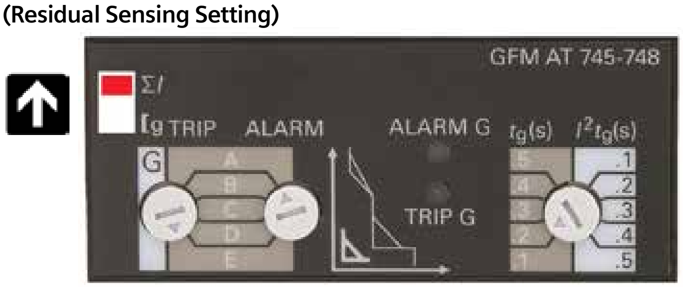
$$t_{Gmax} = \max\{ ((1.2 \times 3 \times I_G)^2 \times (t_G + 0.05)) / i^2 , t_G + 0.05 \}$$

$$t_{Gmin} = \max\{ ((3 \times I_G)^2 \times t_G) / i^2 , t_G \}$$

- **Ground Fault Mode Selection**
  The WLETU727 trip unit is only capable of performing 3-wire or 4-wire residual ground fault detection.

  The WLETU745 and WLETU748 trip units may be set to either 3-wire residual, 4-wire residual, or direct ground current sensing, when equipped with a ground fault detection module. The mode selection is made via a switch located on the left-hand face of the ground fault module. The selector switch can only be accessed with the circuit breaker front cover removed. In Figure 1, the switch, is shown in the residual position.

Figure 1: WLGFM48 Ground Fault Module (Residual Sensing Setting)



The WLETU776 trip unit may be set to 3-wire residual, 4-wire residual, or direct ground current sensing, when equipped with a ground fault detection module. The mode selection may be changed via soft-key selection, while the trip unit display and control pad is powered by load (greater than 100A of single phase load on 3200A frame circuit breakers and below, or greater than 150A of single phase load on a 4000A and above frame circuit breaker), or control power. The mode can not be changed while the trip unit is in pick-up.

Three and Four Wire Systems

- **Three Wire Systems**
  Low voltage solidly grounded systems may be either 3-wire or 4-wire, depending on the load connections. If all loads are connected phase-to-phase, then it is a 3-wire system. The system neutral bus is not carried throughout the system. Examples of these types of loads include motors and lighting transformers.

- **Four Wire Systems**
  If the system has single phase loads connected from line-to-neutral, then it is a 4-wire system. The system neutral must be carried to the line-to-neutral loads, in addition to the ground. The residual ground current sensing shown in Figure 2 is suitable for 3-wire systems. However, if this is applied to a 4-wire circuit, the normal neutral current will appear to be a ground fault to the ground trip element. If the normal neutral current exceeds the pickup setting, it will cause false tripping.

- **Source of Neutral Current**
  Neutral current in 4-wire circuits will exist under normal conditions if the loads are not balanced between phases Furthermore, the arc discharge of fluorescent or mercury vapor lamps, with their associated capacitors and ballasts, are a combined source of harmonics – particularly third order harmonics. Experience shows that the third harmonic current may be as high as 30% of the fundamental in the phase conductors and 173% in the neutral. Feeder circuits serving such lighting predominantly have the neutral conductor rated 100% of the lighting load, and the trip devices must not cause false tripping on this normal neutral current. Thus, the neutral current may be a low value of fundamental in some applications, a combination of fundamental and third harmonic in other applications, and possibly, all third harmonic (up to 173% of the magnitude of phase current) in still others.

Methods of Ground Fault Sensing

- **Residual Ground Current Sensing – 3-Wire System**
  Air core current sensors (also called Rogowski coils) are mounted inside the circuit breaker case in the current path on each phase. These current sensors detect fault currents for overcurrent protection (solid state trip device options are described in Table 3). Under normal conditions, with properly balanced single phase or three phase loads, the vector sum of the current in all of the phases equals zero. No current imbalance is detected by the ground fault module, and therefore the alarm and trip elements will not pick-up. It is also true that the ground fault module will not pick-up during a purely phase-to-phase fault because, again, all of the current would still sum to zero.

  A phase-to-ground fault event will cause imbalanced current flow (measured within the ground fault module). If the magnitude of the imbalanced current exceeds and maintains at or above the pickup setting for longer than the specified time delay, the trip device will trip the circuit breaker.

  A block diagram of the tripping system using residual ground current sensing is shown in Figure 2.

  1. The sensing is conducted by the same internal air core current sensors that provide the phase overcurrent protection.
  2. The switch position on the ground fault module is set to the "residual" position (graphically represented in Figure 1).
  3. The terminals X8.9 and X8.10 on the circuit breaker secondary disconnects must be shorted together to prevent ambient noise (stray voltages in the system environment) from being detected by the trip unit as a ground fault input.

Table 3: Solid State Trip Units for Ground Fault Protection

ETU Type	Catalog Number
LSIG, knob adjustments	WLETU727
LSI, knob adjustments ①	WLETU745
LSI, knob adjustments, Metering*PLUS* ①	WLETU745MP
LS, knob adjustments ①	WLETU748
LS, knob adjustments, Metering*PLUS* ①	WLETU748MP
LSI, no local controls ①	WLETU755
LSI, no local controls, Metering*PLUS* ①	WLETU755MP
LSI, soft-key and remote controls ①	WLETU776
LSI, soft-key and remote controls, Metering*PLUS* ①	WLETU776MP

① Also requires a plug-in ground fault module (selected from Table 4)

Figure 2: Residual Ground Current Sensing – 3-Wire System

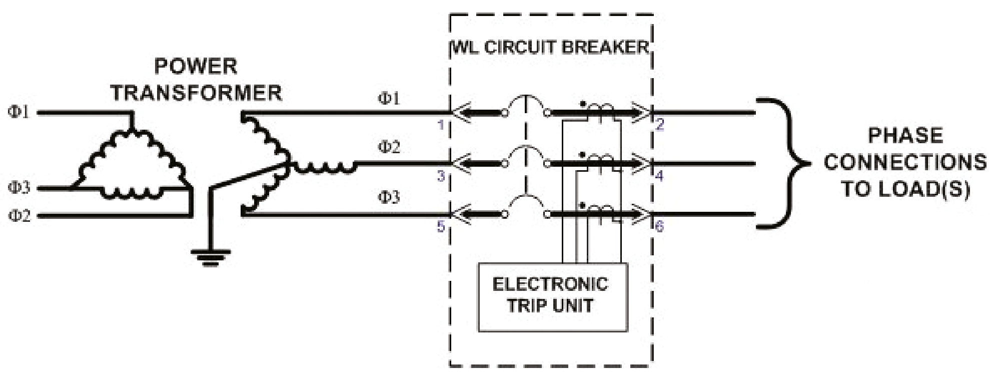


Table 4: Plug-in Ground Fault Modules for Solid State Trip Units Type 745-776

Ground Fault Module	Catalog Number
For WLETU745-748 Alarm only	WLGFA48
For WLETU745-748 Alarm and Trip	WLGFM48
For WLETU755-776 Alarm only	WLGFA76
For WLETU755-776 Alarm and Trip	WLGFM76

- **Residual Ground Current Sensing – 4-Wire System**
  To avoid false tripping in a 4-wire system, a fourth current sensor is required to be connected in-line with the neutral conductor to sense normal neutral current. This fourth sensor is polarity sensitive, and must be connected so that it cancels the normal neutral current which is developed in the residual circuit.

