Instruction Bulletin

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Ground-Fault Interface Module with Current Sensor

For Masterpact® NT and NW, PowerPact® P- and R-Frame and Compact NS630b–NS3200 Circuit Breakers

Retain for future use.

GENERAL INFORMATION

The ground-fault interface module **Figure 1** is used to sum the current flow in three-phase, four-wire systems and multiple-sourced systems using one or more specially designed current sensors **Figure 1** to measure current flow. Specific procedures for installing the ground-fault interface module and current sensors vary depending on the type of system and equipment with which they are used.

Figure 1: Ground-Fault Interface Module and Current Sensor

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This instruction bulletin provides general installation procedures and wiring diagrams for two common applications for the ground-fault interface module and associated current sensors. The system models described are a ground-source return ground-fault sensing system and a modified differential ground-fault (MDGF) system. More complex systems are possible. For information about these, contact a Field Sales representative.

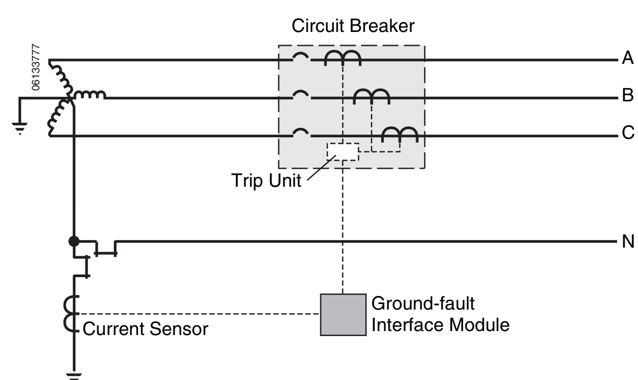
In a multiple source MDGF system like in a main-tie-main system, different types of circuit breakers (Masterpact® NT and NW (3- and 6-pole), PowerPact® P-, and R-frame, and Compact NS630b-NS3200) can be used together. Example: A Masterpact 6-pole (main), PowerPact R-frame (tie), and another Masterpact 3-pole (main) is appropriate as long as all three circuit breakers are connected to their correct MDGF output terminals on the MDGF summing module (i.e. standard construction [3-pole] or wide construction [6-pole] output terminals).

GROUND-SOURCE RETURN GROUND-FAULT SENSING SYSTEM

Ground-source return ground-fault sensing systems use one current sensor on the ground conductor connected to the circuit breaker via a ground-fault interface module. The current sensor measures the ground current flow.

The system location diagram in **Figure 2** shows the current sensor in a three-phase, four-wire system. Ground-source return can also be used on grounded systems which do not carry the neutral.

Figure 2: System Location Diagram



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Installation

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

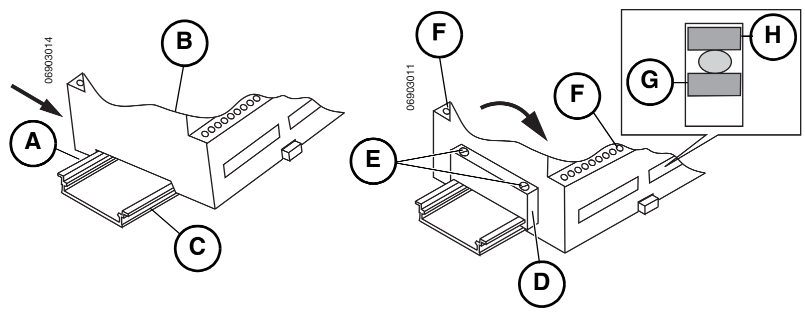
- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors and covers before turning on power to this equipment.
- Disconnect all power supplying the current sensor primary circuit before working on current sensor terminals.
- Make sure to allow at least 1.0 in. (26 mm) clearance between current sensor terminals and any live voltages.
- Make sure to allow at least 0.5 in. (13 mm) clearance between the ground-fault interface module wire terminals (F) and any metal parts.
- Open current sensors can generate dangerous voltages. Do not turn on power to the current sensor primary circuit when current sensors remain open.
- Make sure wires connected to ground-fault interface module terminal strip are secured between the clamp plate (G) and terminal (H). Open current sensors can result from loose connections.

Failure to follow these instructions will result in death or serious injury.

1. Turn off all power supplying this equipment before working on or inside equipment.
2. Select a suitable location in the equipment and install 35 mm mounting rail (A) for mounting ground-fault interface module.
3. Slide module (B) onto back side of rail (A), then rotate module downward to snap it on front side of rail (C). Install mounting rail end clamps (D) on both sides of module and secure clamps by tightening screws (E). Tighten screws to max. 4.5 lb-in (0.6 N•m).

NOTE: There must be a minimum of 0.5 in. (13 mm) clearance between the wire terminals (F) and any metal parts.

