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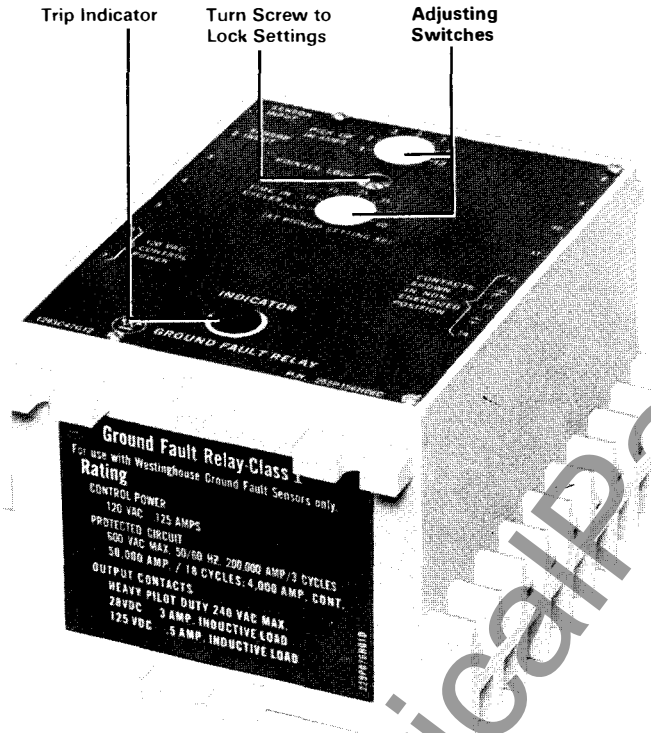
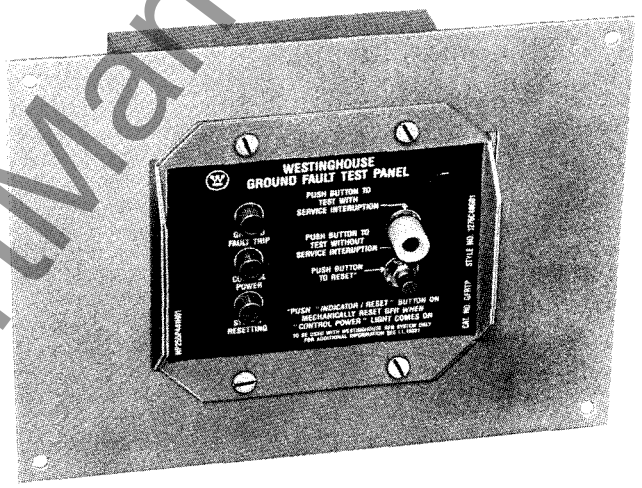
Type GFR Ground Fault Protection System

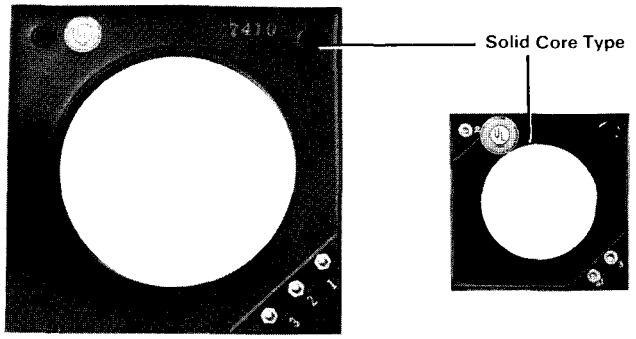


Ground Fault Relay



Test Panel

Removable Link Type



Typical Ground Fault Sensors

Description
A basic Type GFR ground fault protection system consists of a ground fault relay, a ground fault current sensor and a disconnect device equipped with a shunt trip device. This disconnect device can be a molded case circuit breaker, a power circuit breaker, a bolted pressure switch or other fusible disconnect device, suitable for application with UL Class I Ground Fault Sensing and Relaying equipment.

Type GFR ground fault relays, current sensors, test panels and accessory devices are listed by Underwriters' Laboratories, Inc. in accordance with their standard for Ground Fault Sensing and Relaying Equipment, UL 1053, under File E48381.

A Type GFR ground fault protection system, when properly installed on a grounded electrical system, will sense phase to ground fault currents. When the level of fault current is in excess of the pre-selected current pick-up and time delay settings, the GFR relay will initiate a trip action of a disconnect device, which will open the faulted circuit and clear the fault.

The GFR devices are UL Class I devices designed to protect electrical equipment against extensive damage from arcing ground faults.

Ground Fault Signal Memory
Arcing ground fault currents are, erratic in nature being caused by the intermittent striking and restriking of an arcing ground fault. To avoid the instantaneous resetting of the solid state timing circuitry every time the fault current drops to zero, Type GFR ground fault relays are equipped with a memory response, which integrates these intermittent faults with time using a seven second time constant.

Application

General
Type GFR ground fault protective devices are designed to be used primarily on solidly grounded electrical distribution systems rated up to a maximum of 600 volts, 50/60 Hz, to provide for rapid clearing of arcing ground faults.

When properly applied, these devices will satisfy the requirements for ground fault protection of service entrance equipment as outlined in Sections 230-95 and 517-14 of the National Electrical code. When these devices are added to downstream feeder and branch circuits as well as the main service disconnecting devices as suggested in 230-95 and to the downstream feeders as required in 517-14, additional protection will be provided.

There are two basic methods of achieving selective coordination between different levels of ground fault protective devices in a distribution system.