  Under normal conditions, the vector sum of the current in all phases equals the neutral current. Disregarding the effects of the neutral sensor connections, the neutral current would flow through the ground trip element. Since this is normal neutral current, pickup of the ground trip element is not desired. A sensor added to the neutral bus will see the neutral current flowing in the opposite direction. The result is a circulating current between the phase sensing current sensors and the neutral sensor, with no current flowing through the ground trip element

  A block diagram of the tripping system using residual ground current sensing is shown in Figure 3.

  1. The sensing is conducted by the same internal air core current sensors that provide the phase overcurrent protection, plus an identical air core current sensor mounted on the neutral conductor.

Figure 3: Residual Ground Current Sensing – 4-Wire System

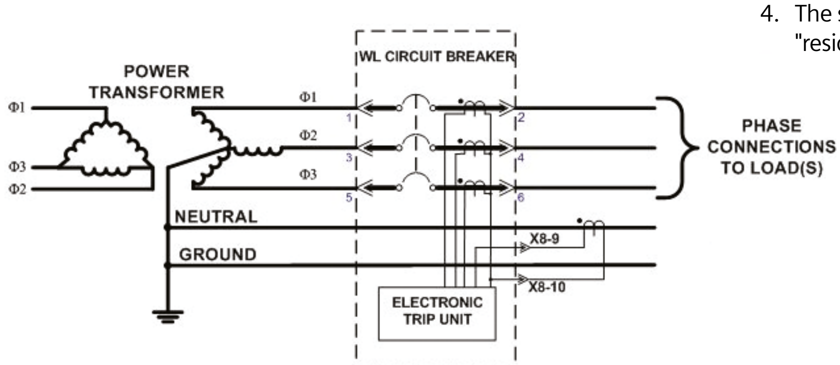


Table 5: Air Core Neutral Sensors for 4W Residual Ground Fault Protection

Sensor Type	Catalog Number
Small air core neutral sensor ①	WLNCT2
Small air core neutral sensor with through bus supplied ②	WLNCT2CB
Large air core neutral sensor ③	WLNCT3
Large air core neutral sensor with through bus supplied ④	WLNCT3CB

① See page 14 for an outline drawing
② See page 15 for an outline drawing
③ See page 16 for an outline drawing
④ See page 17 for an outline drawing

2. The neutral sensor is located on the neutral bus in-line with the phase sensors. The sensor is marked with a "P2" stamp on the side of the sensor which faces away from the source for a "top fed" system. The "P1" ("dot") side of the sensor is not marked (refer to Figure 4).

Figure 4: WL Air Core Neutral Current Sensor

3. The connection of the external air core neutral sensor to the circuit breaker's secondary disconnects must be made. The X8.9 terminal on the circuit breaker is connected to the "P1" terminal and X8.10 is connected to the "P2" terminal (common) on the neutral sensor. The connections from the secondary disconnects to the neutral sensor must be made with twisted pair wire.

4. The switch position on the ground fault module is set to the "residual" position (graphically represented in Figure 1).

- **Direct Ground Current Sensing – 3-Wire or 4-Wire System**
  In this alternate scheme, the ground trip element is fed directly from a current sensor in the ground strap of the system. Since there is only one such grounding point for a low voltage system, this method can only be used for main and tie circuit breakers. It is principally used in the 4-wire double ended substation application shown later (Figure 8).

Table 6: Solid State Trip Units for Ground Fault Protection

ETU Type	Catalog Number
LSI, knob adjustments	WLETU745
LSI, knob adjustments, Metering*PLUS* ①	WLETU745MP
LS, knob adjustments ①	WLETU748
LS, knob adjustments, Metering*PLUS* ①	WLETU748MP
LSI, no local controls ①	WLETU755
LSI, no local controls, Metering*PLUS* ①	WLETU755MP
LSI, soft-key and remote controls ①	WLETU776
LSI, soft-key and remote controls, Metering*PLUS* ①	WLETU776MP

① Also requires a plug-in ground fault module (selected from Table 4)

Under normal conditions, there would be no current flowing between the ground and neutral bus through the ground strap. When a phase-to-ground fault occurs, the return path of the ground fault current is from the ground bus to the neutral bus through the ground strap. The ground strap current sensor senses this current and applies it directly to the ground trip element. If the magnitude of the fault exceeds the pickup setting of the ground fault module, the trip device will trip the circuit breaker.

A block diagram of the tripping system using direct ground current sensing is shown in Figure 5.

Notice four significant differences from the residual sensing method previously described:

1. The air core neutral sensor is replaced by an iron core neutral sensor (Figure 6).

Figure 5: Direct Ground Current Sensing – 3-Wire or 4-Wire System

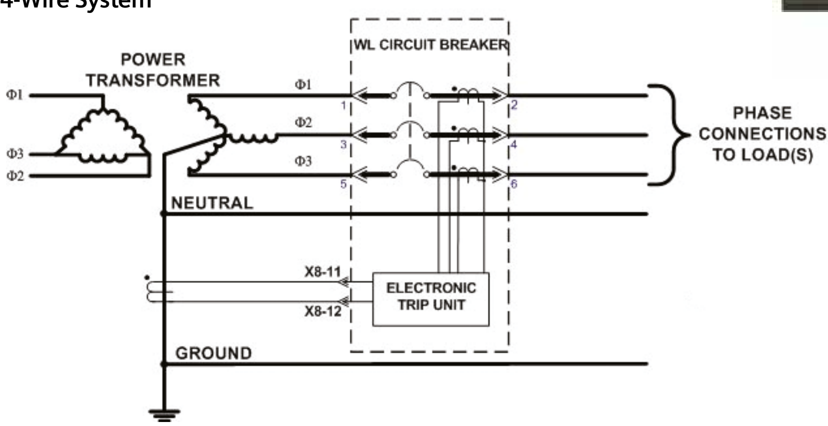


Figure 6: WL Iron Core Neutral Current Sensor

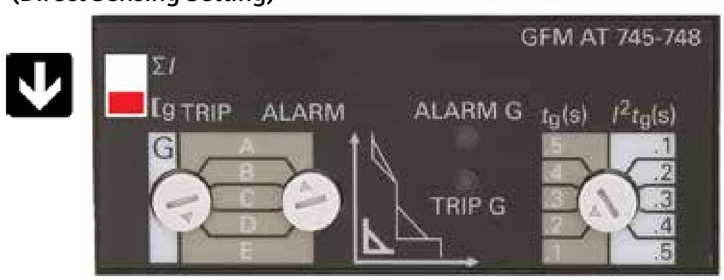
2. The neutral sensor is relocated from the neutral bus (in line with the phase sensors) to the bonding strap connecting the neutral bus to ground.

3. The connection points of the iron core neutral sensor to the circuit breaker's secondary disconnects is relocated. The X8.11 terminal on the circuit breaker is connected to the "X1" terminal (with the "H1" side facing the neutral bus) and X8.12 is connected to the "X2" terminal (common) on the neutral sensor.

   Note – Twisted pair wire is not required for iron core sensor leads (only required for air core sensors, used in 4-wire residual circuits).