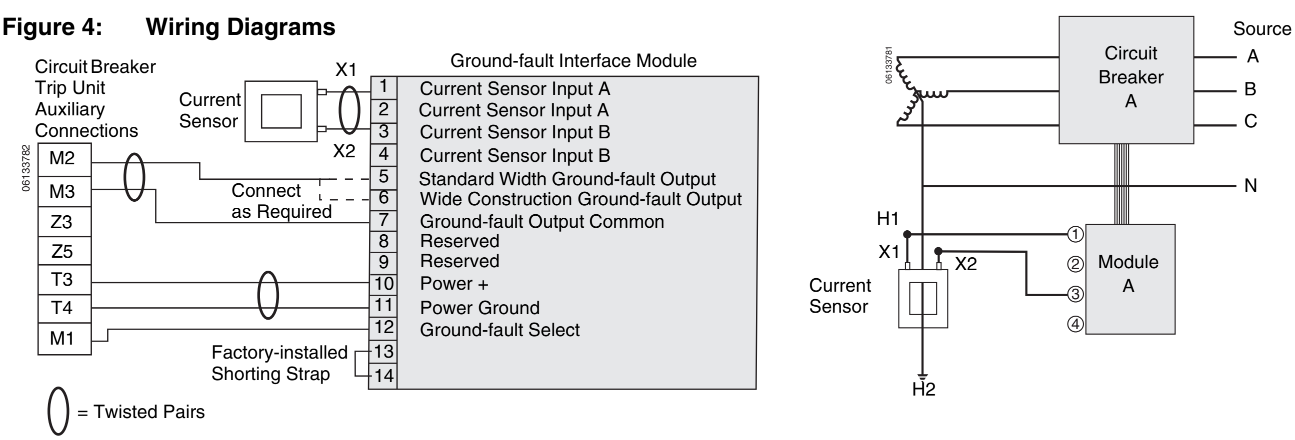
Figure 3: Installing Mounting Rail



4. Connect ground-fault interface module in the power system using wiring diagrams shown in **Figure 4**. Ground-fault interface module to circuit breaker connection requires a minimum of #18 AWG (0.82 mm^2) shielded cable. Maximum cable length is 32 ft. (10 m).
5. Install current sensor and connect it to ground-fault interface module using the wiring diagram shown in **Figure 4**. Ground wire must pass through current sensor window. Position current sensor in system as instructed in Current Sensor Positioning Guidelines on **page 8**. Make sure the H1 polarity mark on current sensor faces current source. Current sensor to ground-fault interface module connection requires a minimum of #14 AWG (2,082 mm^2) shielded cable. Maximum cable length is 500 ft. (152.4 m).

NOTE: There must be a minimum of 1.0 in. (26 mm) clearance between current sensor terminals and live voltages from bussing or other sources.

Figure 4: Wiring Diagrams



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6. Make sure shorting strap between Terminals 13 and 14 of the ground-fault interface module remains inserted to ensure proper operation.
7. Replace any necessary plates, covers and doors before re-energizing the equipment.

NOTE: It is recommended that primary injection testing be performed to ensure that all trip system connections have been correctly made.

MODIFIED DIFFERENTIAL GROUND-FAULT SYSTEM (MDGF)

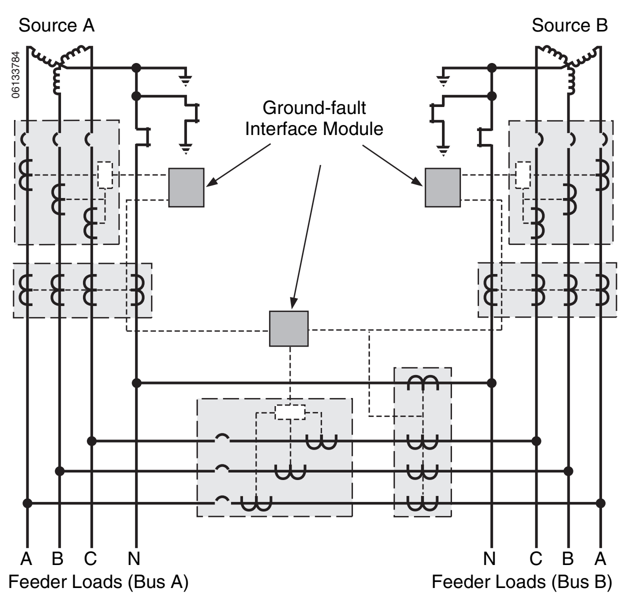
NOTE: The MDGF system uses individual sensors to sum phase and neutral currents. The system layout and wiring can affect the ability of the sensors to correctly sum the currents due to sensor saturation. The following conditions can contribute to sensor saturation and improper summing: 1) Positioning of the sensors in relation to the conductors. 2) Resistance of interconnecting cables between sensors and MDGF modules. 3) High inrush currents during start-up or system operation.

A modified differential ground-fault system is used for multiple-sourced systems. Normal residual and ground-source return systems will not correctly sum all of the circulating currents caused by the multiple neutral paths and multiple grounds.

The system location diagram in **Figure 5** shows a typical main-tie-main system. Each source transformer is grounded and the service entrance neutral is bonded to ground. Multiple neutral paths allow current to circulate and return to the supplying transformer by several different paths. The ground-fault system must be capable of correctly summing these circulating currents to minimize nuisance tripping. This example is one of numerous possibilities involving multiple sources and multiple circuit breakers. Systems more complex than the typical main-tie-main system will require wiring and installation instructions that are application specific. For information about these, contact a Field Sales representative.

The proper positioning of the sensors along with minimum resistance in the interconnecting cables **will reduce** summing error due to sensor saturation. See the Current Sensor Positioning Guidelines on page 6. If for any reason the sensors cannot be properly positioned or the interconnecting cables exceed 260 ft. (79 m), refer to **page 9** for information on ways to minimize improper operation.