The first method employs adjustable time delay and current pick-up settings to achieve selectivity between upstream and downstream devices. When properly coordinated, downstream detection devices will use a time-current band setting that will initiate a downstream tripping operation and clear the faulted circuit before any upstream interrupting device tripping action can be initiated. This type of coordination necessarily requires the longest time delay settings to be placed on the upstream devices. This type of coordination is fine if the faults are always downstream.

The second method is zone selective interlocking in a system employing zone selective interlocking type devices, selective coordination is still achieved for downstream faults by the use of time-current band settings. With appropriate settings, downstream interrupting devices will clear the faulted circuit before any upstream device can operate. However, with zone selective interlocking, additional intelligence is automatically programmed into the time-current coordination scheme to allow for variations in the pre-established tripping sequence to allow for alternate locations of the arcing ground fault. A zone selective interlock coordinated system provides for fast tripping of the nearest interrupting device upstream of the arcing ground fault regardless of the pre-set time delay settings. With this type of protection, the resulting systems damage level is the lowest possible because the interrupting devices are allowed to clear the fault as quickly as they can respond.

Zone interlock wiring is only applicable to Type GFR relays equipped with zone selective interlocking. These relays are equipped with four additional terminals

To make the relays function in a zone interlocking mode, all relays must be of the interlocking type and additional wiring connections are required. Typical connections for a main with multiple feeders and multiple branch circuits is illustrated in Fig. 1.

As shown by Note 1 in Fig. 1, twisted pair wiring must be used for interlock wiring to reduce the influence of stray magnetic fields in switchboards with high ampacity bus systems. Interlock wiring must be routed away from bus bars and separate from concentrated control wire groupings.

Up to 50 – Type GFR relays may be wired in parallel to transmit a single signal to upstream device. No supplementary relaying is required for this function.

Regardless of the time delay setting, any interlocking Type GFR relay will respond near instantaneously unless a restraint signal – which is indicative of a ground fault further downstream in the next protective zone – acts to change the mode of operation to the preset time delay. On downstream circuits, it is frequently desired that a short time delay be observed before a tripping action is initiated. This can be accomplished by adding a jumper between terminals 9 and 10 on the downstream relay as indicated by Note 2 on Fig. 1. This jumper should not be used on any upstream relay as it will defeat the zone interlocking function.

Relay Settings
The exact individual relay time/current settings will vary between system installations depending upon the type of protection and level of selectivity desired. The Specifying Engineer can best make these decisions for any specific installation for general applications, settings as described in the following conditions may be considered.

Single Zone Level of Protection
Minimum Pick-up: 20% of disconnect rating. Increase to maximum pick-up setting (1200 Amp) where maximum service continuity is desired.

Minimum Time Delay: 10 cycles. Any faster time will invite nuisance trips. Increase time when more than minimum damage level can be tolerated.

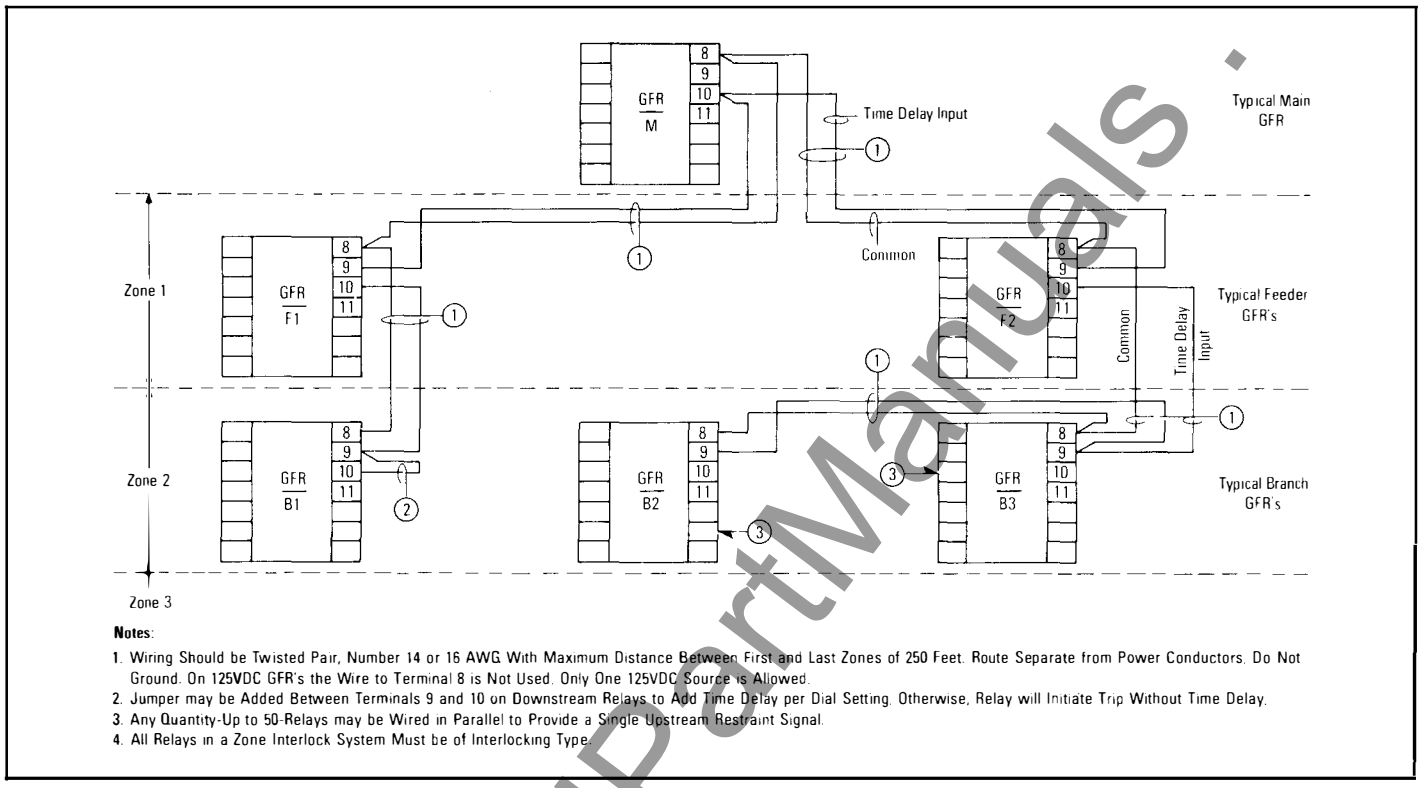
Multiple Zones of Protection Without Zone Interlocking
Minimum Pick-up: The pick-up setting of the downstream device should still be no less than 20% of the disconnect rating. Successive upstream settings should be at least one step greater than the nearest downstream device pick-up setting.