4. The switch position on the ground fault module is shifted from the "residual" to the "direct sensing" position (graphically represented in Figure 7).
   Note – The ground fault element in the WLETU727 trip unit model is not capable of direct ground fault sensing.

Figure 7: WLGFAT748 Ground Fault Module (Direct Sensing Setting)



Ground Fault Protection Applied to 4-Wire Double Ended Secondary Substations

The following discussion describes two common methodologies for designing ground fault systems for double ended secondary substations:

- single point grounding
- modified differential

- **Direct Ground Current Sensing, Single Point Grounding**
The direct ground sensing trip device (see Table 6) can be used for main and tie circuit breakers in double ended substations and substations with provisions for future double ending. One connection from the ground bus to the neutral bus is made, and a special configuration of the direct ground current sensing scheme is applied. Because physical location of the neutral current sensors is critical, each application should be carefully designed.

Under normal conditions the tie will be open. Normal neutral current will not go through either main circuit breaker ground sensing current sensors due to their physical location. A bus ground fault will trip the main circuit breaker for its bus.

When a main circuit breaker is open and the tie circuit breaker is closed, the auxiliary contacts create a differential circuit, so normal neutral current will cancel, and will not cause false tripping. A bus ground fault will trip the tie circuit breaker, isolating the bus. If the fault is not cleared, the associated main circuit breaker will then trip.

System requirements for this application which should be considered are as follows:

1. The neutral bus must only be grounded at one point and this is desirable to be as near to the bus tie breaker as possible. The neutral current sensor for the tie breaker should be mounted on the bonding link between the neutral bus and the ground bus. The neutral current sensors (see Table 7) for the main breaker should be mounted on the neutral bus immediately adjacent and on each side of the ground link connection.
2. When the source is located remote from the switchgear, the source neutral must be carried as an insulated ungrounded conductor into the switchgear. It must not be grounded at the source.

Table 7: Iron Core Neutral Sensor for 4W Direct Sensing Ground Fault Protection

Sensor Type	Catalog Number
Iron core neutral sensor ①	WLGNMDGCT23

① See page 18 for an outline drawing

3. Each main circuit breaker must have one *"a"* auxiliary switch contact (see Table 8) available for the ground sensing circuit.

Table 8: Auxiliary Switches

Auxiliary Switch Type	Catalog Number
2*a* + 2*b* contacts	WLAS2
4*a* + 4*b* contacts	WLAS4

4. When using drawout circuit breakers, the tie circuit breaker must have one *"a"* auxiliary switch contact and one *"b"* TOC switch contact (see Table 9) for the ground sensor circuit. For fixed-mounted circuit breakers, this should be omitted.

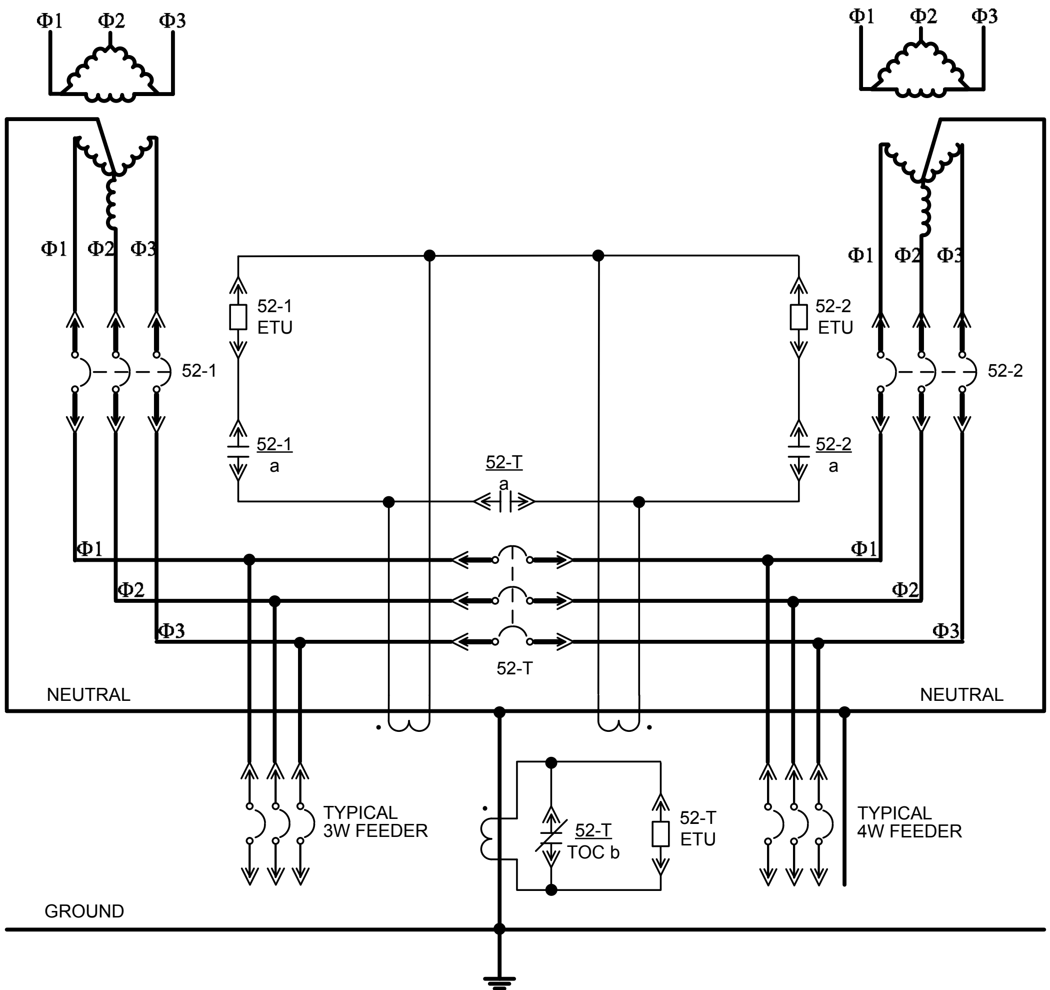
Table 9: TOC Switches

TOC Switch Type	Catalog Number
1c: DISCONNECT 1c: TEST 1c: CONNECT	WLGSGSW111
1c: DISCONNECT 2c: TEST 3c: CONNECT	WLGSGSW123
6c: CONNECT	WLGSGSW6

5. The trip units for the main and tie circuit breakers must have ground fault modules set (switch setting) to direct ground sensing (graphically represented in Figure 5).

A neutral bus must be furnished extending through all low voltage cubicles. All neutral load connections must be made between the source neutral and the main circuit breaker neutral current sensor (refer to Figure 8).

Figure 8: Single Point Grounding Scheme



Notes

1. The system ground connection is at the tie circuit breaker, as shown. Do not ground at the source. The feeder neutrals must connect to the neutral bus between the main and tie, as shown.

2. The main circuit breakers should have longer time delay setting selected, when compared to the tie circuit breaker, but are otherwise interchangeable.