Figure 5: Typical Main-Tie-Main System



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Installation

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

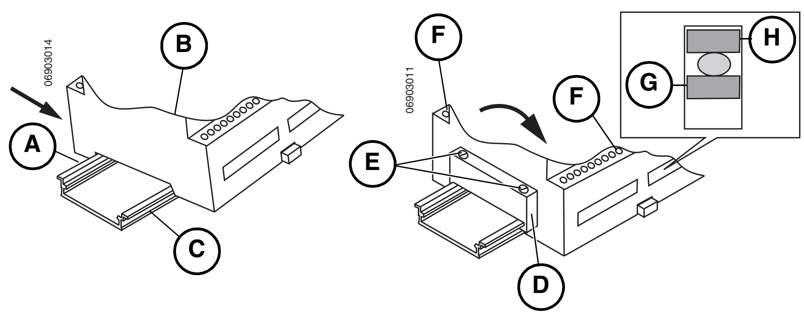
- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors and covers before turning on power to this equipment.
- Disconnect all power supplying the current sensor primary circuit before working on current sensor terminals.
- Make sure to allow at least 1.0 in. (26 mm) clearance between current sensor terminals and any live voltages.
- Make sure to allow at least 0.5 in. (13 mm) clearance between the ground-fault interface module wire terminals (F) and any metal parts.
- Open current sensors can generate dangerous voltages. Do not turn on power to the current sensor primary circuit when current sensors remain open.
- Make sure wires connected to ground-fault interface module terminal strip are secured between the clamp plate (G) and terminal (H). Open current sensors can result from loose connections.

Failure to follow these instructions will result in death or serious injury.

1. Turn off all power supplying this equipment before working on or inside equipment. For multiple-sourced systems, make sure all associated power sources are disconnected before working on or inside equipment.
2. Select a suitable location in the equipment and install 35 mm mounting rail (A) for mounting ground-fault interface module.
3. Slide module (B) onto back side of rail (A), then rotate module downward to snap it on front side of rail (C). Install mounting rail end clamps (D) on both sides of module and secure clamps by tightening screws (E). Tighten screws to max. 4.5 lb-in (0.6 N•m).

NOTE: There must be a minimum of 0.5 in. (13 mm) clearance between the wire terminals (F) and any metal parts.

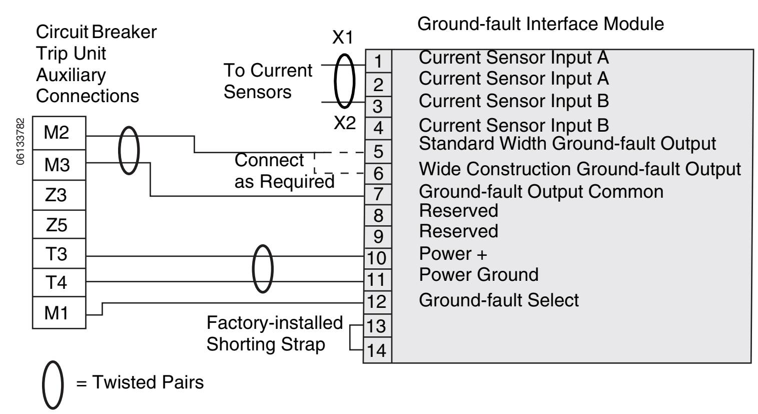
Figure 6: Installing Mounting Rail



4. Connect ground-fault interface module in the power system using wiring diagrams shown in **Figures 7** and **8**. Ground-fault interface module to circuit breaker connection requires a minimum of #18 AWG (0,82 mm²) shielded cable. Maximum cable length is 32 ft. (10 m).

Figure 7: Current Sensor System

*NOTE: See **Figure 8** for connections to current sensor system.*



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5. Install current sensors and connect them to ground-fault interface modules using the wiring diagram shown in **Figure 8**. Position current sensors in system as instructed in Current Sensor Positioning Guidelines on **page 8**. Current sensor to ground-fault interface module connections require a minimum of 14 AWG shielded cable. Maximum cable length is 260 ft. (79 m). If maximum cable length must exceed 260 ft. (79 m), see **page 9**.

- Make sure the H1 polarity mark on each current sensor faces current source
- If using a tie circuit breaker, make sure the H1 polarity mark on each current sensor faces the tie circuit breaker