Minimum Time Delay: The shortest time possible should be used on the branch circuit downstream. Increase the time delay on upstream devices in increments of one step or more for molded case breakers and two steps or more for other slower operating type devices.

Multiple Zones of Protection With Zone Selective Interlocking
Establish time/current coordination for multiple zones with zone interlocking. This is done on the basis that most faults occur downstream and that the most downstream device should be set to clear the fault first leaving upstream devices for back-up fault protection.

Add zone interlocking to provide fast tripping of upstream devices regardless of pre-set time delay for faults in the upstream zones.

Where desired, nearly instantaneous operation of downstream devices can be defeated where time delayed operations are adequate.



Notes:

1. Wiring Should be Twisted Pair, Number 14 or 16 AWG With Maximum Distance Between First and Last Zones of 250 Feet. Route Separate from Power Conductors. Do Not Ground. On 125VDC GFR's the Wire to Terminal 8 is Not Used. Only One 125VDC Source is Allowed.
2. Jumper may be Added Between Terminals 9 and 10 on Downstream Relays to Add Time Delay per Dial Setting. Otherwise, Relay will Initiate Trip Without Time Delay.
3. Any Quantity-Up to 50-Relays may be Wired in Parallel to Provide a Single Upstream Restraint Signal.
4. All Relays in a Zone Interlock System Must be of Interlocking Type.

Fig. 1: Connection Diagram for Typical Zone Selective Interlocking System

Available Relay Types

The GFR ground fault relays are available in two basic types, ie., with and without zone selective interlocking. Each type relay must be reset following a trip operation. Each of the basic type relays is available with either an electrically held or mechanically latched output relay. The electrically held type must be electrically reset remotely – usually via a normally closed, momentary pushbutton in the control power circuit. In this type, a red lamp is provided for visual ground fault trip indication. The mechanically latched type must be manually reset by depressing the pushbutton on the face of the GFR relay. This manual reset button also serves as a mechanical pop-up trip indicator.

Table 1: GFR Relays

GFR Relay Types	Catalog Number		
	Pick-up Amperes		
	1-12	5-60	100-1200
120 Volt, 50/60 Hz Control			
Electric Reset with Zone Interlocking	GFR12EI	GFR60EI	GFR1200EI
Electrical Reset without Zone Interlocking	GFR12E	GFR60E	GFR1200E
Mechanical Reset with Zone Interlocking	GFR12MI	GFR60MI	GFR1200MI
Mechanical Reset without Zone Interlocking	GFR12M	GFR60M	GFR1200M
125 Volt DC Control			
Electric Reset with Zone Interlocking	GFR12EID	GFR60EID	GFR1200EID
Electrical Reset without Zone Interlocking	GFR12ED	GFR60ED	GFR1200ED
Mechanical Reset with Zone Interlocking	GFR12MID	GFR60MID	GFR1200MID
Mechanical Reset without Zone Interlocking	GFR12MD	GFR60MD	GFR1200MD