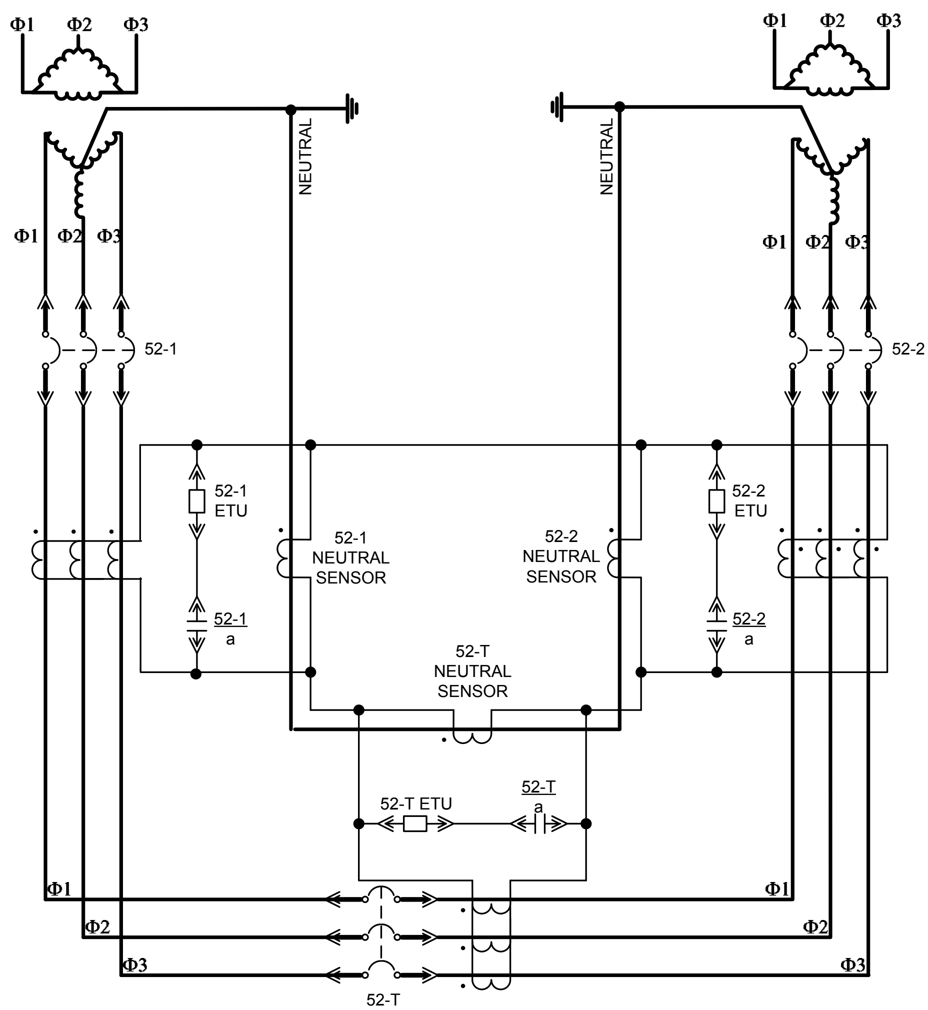
- **Modified Differential Residual Sensing Method**
  There are some double ended substation applications that prevent the use of the T connection single point ground previously discussed such as transformers located remote from the switchgear and grounded at their location. This is defined as a multiple source, multiple ground system and creates additional ground return paths for the ground fault current. Standard direct sensing or residual sensing ground fault schemes may not properly recognize the level of ground current due to ground current flow in the neutral bus of the switchgear. In these cases a Modified Differential Ground Fault Sensing (MDGF) Scheme should be used for main and tie circuit breakers.

  Under normal conditions the tie circuit breaker will be open. The open *"a"* contact at the tie circuit breaker will force any secondary neutral sensor current at the tie breaker around the loop. Normal neutral current will not cause tripping of either main circuit breaker. The balance of currents in the residual circuit that is set up by the phase and neutral sensors at either of the breaker will prevent current flow through their ground pickup elements.

  Similarly, if the tie breaker were closed and one of the main breakers open, the open *"a"* contact will force any secondary neutral current sensed by that breaker's neutral sensor to flow around the loop. This effectively balances the phase and neutral currents sensed at the tie circuit breaker and the main circuit breaker that is closed and will prevent false tripping.

  Under ground fault conditions, any portion of the ground fault returning to the source through the supply source ground point will bypass all the neutral current sensors. A portion of the ground fault current may return to the supply source through the second source ground point. This ground fault current will return to the supply source from the second source ground point via the switchgear neutral bus. The neutral sensor for each main and tie circuit breaker will see the same ground fault current and the same secondary neutral sensor current will be generated by all three sensors. Since this value is the same for all three neutral sensors the secondary current will be forced around the loop bypassing all three trip devices. An imbalance equal to the full magnitude of the fault will then be created in the residual sensing circuit of the breaker(s) supplying the fault current and those circuit breakers will then trip. Main and tie circuit breakers should have proper selective coordination to allow the circuit breaker closest to the fault to trip first.

Figure 9: Modified Differential Ground Fault Sensing Scheme



- **Fixed-Mounted WL Circuit Breakers**
  For proper integration of this scheme the following system requirements must be observed:

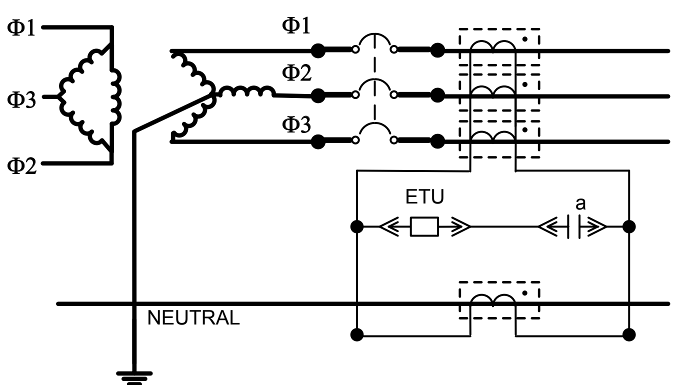
1. Each main and tie circuit breaker must have one of the types of WL electronic trip units found in Table 6.
2. The trip units for the main and tie circuit breakers must have ground fault modules set to direct ground sensing. Ground fault module options can be found in Table 4.
3. At each main and tie circuit breaker, an iron core current sensor must be mounted over each phase, and connected together in parallel with each other and an iron core neutral current sensor (refer to Figure 10). Iron core sensor options can be found in Table 10.

Table 10: Iron Core Sensors for 4W Modified Differential Ground Fault Protection

Sensor Type	Catalog Number
Iron core phase sensor ①	WLGNMDGCT23
Iron core neutral sensor ①	WLGNMDGCT23

① See page 18 for an outline drawing

Figure 10: MDGF Sensor Arrangement for Fixed-Mounted WL Breakers



4. For each main and tie circuit breaker. These paralleled sensors must be connected in a ring with each other main and tie circuit breaker (see Figure 9).
5. Each main and tie circuit breaker must have one "*a*" auxiliary contact for use in the neutral current sensor circuit (refer to Figure 9). Auxiliary switch options are listed in Table 8.