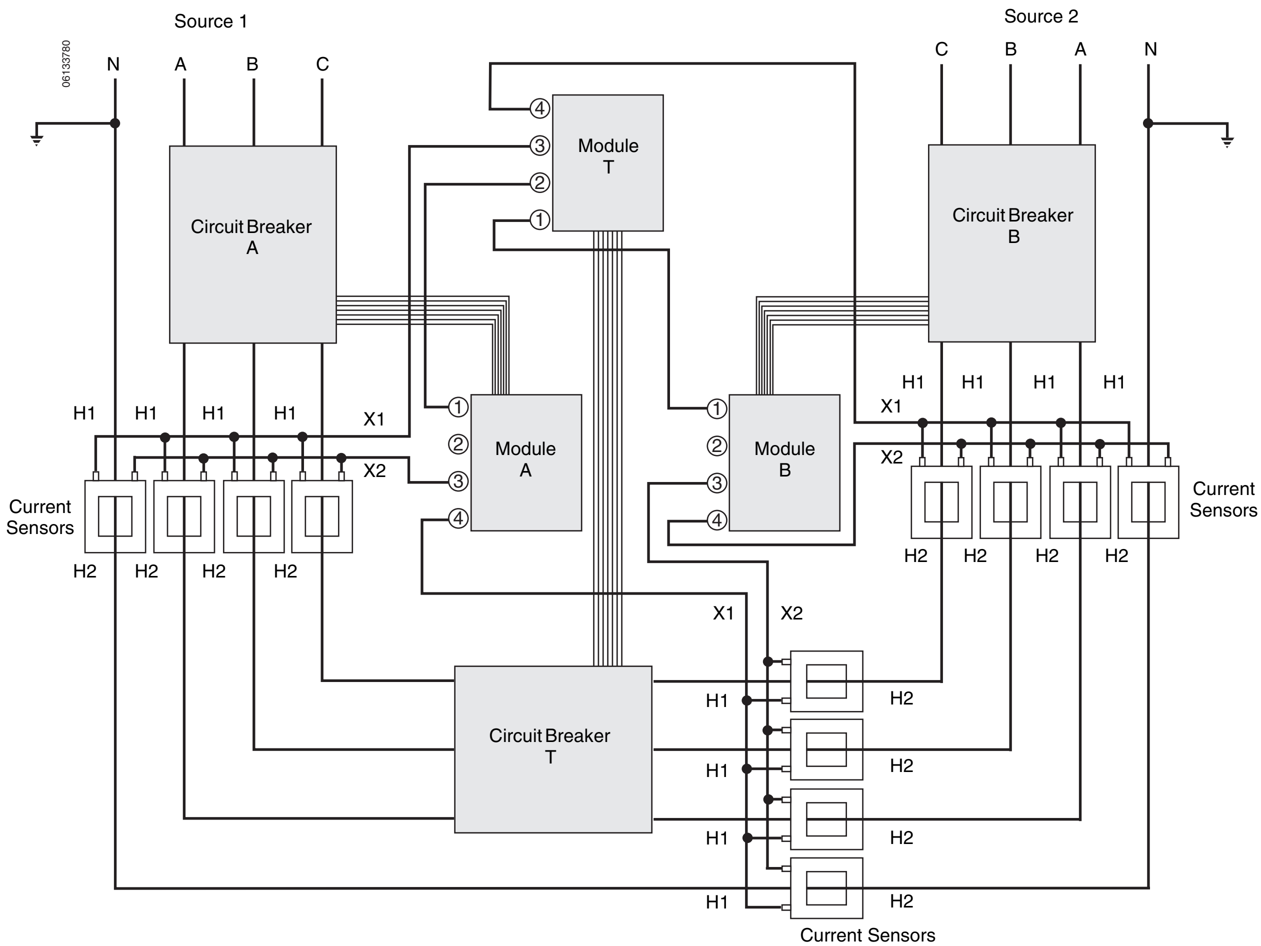
NOTE: There must be a minimum of 1.0 in. (25.4 mm) clearance between current sensor terminals and live voltages from bussing or other sources.

6. Make sure shorting strap between Terminals 13 and 14 of each ground-fault interface module remains inserted to ensure proper operation.
7. Replace any necessary plates, covers and doors before re-energizing equipment.

NOTE: It is recommended that primary injection testing be performed to ensure that all system connections have been correctly made.

8. Refer to Tables 1, 2, or 3 **(pages 6 and 7)** for minimum ground-fault settings and lowest test currents.

Figure 8: Wiring Diagram



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Minimum Ground Fault Settings and Test Currents

The tables in this section indicate the various sensor plugs that can be used with Masterpact NT and NW, PowerPact P- and R-frame, and Compact NS630b–NS3200 circuit breakers.

NOTE: This data is applicable only for ANSI, UL, or IEC circuit breakers when the ground-fault current metering and monitoring for the circuit breaker or the system (single or multi-sourced) is provided by the MDGF equipment (i.e. summing module and current sensor).

"Lowest Ground-Fault Setting" is the lowest setting of ground-fault available on the various sensor plugs. This is effective under normal operation of the circuit breaker in a MDGF system.

"Lowest Test Current" is the lowest ground-fault current at which the breaker in a MDGF system can be tested. The lowest ground-fault settings for various sensor plugs are not applicable under test conditions.

The sensor plugs that allow ground-fault settings above 300 A can be used for testing. Note that on some sensor plugs, the lowest ground-fault setting is 500 A, so the lowest test current is also 500 A.

Table 1: Masterpact NT and NW Circuit Breakers

Sensor Plugs	NT (T-Frame/3-Pole)			NW (W-Frame/Standard Width)			NW (Y-Frame/Wide Construction)		
	Usability	Lowest Ground Fault Setting	Lowest Test Current	Usability	Lowest Ground Fault Setting	Lowest Test Current	Usability	Lowest Ground Fault Setting	Lowest Test Current
100	No	X	X	No	X	X	N/A	X	X
250	No	X	X	No	X	X	N/A	X	X
400	Yes	120	300	Yes	120	300	N/A	X	X
600	Yes	120	300	Yes	120	300	N/A	X	X
630	Yes	126	300	Yes	126	300	N/A	X	X
800	Yes	160	300	Yes	160	300	N/A	X	X
1000	Yes	200	300	Yes	200	300	N/A	X	X
1200	Yes	240	300	Yes	240	300	N/A	X	X
1250	Yes	500	500	Yes	500	500	N/A	X	X
1600	Yes	500	500	Yes	500	500	N/A	X	X
2000	N/A	X	X	Yes	500	500	Yes	500	500
2500	N/A	X	X	Yes	500	500	Yes	500	500
3000	N/A	X	X	Yes	500	500	Yes	500	500
3200	N/A	X	X	Yes	500	500	Yes	500	500
4000	N/A	X	X	Yes[1]	500	500	Yes	500	500
5000	N/A	X	X	N/A	X	X	Yes	500	500
6000	N/A	X	X	N/A	X	X	Yes	500	500
6300	N/A	X	X	N/A	X	X	Yes	500	500

[1] The MDGF system can only be used on a 3-pole 4000 A fixed NW circuit breaker if two sensors are used per phase and the current is equally split among the two sensors per phase.