Setting Adjustments

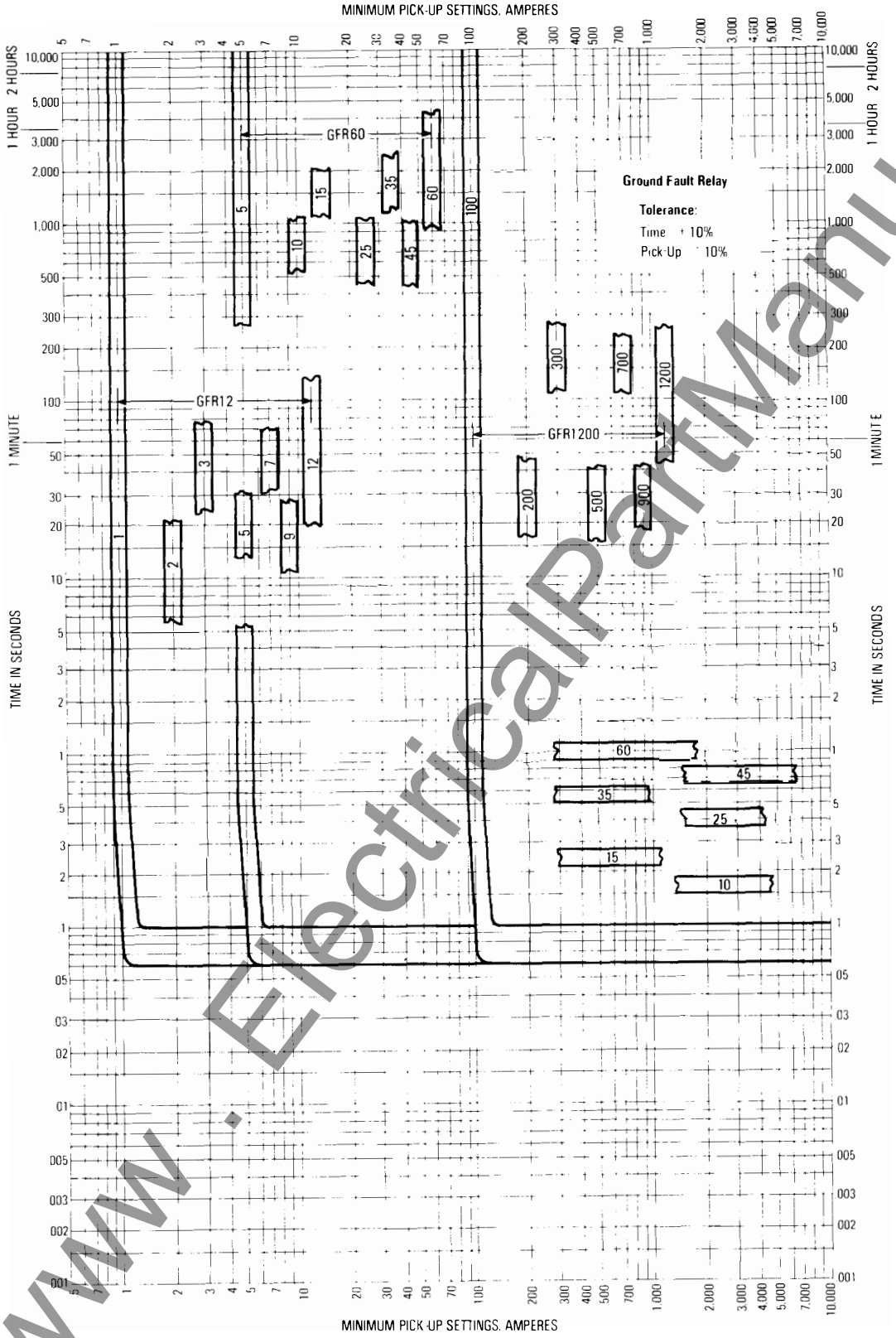
Each type relay is provided with two switches that are adjustable over the range selected. The top adjusting knob, adjusts the pick-up level of the ground fault current. The Bottom adjusting knob adjusts the time delay range. After the desired values have been pre-set, the adjusting knobs can be locked in position.

Table 2: Setting Adjustments

Pick-up Amperes	Dial Marking①						
1-12	1	2	3	5	7	9	12
5-60	5	10	15	25	35	45	60
100-1200	100	200	300	500	700	900	1200
Time Delay Cycles	1	10	15	25	35	45	60

① All adjustments are in discrete steps.

Fig. 2: GFR Relay Time-Current Curve



Relay Selection

General
The specific type and pick-up range of relay selected is a factor of its intended application, which the specifying engineer can best determine. In general, the ratings may be selected on the following general basis:

Type of Selectivity
Relays without zone interlocking are best suited for single level applications where it is desired to only satisfy the minimum requirements of the National Electrical Code. Zone selective interlocking type relays should be selected for multi-level system applications where only the minimum amount of system damage can be tolerated following an arcing ground fault.

Type of Operation
Electrically held relays will satisfy most applications where reliable control power is available following a fault interruption. Where control power is derived from the load side of the disconnect device and a visual trip indication is desired, the mechanically held relay should be selected. Also, in applications where the control power is less than reliable and where an automatic reset could affect interlocking circuitry, the mechanically held relay should be selected.

Time/Current Curves
The time/current performance curve of a Type GFR relay has a flat response, ie., the operating time of any given fault current above its pick-up setting is essentially constant. There is some small variation in the lower ranges, but very little. The pick-up and time delay tolerances, are ±10%.

Ground Fault Sensors
Ground Fault Current Sensors (GFS) are available in a variety of physical sizes and current ratings to match the application requirements of the distribution system. Sensors should be selected to match the ampere rating of the specified GFR relay. The physical size should be selected to properly encompass the required conductor configuration with space allowed for minimum clearances as shown in the applicable outline mounting figure.

Sensors are available with solid cores having round conductor openings, and in split core designs with various size rectangular openings. On the split core designs, one core leg is removable to permit ease of installation around existing conductor assemblies.

Ground Fault Current Sensors are special rated current transformers and must be applied only with Type GFR relays shown in Table 1. Sensors cannot be used with any other equipment.

Sensors are insulated with cast epoxy and can be mounted directly to enclosure surfaces. Ideally, they should be installed so that all conductors passing through the sensor opening are physically centered in the window opening. Minimum clearances are specified in the applicable outline, but greater clearances will help reduce any possible error signals. Rectangular configurations are provided with compensating windings to reduce potential error signals.

All sensors are provided with integral test winding for use under simulated ground fault test conditions. With an input of 1.2 amps into terminals 2-3, a rated output of 240 MA should be produced in terminals 1-3 with a tolerance of ±15%.