- **Drawout WL Circuit Breakers**
  For proper integration of this scheme the following system requirements must be observed:

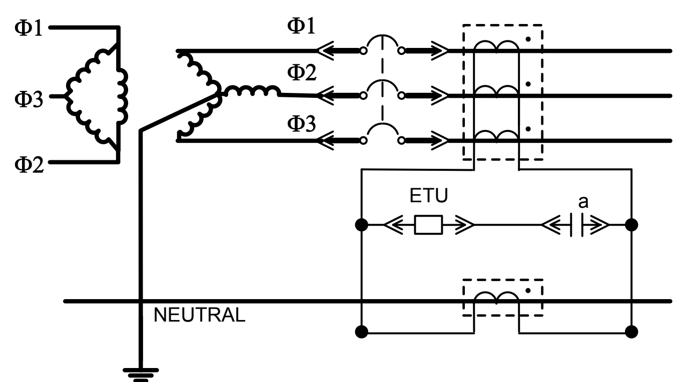
1. Each main and tie circuit breaker must have one of the types of WL electronic trip units found in Table 6.
2. The trip units for the main and tie circuit breakers must have ground fault modules set to direct ground sensing. Ground fault module options can be found in Table 4.
3. At each main and tie circuit breaker, an iron core current sensor must be mounted over each phase, and connected together in parallel with each other and an iron core neutral current sensor (refer to Figure 11). Iron core sensor options can be found in Table 11.

Table 11: Iron Core Sensors for 4W Modified Differential Ground Fault Protection

Sensor Type	Catalog Number
Iron core three-phase sensor for Frame Size 1 and 2 drawout breaker cradles	WLGNMDGCT2
Iron core three-phase sensor for Frame Size 3 drawout breaker cradles	WLGNMDGCT3
Iron core neutral sensor ①	WLGNMDGCT23

① See page 18 for an outline drawing

Figure 11: MDGF Sensor Arrangement for Drawout WL Breakers



Time-Current Curves

The total clearing time of the WL circuit breaker is represented by the following time-current characteristic curve, as shown in Figure 12

Figure 12: WL Ground Fault Time-Current Characteristics

.

Total Clearing Time for GF with i^2t:

$t_{c\,G\,max} = \max\{((1.2 \times 3 \times I_G)^2 \times (t_G + 0.05)) / i^2 , t_G + 0.065 \}$

$t_{c\,G\,min} = \max\{((3 \times I_G)^2 \times t_G) / i^2 , t_G + 0.035 \}$

Total Clearing Time for GF with definite time:

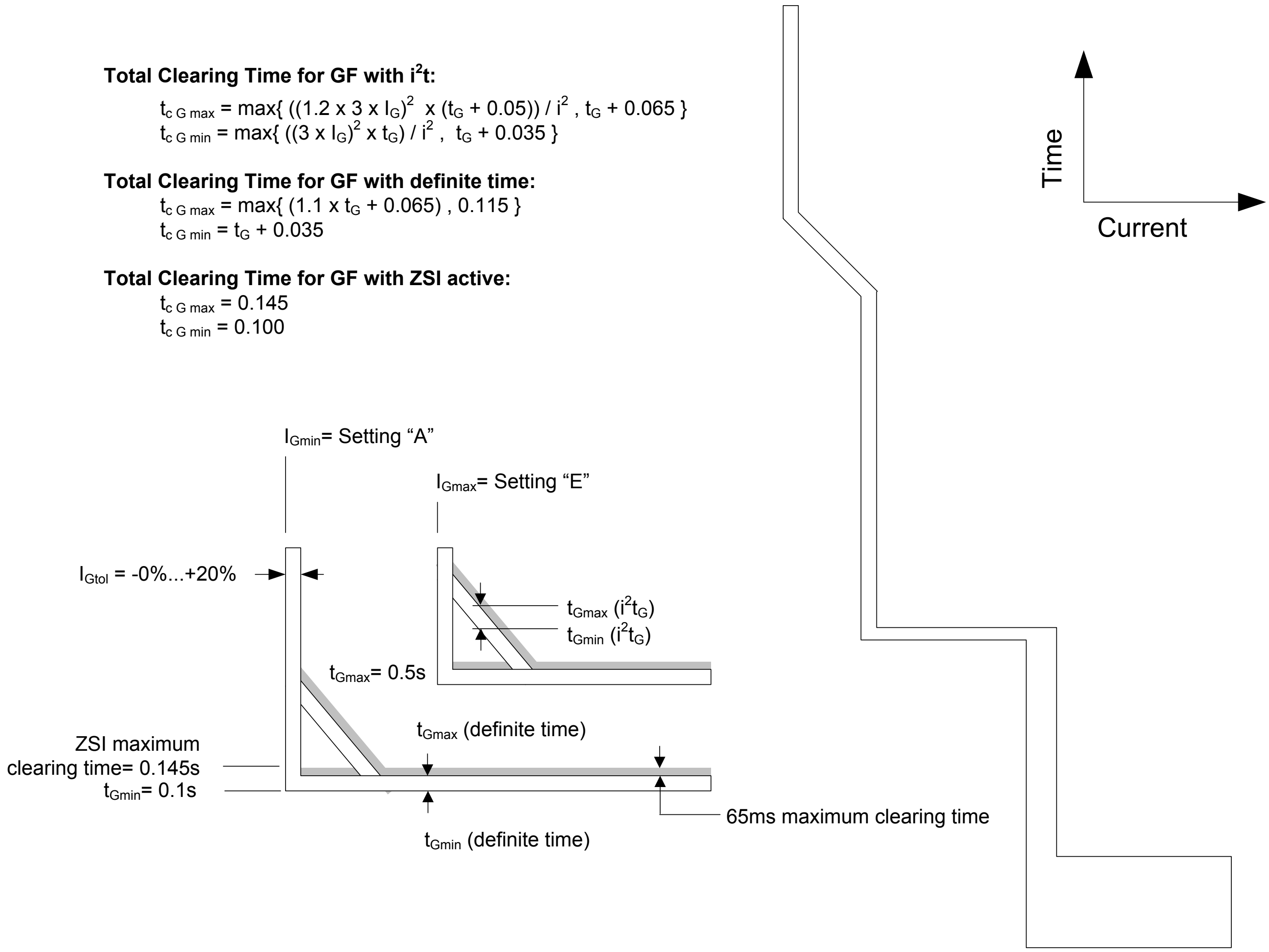
$t_{c\,G\,max} = \max\{(1.1 \times t_G + 0.065) , 0.115 \}$

$t_{c\,G\,min} = t_G + 0.035$

Total Clearing Time for GF with ZSI active:

$t_{c\,G\,max} = 0.145$

$t_{c\,G\,min} = 0.100$



ETU 727 – 748 LT Pickup Settings:

I_G = A, B, C, D, or E

ETU 755 – 776 LT Pickup Settings:

I_G = A – E

Via ETU Keypad: 10 ampere steps

Via WLBDA, MODBUS, or PROFIBUS: 1 ampere steps

ETU 727 – 748 GF Delay Settings‡:

t_G = 0.1, 0.2, 0.3, 0.4, or 0.5

ETU 755 – 776 GF Delay Settings:

t_G (definite time or i^2t) = 0.1 – 0.5 seconds

Via ETU Keypad: 0.005 second steps

Via WLBDA, MODBUS, or PROFIBUS: 0.001 sec steps

Ground Fault Pickup Settings:

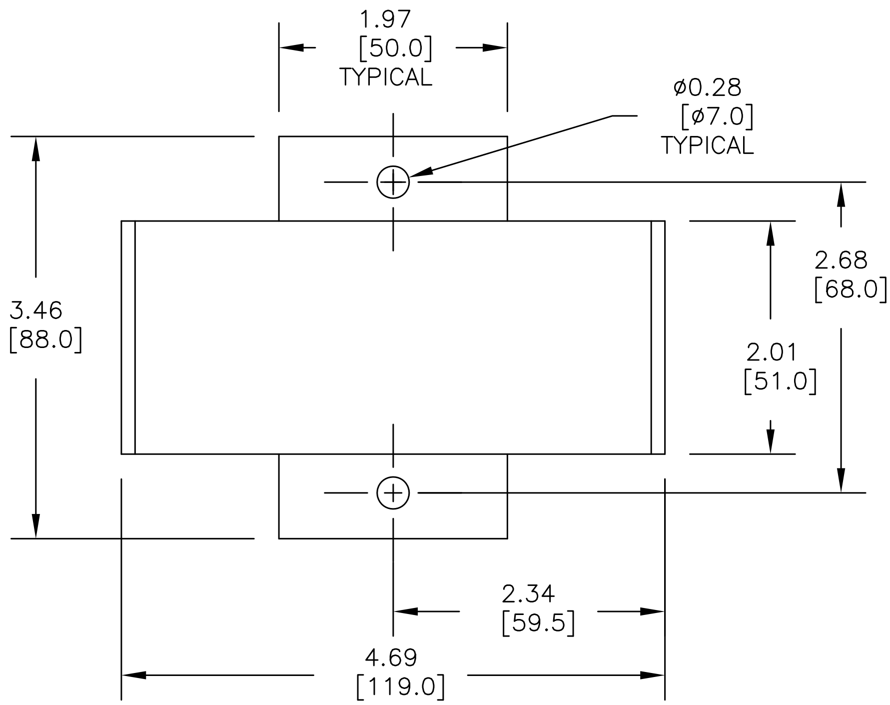
	Frame Size		
	1	2	3
A	100A	100A	400A
B	300A	300A	600A
C	600A	600A	800A
D	900A	900A	1000A
E	1200A	1200A	1200A

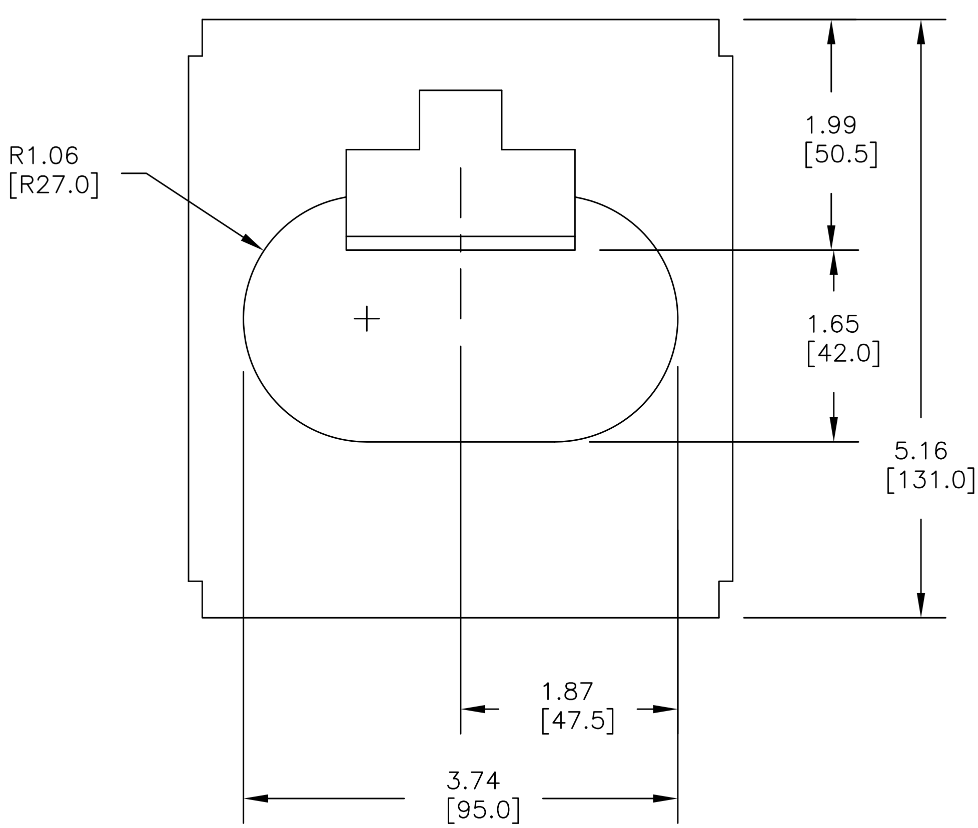
‡ ETU 727 features only definite time delay.

Outline Drawings

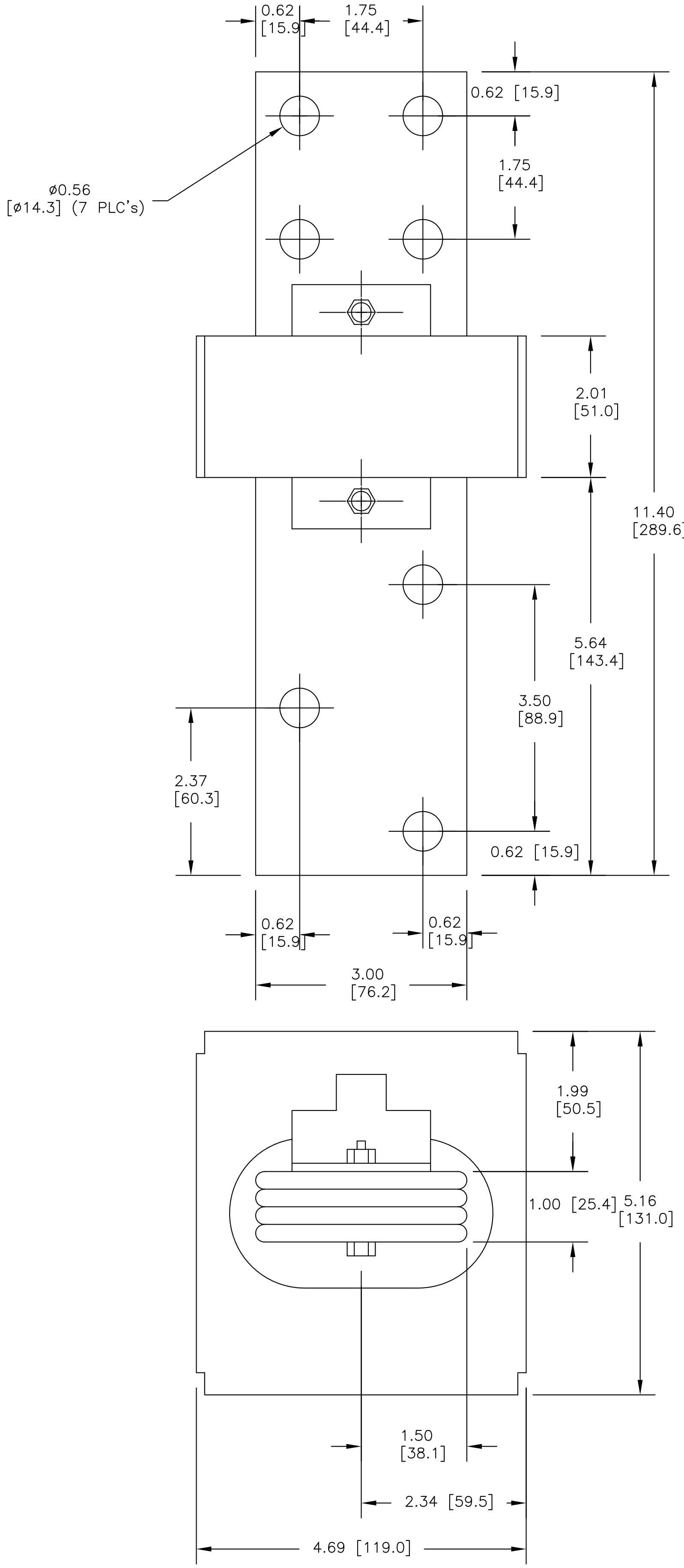
The following sections contain outline drawings which describe the externally mounted sensors discussed within this document.