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Table 2: PowerPact P- and R-frame Circuit Breakers

Sensor Plugs	P-Frame (3-Pole)			R-Frame (3-Pole)		
	Usability	Lowest Ground Fault Setting	Lowest Test Current	Usability	Lowest Ground Fault Setting	Lowest Test Current
250	No	X	X	N/A	X	X
400	Yes	120	300	N/A	X	X
600	Yes	120	300	Yes	120	300
800	Yes	160	300	Yes	160	300
1000	Yes	200	300	Yes	200	300
1200	Yes	240	300	Yes	240	300
1600	N/A	X	X	Yes	500	500
2000	N/A	X	X	Yes	500	500
2500	N/A	X	X	Yes	500	500
3000	N/A	X	X	Yes	500	500

Table 3: Compact NS630b–NS1600 and NS1600b–NS3200 Circuit Breakers

Sensor Plugs	NS630b–NS1600 (3-Pole)			NS1600b–NS3200 (3-Pole)		
	Usability	Lowest Ground Fault Setting	Lowest Test Current	Usability	Lowest Ground Fault Setting	Lowest Test Current
630	Yes	135	300	N/A	X	X
800	Yes	160	300	N/A	X	X
1000	Yes	200	300	N/A	X	X
1250	Yes	250	300	N/A	X	X
1600	Yes	500	500	Yes	500	500
2000	N/A	X	X	Yes	500	500
2500	N/A	X	X	Yes	500	500
3200	N/A	X	X	Yes	500	500

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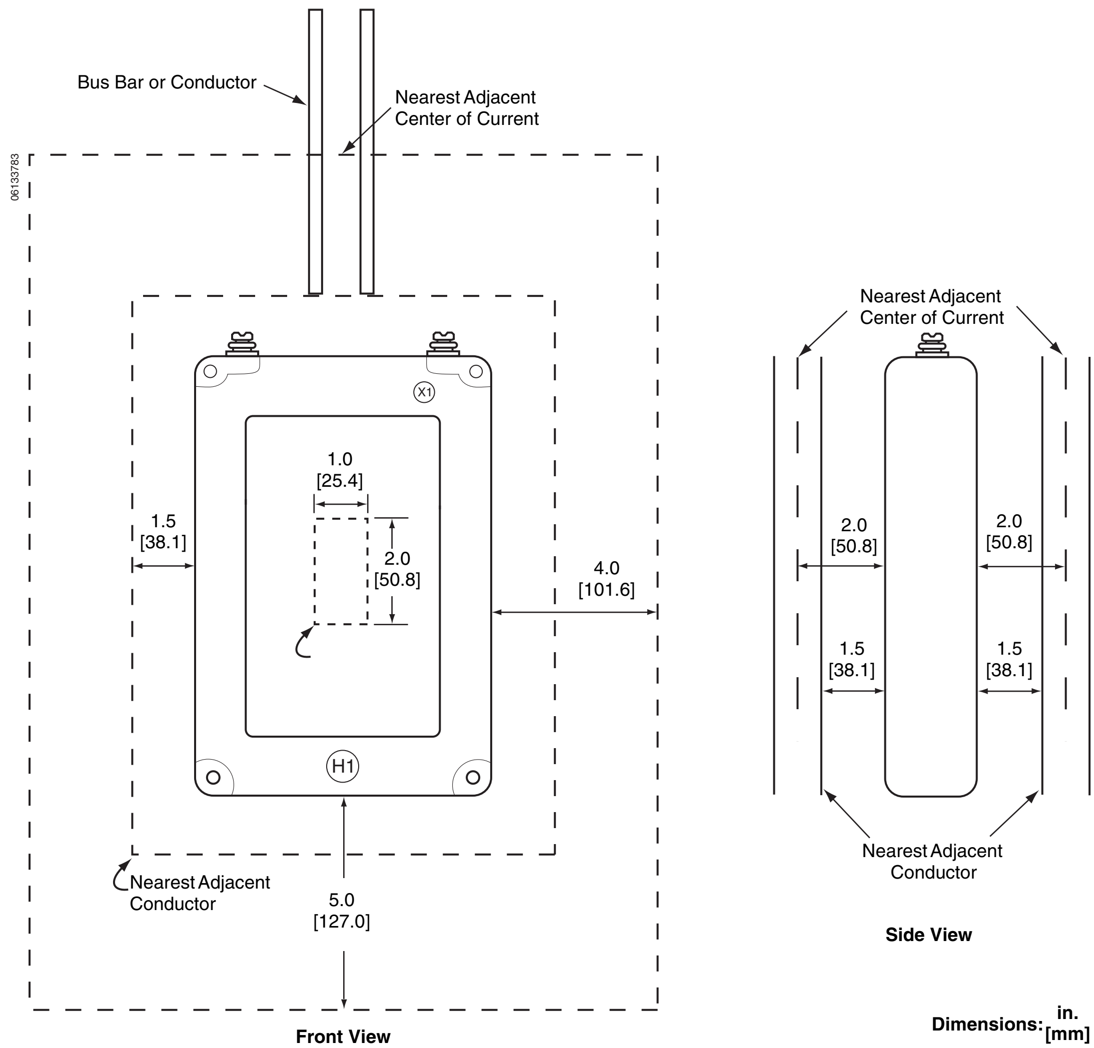
CURRENT SENSOR POSITIONING GUIDELINES

1. The conductors passing through the current sensor must be centered in current sensor window.
2. The nearest adjacent conductor must be a minimum of 1.5 in. (38.1 mm) from the outside edge of the current sensor. The center of current for adjacent conductors must be a minimum of 5 in. (127 mm) from the outside edge of the current sensor along the short dimension and 4 in. (101.6 mm) from the outside edge of the current sensor along the long dimension. From the front and back, the center of current for adjacent conductors must be a minimum of 2 in. (50.8 mm) from the outside edge of the current sensor.