Electrical Ratings

Relay Electrical Ratings
Control Power Required:
120 Volts, 50/60 Hz., 0.125 Amps or
125 Volts, Dc, 0.125 Amps

Test Winding Power Required:
120 Volts, 50/60 Hz., 2.5 Amps

Output Contacts:
UL Heavy Duty Pilot Rating:
240 Volts, 50/60 Hz., 3.0 Amps Continuous, 30 Amps Inrush
120 Volts, 50/60 Hz., 6.0 Amps Continuous, 60 Amps Inrush
28 Volts, Dc, 3.0 Amps, Inductive Load
125 Volts, Dc, 0.5 Amps, Inductive Load

Zone Interlock, Contacts 8-9:
Output Voltage, 6 Volts Dc
Rated Amps, .01 Amps, Dc

Maximum Dielectric:
Terminals to mounting screw 3000 Volts

Sensor Electrical Ratings
Maximum System Voltage
600 V. @ 50/60 Hz.

Withstand:

Primary Amps	Time Seconds
200KA	0.05
50KA	0.3
4KA ①	Continuous

① Except 1 KA on 12 A. Solid Core Sensors

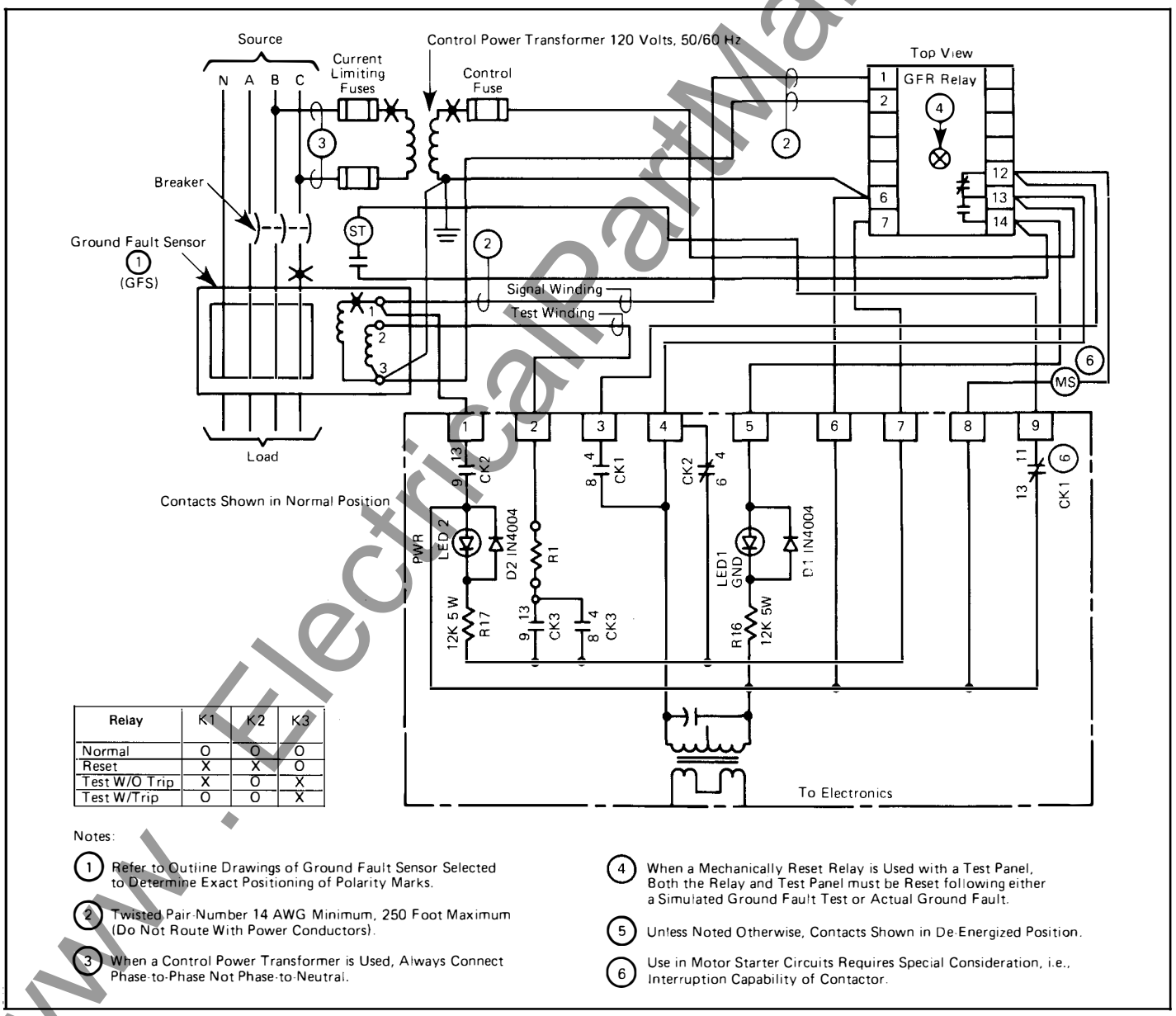
Dielectric Withstand:
Windings to Mounting Holes: 3KV
Windings to Inner Core Surface: 3KV
Mounting Surface to Inner Core Surface: 3KV

Maximum Error Signal With Bolted Phase Through Fault:
12 Amp Solid Core Sensors 1.0 A @ 144A
60 Amp Solid Core Sensors 5.0 A @ 720A
1200 Amp Solid Core Sensors 100 A @ 14.4KA
60/1200 Amp Split Core Sensors 100 A @ 15KA

Ground Fault Test Panel
The test panel is designed to test the ground fault circuitry in the Type GFR Ground Fault Relay along with its associated disconnect with a simulated, low-level test current from a location remote from the disconnect using a separate power source. Provisions are available to conduct a test in either of two operational modes: By opening the disconnect or by not opening the disconnect.