- **WLNCT2**



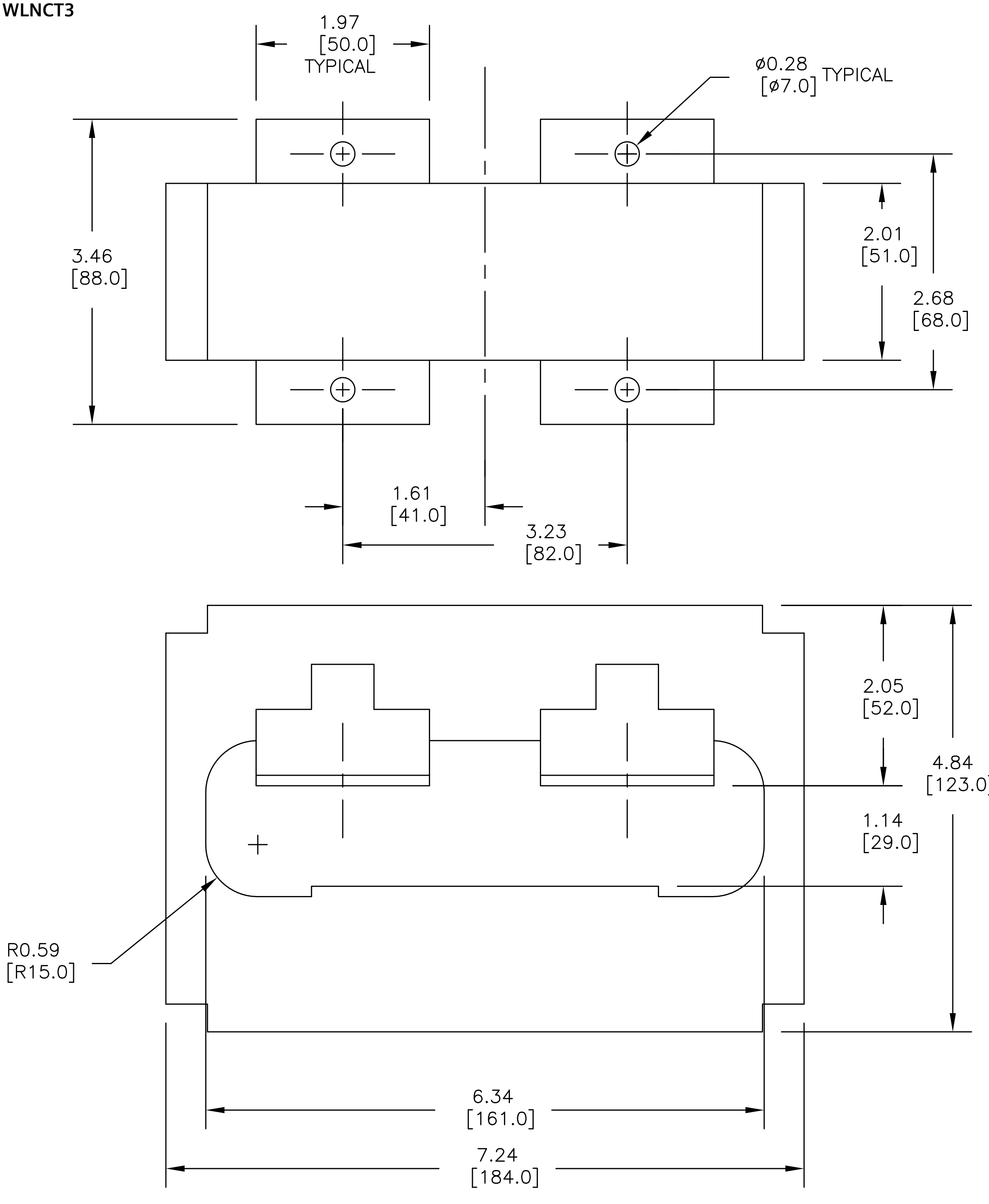


- **WLNCT2CB**

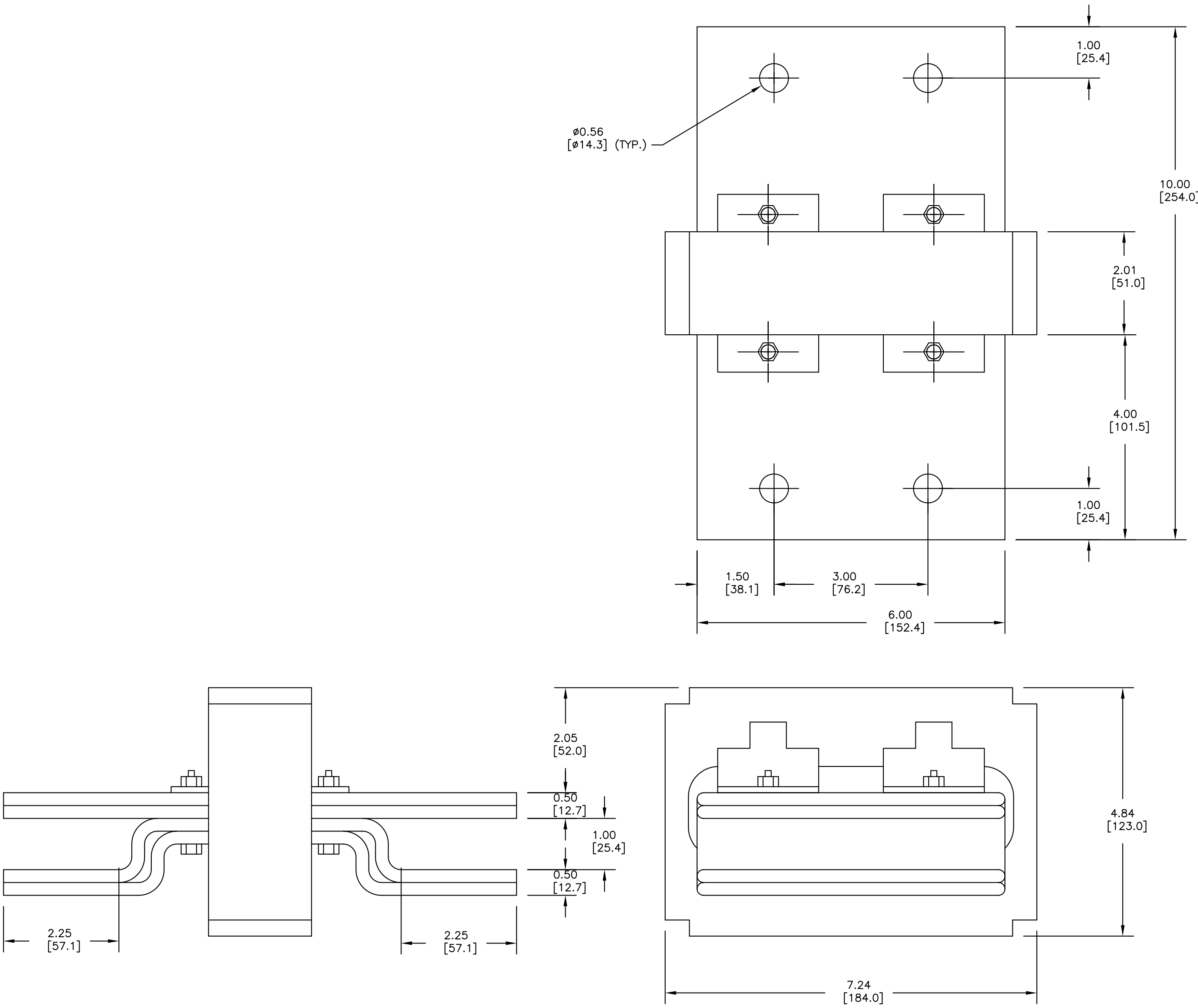


0.62
[15.9]
1.75
[44.4]
0.62 [15.9]
1.75
[44.4]
ø0.56
[ø14.3] (7 PLC's)
2.01
[51.0]
11.40
[289.6]
5.64
[143.4]
3.50
[88.9]
2.37
[60.3]
0.62 [15.9]
0.62
[15.9]
0.62
[15.9]
3.00
[76.2]
1.99
[50.5]
1.00 [25.4]
5.16
[131.0]
1.50
[38.1]
2.34 [59.5]
4.69 [119.0]

- **WLNCT3**

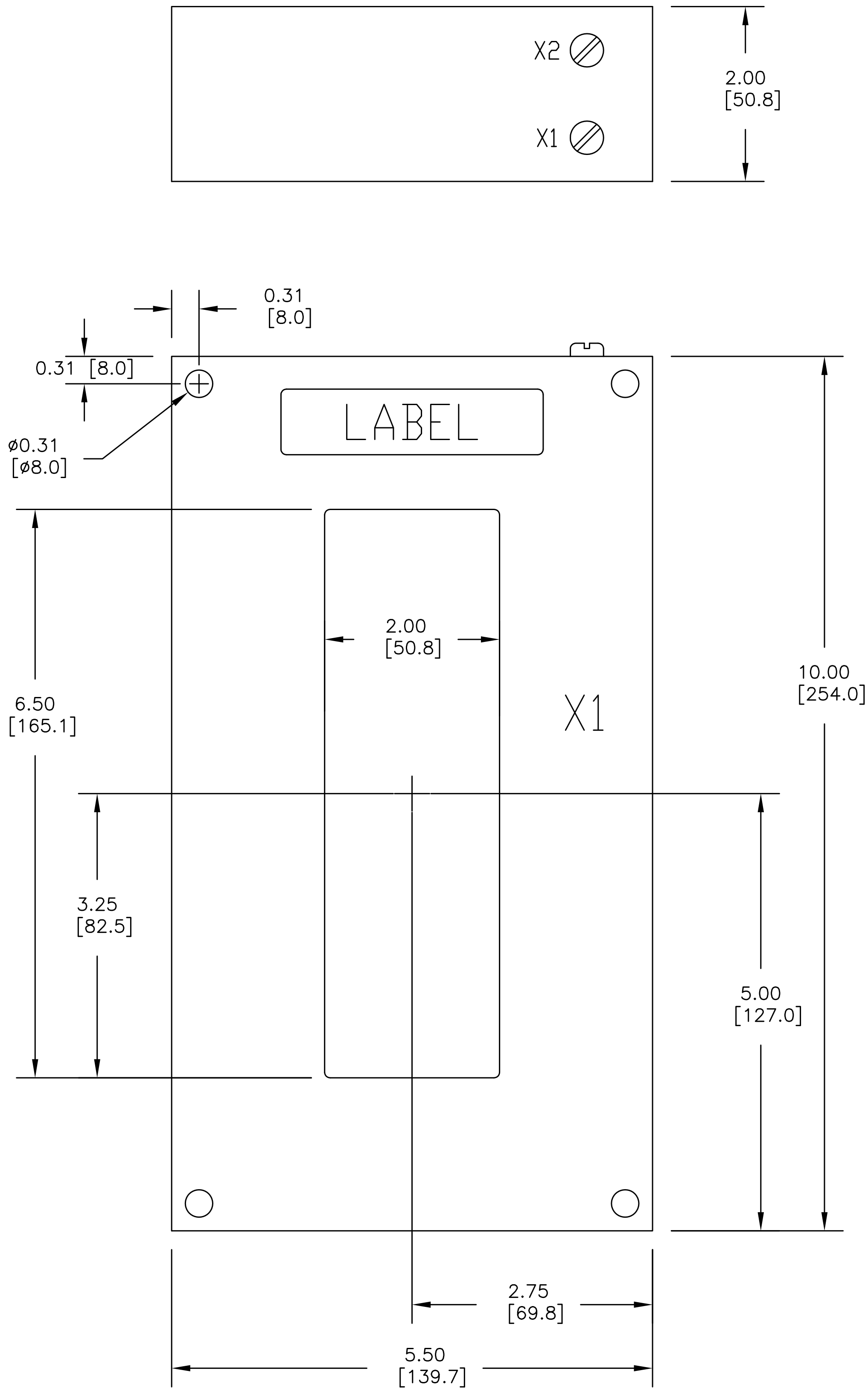

1.97
[50.0]
TYPICAL
ø0.28
[ø7.0]
TYPICAL
3.46
[88.0]
2.01
[51.0]
2.68
[68.0]
1.61
[41.0]
3.23
[82.0]
2.05
[52.0]
4.84
[123.0]
1.14
[29.0]
R0.59
[R15.0]
6.34
[161.0]
7.24
[184.0]

- **WLNCT3CB**



1.00
[25.4]
ø0.56
[ø14.3] (TYP.)
10.00
[254.0]
2.01
[51.0]
4.00
[101.5]
1.00
[25.4]
1.50
[38.1]
3.00
[76.2]
6.00
[152.4]
2.05
[52.0]
0.50
[12.7]
1.00
[25.4]
0.50
[12.7]
2.25
[57.1]
2.25
[57.1]
4.84
[123.0]
7.24
[184.0]

- **WLGNMDGCT23**



Abbreviations

i	Measured current flow in system
I_G	Ground fault pickup setting
I_{Gmax}	Maximum allowable ground fault pickup setting
I_{Gmin}	Minimum allowable ground fault pickup setting
I_{Gtol}	Ground fault pickup tolerance
t_{cGmax}	Maximum ground fault clearing time for associated setting I_G
t_{cGmin}	Minimum ground fault clearing time for associated setting I_G
t_G	Ground fault delay setting
t_{Gmax}	Maximum ground fault tripping time for associated setting I_G
t_{Gmin}	Minimum ground fault tripping time for associated setting I_G

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