Figure 9: Current Sensor Positioning Guidelines



SYSTEM WIRING AND SETTINGS FOR SYSTEMS WITH DEVIATION FROM PROPER SENSOR POSITIONING

*NOTE: It is recommended that all efforts be made to properly position the sensors according to the guidelines on **page 8**. If there is deviation from the proper positionings guidelines, etc., see the following topics:*

W-frame Circuit Breakers with Sensors 3200 A and Below

Standard-Width Circuit Breakers (Masterpact NT/NW 3-Pole, PowerPact P- and R-Frame, and Compact NS630b–NS3200)

To minimize summing error during high inrush currents, control the total resistance in the interconnection wiring between the sensors and the ground-fault interface module for each circuit breaker in the system. The wire size and length of wire between sensors and summing module affects the summing error. The longer the wiring and/or the smaller the AWG of the wire, the larger the summing errors. Any additional resistance that is in series with the wiring, such as terminal blocks, etc., will also increase the summing error.

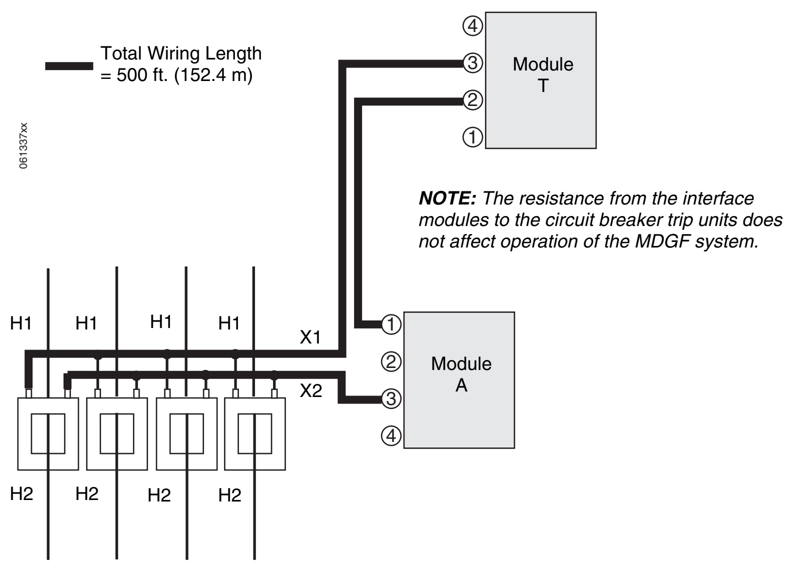
If there is deviation from the proper sensor positioning guidelines, keep the total interconnection cable resistance below 0.668 ohms. This will minimize summing errors during high inrush currents. Use the following example to help determine the cable size required to keep the wiring resistance below 0.668 ohms.

Example:

*NOTE: Due to the design of the equipment, the MDGF sensor positioning deviates from the proper sensor positioning guidelines on **page 8**.*

During system planning and layout, it has been determined that the total length of wiring must be about 500 ft. (152.4 m). This includes the wiring between the sensors and from the sensors to the ground-fault interface modules.

Figure 10: Wiring Diagram



The total resistance of 500 ft. (152.4 m) of 14 AWG cable is 1.263 ohms of resistance.[1] Because the resistance of the 500 ft. (152.4 m) of 14 AWG (2.08 mm^2) cable exceeds the maximum total resistance of 0.668 ohms, the

[1] 0.002525 ohms/ft. X 500 ft. (152.4 m) = 1.263 ohms.