The test panel provides the easiest and most inexpensive method to conduct ground fault tests on a repeat basis. Tests can be conducted by qualified maintenance personnel during routine maintenance schedules.

The test panel is available only as a flush, cover mounted assembly under Cat. No. GFRTP or GFRTPD (for d-c control) as illustrated on page 1. It is provided with switches for initiating the desired test sequence, a red lamp to signify a ground fault trip operation, the availability of control power to the test panel, system reset and an instruction nameplate.



Relay	K1	K2	K3
Normal	O	O	O
Reset	X	X	O
Test W/O Trip	X	O	X
Test W/Trip	O	O	X

Notes:

1. Refer to Outline Drawings of Ground Fault Sensor Selected to Determine Exact Positioning of Polarity Marks.
2. Twisted Pair-Number 14 AWG Minimum, 250 Foot Maximum (Do Not Route With Power Conductors).
3. When a Control Power Transformer is Used, Always Connect Phase-to-Phase Not Phase-to-Neutral.
4. When a Mechanically Reset Relay is Used with a Test Panel, Both the Relay and Test Panel must be Reset following either a Simulated Ground Fault Test or Actual Ground Fault.
5. Unless Noted Otherwise, Contacts Shown in De-Energized Position.
6. Use in Motor Starter Circuits Requires Special Consideration, i.e., Interruption Capability of Contactor.

Fig. 3: Connection Diagram for 120 Volt, 50/60 Hz Ground Fault Relay used with Test Panel

Alternate Test Diagrams
Where desired, alternate test schemes can be utilized for periodic testing of the Type GFR relay and associated disconnect using a simulated ground fault test current. Two such test schemes are illustrated in Figures 4 and 5. Figure 4 illustrates the connections required for an electrically reset ground fault relay. Figure 5 is for a mechanically reset relay.

In each of the alternate test diagrams, the suggested test resistor rating is 50 ohms, 70 watts. Using a 120 Volt control power source, this will produce a test current of approximately 200% of the maximum pick-up setting of the GFR relay. Simulated field test methods should not be used as a calibration check of the relay. Functional testing only should suffice.

The National Electrical Code under Article 230-95-C requires that any ground-fault protection system be performance tested when first installed. The test shall be conducted in accordance with approved instructions provided with the equipment. A written record of this test shall be made and shall be available to the authority having inspection jurisdiction.

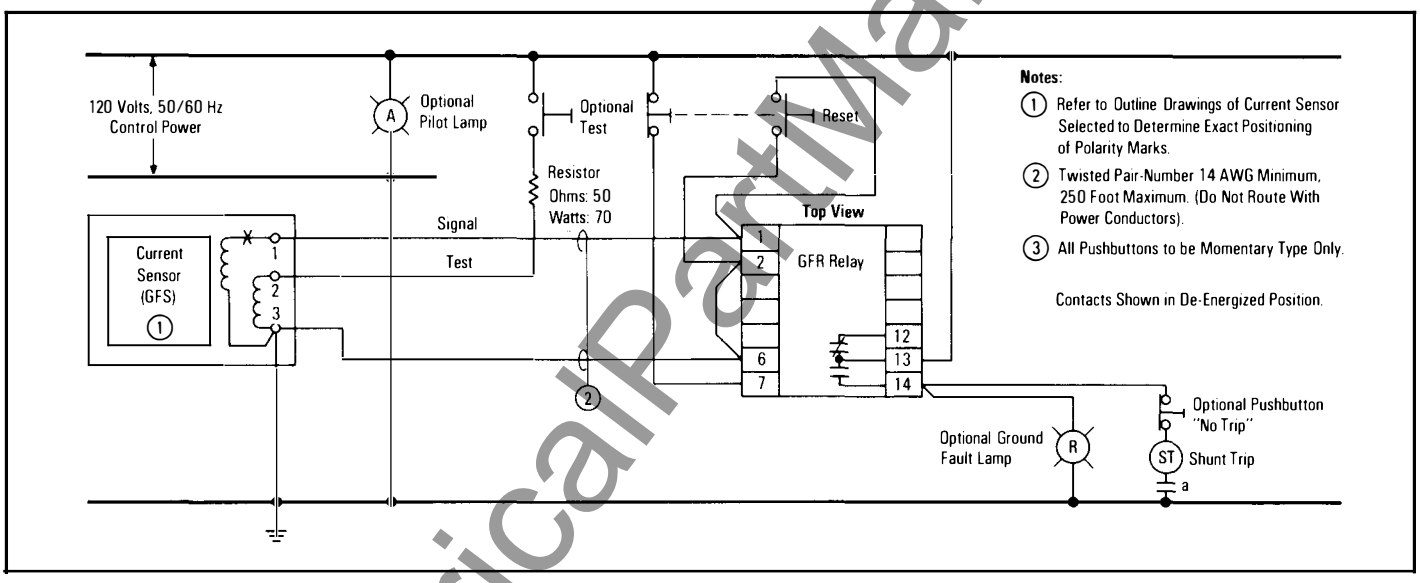


Fig. 4: Connection Diagram for Electrical Reset Ground Fault Relay With Separate Test and Reset Devices