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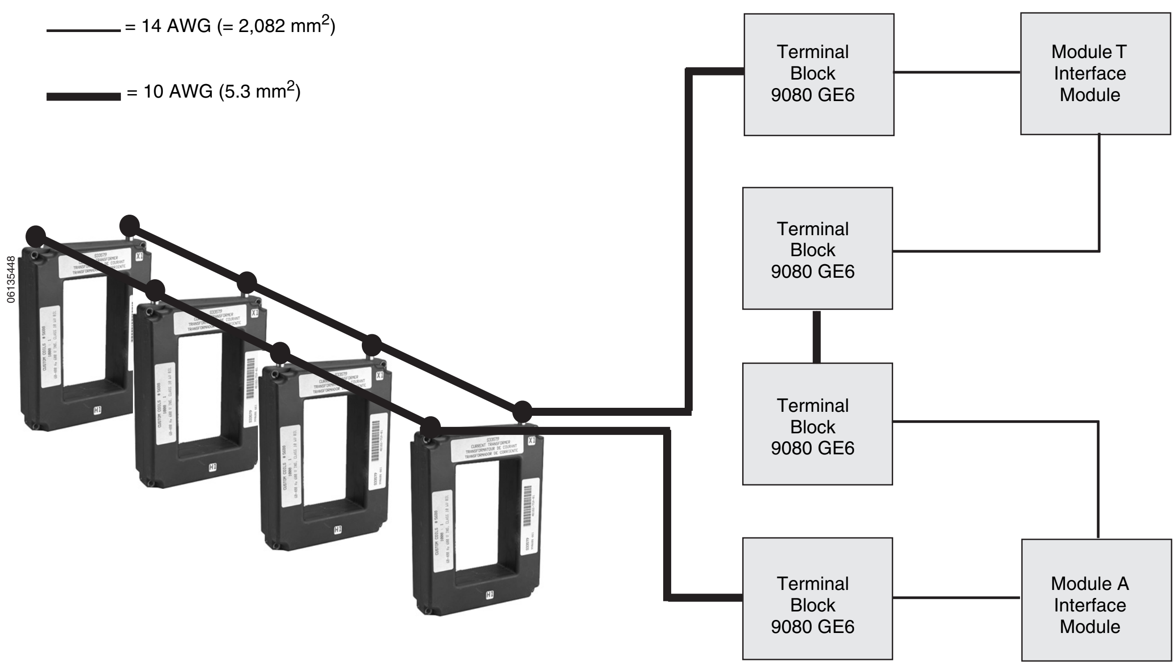
size of the cable needs to be increased. If the cable size increases to a value that is greater than what can be attached to the ground-fault interface module (14 AWG stranded, 12 AWG solid), terminal blocks will need to be added to receive the larger cable.

For this example, the following components have been chosen to meet the 0.668 ohm resistance requirement to minimize the nuisance tripping:

- 490 ft. (149.4 m) of 10 AWG (5.3 mm^2) cable = 0.4894 ohms[2]
- 4, DIN rail, screw-cage terminal blocks (Square D PN: 9080 GE6, Entrelec PN: 115120.17) = 1 mohm per terminal block. Total resistance of the terminal blocks: 4 terminal blocks X 1 mohm = 4 mohm
- 10 ft. (3.0 m) of 14 AWG (2.08 mm^2) stranded cable (used to connect between the terminal block to ground-fault interface module) = 0.02525 ohms
- Resistance through ground-fault interface modules = Already taken into consideration

Total resistance = 0.4894 + 0.004 + 0.02525 = 0.519 ohms.

Figure 11: Wiring Diagram



[2] 0.0009988 ohms/ft. X 490 ft. (149.4 m) = 0.4894.

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Y-frame Circuit Breakers with Sensors 4000 A and Below

Wide-construction Circuit Breakers (Masterpact NW 6-pole)

To minimize summing error due to high inrush currents, control the total resistance in the interconnection wiring between the sensors and the ground-fault interface module for each circuit breaker in the system. The wire size and length of wire between sensors and summing module affects the summing error. The longer the wiring and/or the smaller the AWG of the wire, the larger the summing errors. Any additional resistance that is in series with the wiring, such as terminal blocks, etc., will also increase the summing error.

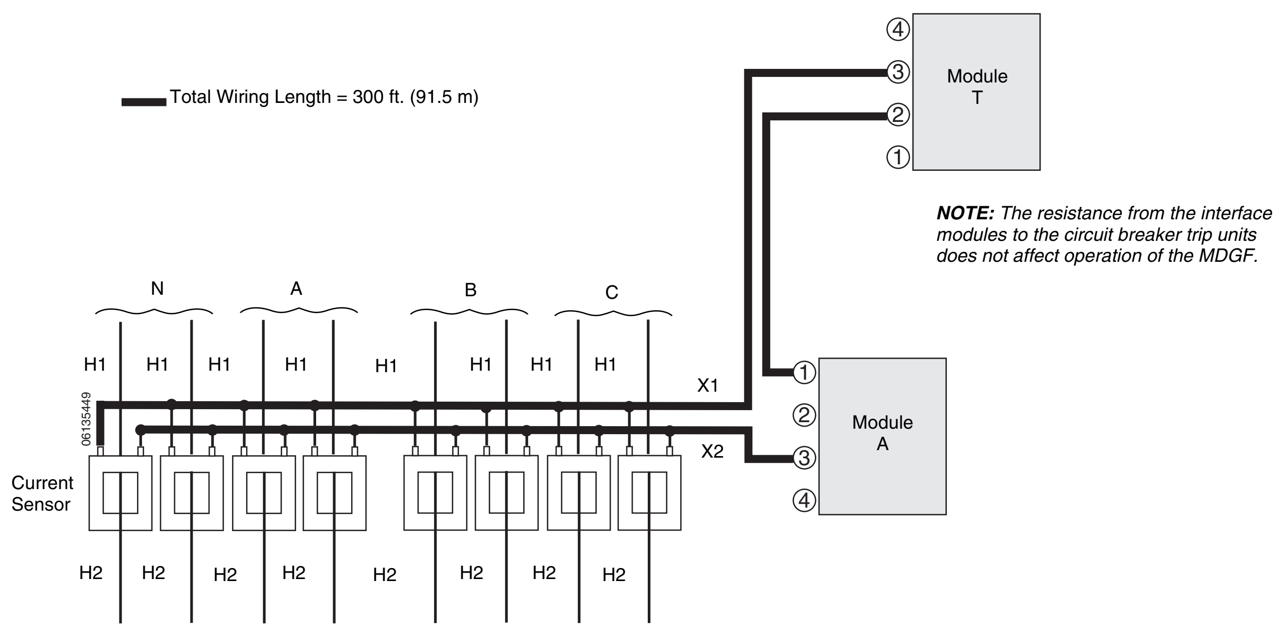
If there is deviation from the proper sensor positioning guidelines, keep the total interconnection cable resistance below 0.668 ohms. This will minimize summing errors during high inrush currents. Use the following example to help determine the cable size required to keep the wiring resistance below 0.668 ohms.