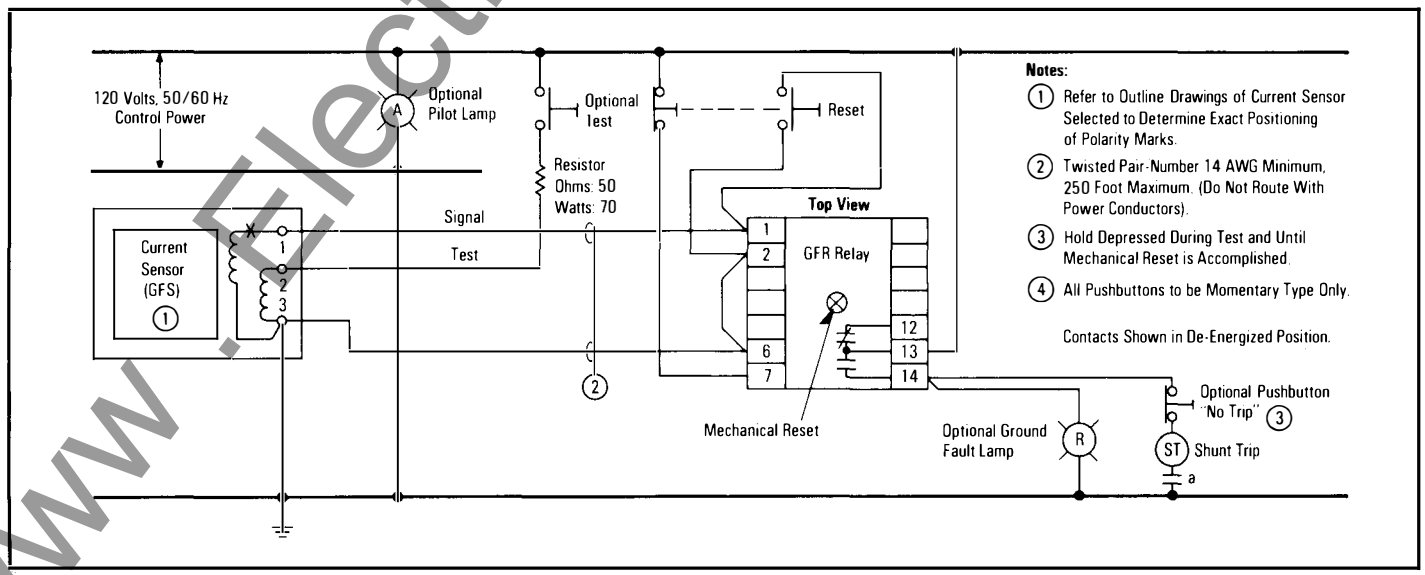


Fig. 5: Connection Diagram for Mechanical Reset Ground Fault Relay With Separate Test and Reset Devices

Ground Fault Warning Indicator Relay

This relay can be used to initiate a remote audio or visual warning of a low level ground fault condition. The non-adjustable relay is set to pick-up at 30-50% of the pick-up setting of the associated Type GFR relay. Thus, a warning of a slow progressing, high resistance type of arcing ground fault can be triggered prior to the circuit clearing actions initiated by the Type GFR relay. The relay requires a 120 volt, 60 Hz., control power source and must be used with a Type GFR relay equipped with zone selective interlocking.

The Warning Indicator Relay is a UL recognized component and available in two types. One type is self-reset following a diminished pick-up signal. The other type requires an electrical reset of control power normally accomplished by a pushbutton in the control power circuit.

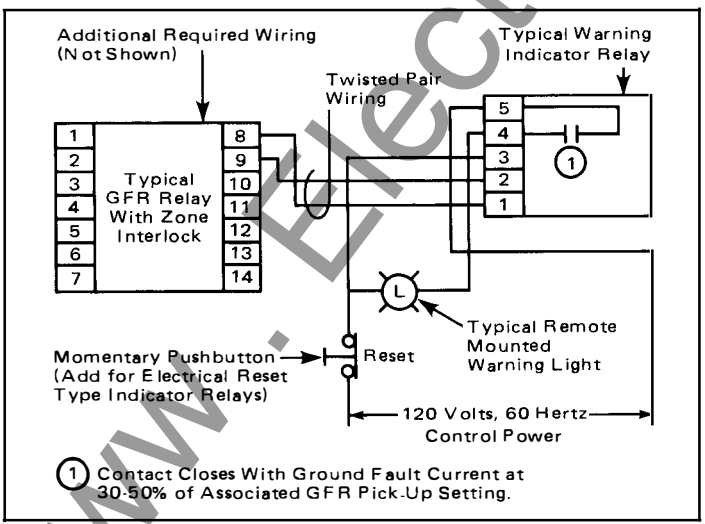
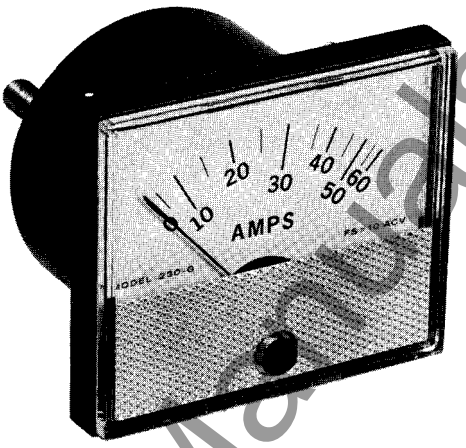


Fig. 6: Connection Diagram for Typical Panel Mounted Ground Fault Warning Indicator Relay

Ground Fault Indicating Ammeter



This ammeter, can be used to visually monitor the actual value of a low level ground current in the distribution circuit. The ammeter, suitable for semi-flush panel mounting, is available in three styles. The ammeter scale rating selected must agree with the maximum ampere rating of the ground fault sensor that it is applied with. The ammeter is used in connection with a momentary contact pushbutton.