Example:

NOTE: Due to the design of the equipment, the MDGF sensor positioning deviates from the proper sensor positioning guidelines on ***page 8****.*

During system planning and layout, it has been determined that the total length of wiring must be about 300 ft. (91.5 m). This includes the wiring between sensors and from the sensors to the ground-fault interface modules.

Figure 12: Wiring Diagram



The resistance of 300 ft. (91.5 m) of 14 AWG (2.08 mm^2) cable is 0.7575 ohms of resistance[3]. Because the resistance of the 300 ft. (91.5 m) of 14 AWG (2.08 mm^2) cable exceeds the maximum total resistance of 0.668 ohms, the size of the cable needs to be increased. If the cable size increases to a value that is greater than what can be attached to the ground-fault interface module (14 AWG stranded, 12 AWG solid), terminal blocks will need to be added to receive the larger cable.

[3] 0.002525 ohms/ft. X 300 ft. = 0.7575 ohms.

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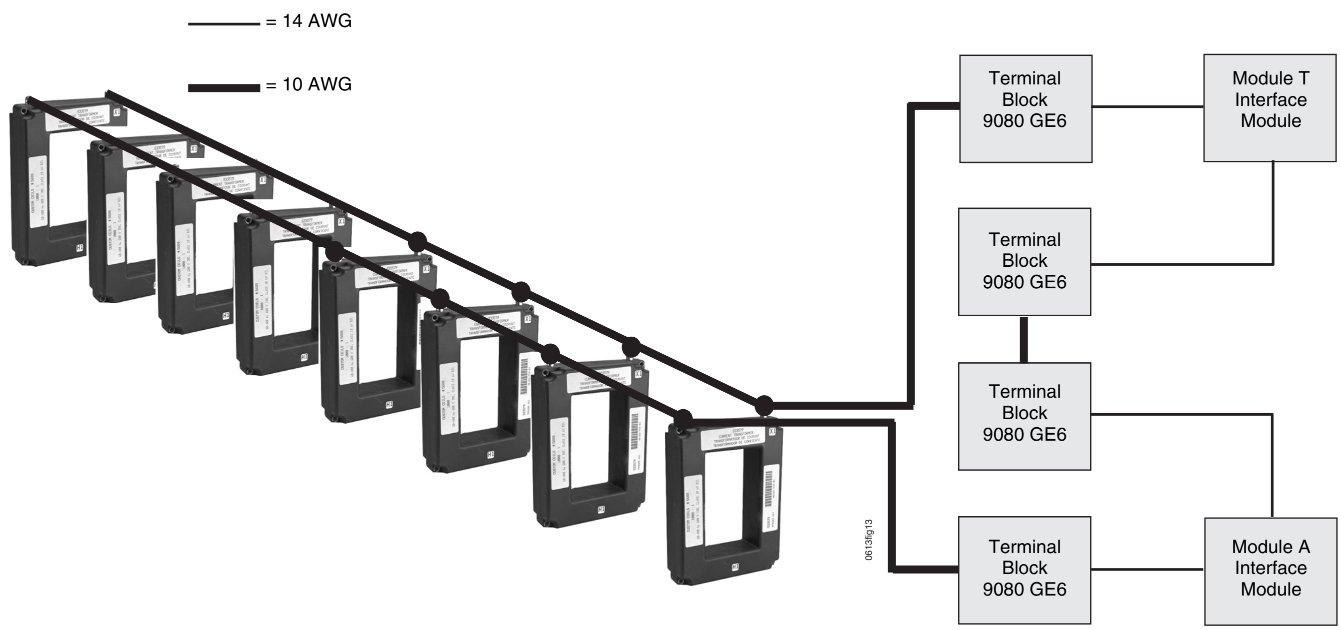
For this example, the following components have been chosen to meet the 0.668 ohm resistance requirement to minimize nuisance tripping.

- 285 ft. (86.9 m) of 12 AWG (3.31 mm^2) cable = 0.452 ohms[4]
- 4, DIN rail, screw-cage terminal blocks (Square D PN: 9080 GE6, Entrelec PN: 115120.17) = 1 mohm per terminal block. Total resistance of the terminal blocks: 4 terminal blocks X 1 mohm = 4 mohm
- 15 ft. (4.6 m) of 14 AWG (2.08 mm^2) stranded cable (used to connect between the terminal block to ground-fault interface module) = 0.379 ohms
- Resistance through ground-fault interface modules = Already taken into consideration

Total resistance = 0.452 + 0.004 + 0.0379 = 0.4939.

Figure 13: Wiring Diagram



Y-frame Circuit Breakers with Sensors 5000 A and 6000 A

Wide-construction Circuit Breakers (Masterpact NW 6-pole)

If there is deviation from the proper sensor positioning guidelines, in addition to controlling the total resistance in the interconnection wiring as shown in the example above, the 5000 A and 6000 A circuit breaker systems also require a minimum ground-fault pick-up setting (Ig = G) of 1040 A and (Ig = H) of 1120 A, respectively.

[4] 0.001588 ohms/ft. X 285 ft. (86.9 m) = 0.452 ohm

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