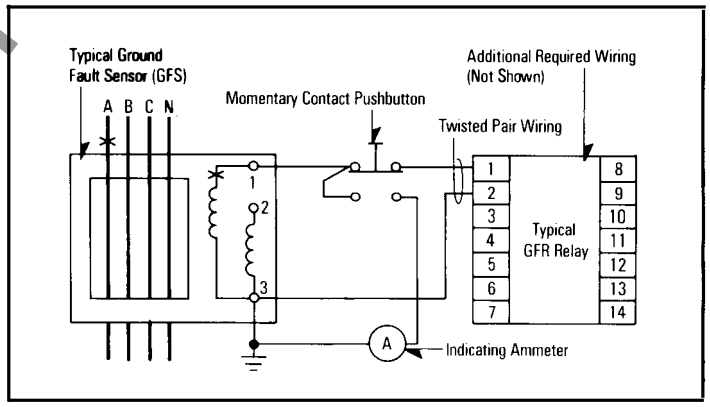


Fig. 7: Connection Diagram for Indicating Ammeter

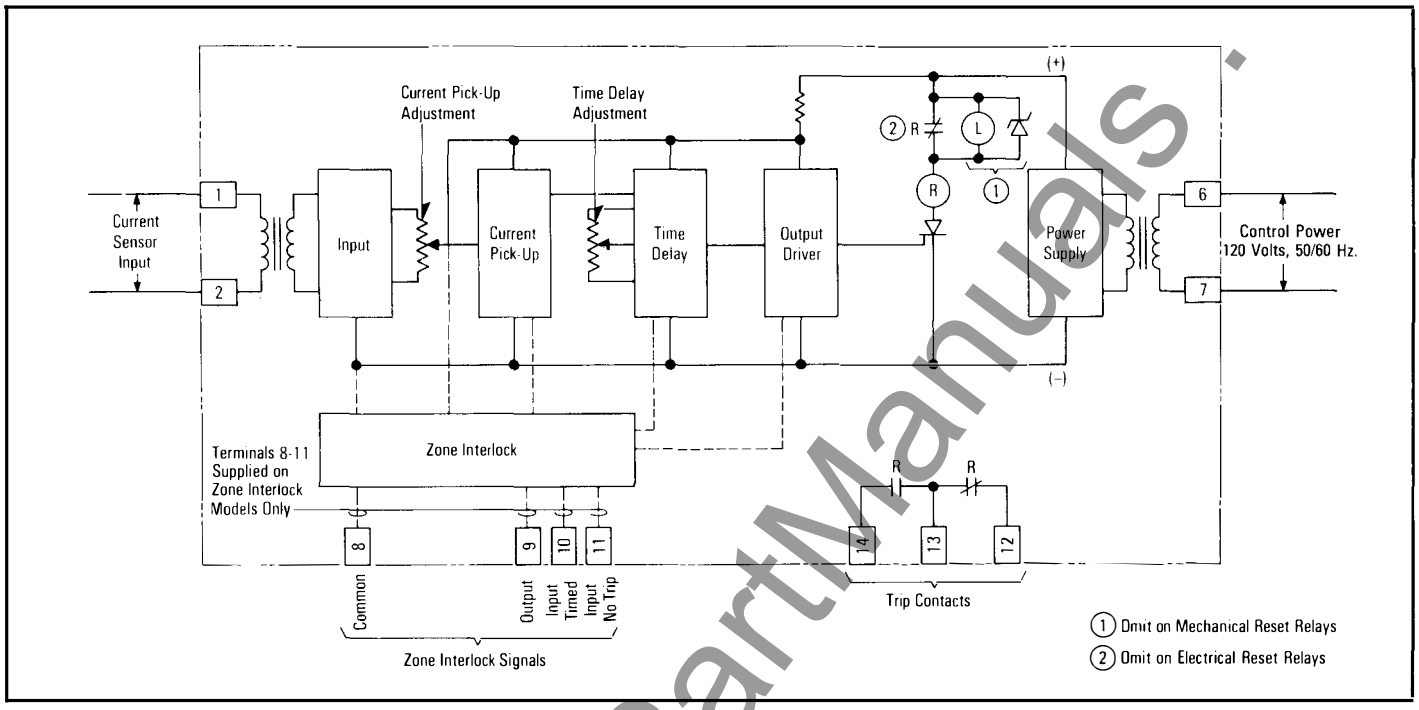


Fig. 8: Block Diagram for Typical GFR Ground Fault Relay

Typical System Diagrams
Basic, typical radial distribution system diagrams are provided for guidance; refer to Figs. 8A, 8B, 8C, 8D and 8E.

Two multiple source distribution systems are illustrated in Figs. 8F and 8H. Fig. 8F illustrates a dual source distribution system with center point grounding as allowed in the National Electrical Code under Artical 250-23a, Exception No. 4. Fig. 8H illustrates a multiple source, multiple ground distribution system with zone differential ground fault sensing methods employed.

Zone Differential GFP Operation Principles – See Fig. 8H
In general, GFR (M1) will operate only for ground faults within Zone 1, and GFR (M2) for Zone 2. This includes ground faults for feeders located in these respective zones.

With "M1" and "T" closed and "M2" open, and with a ground fault in Zone 2, GFR (M1) will not operate to trip "M1" but, GFR (M2) will operate to trip "T".

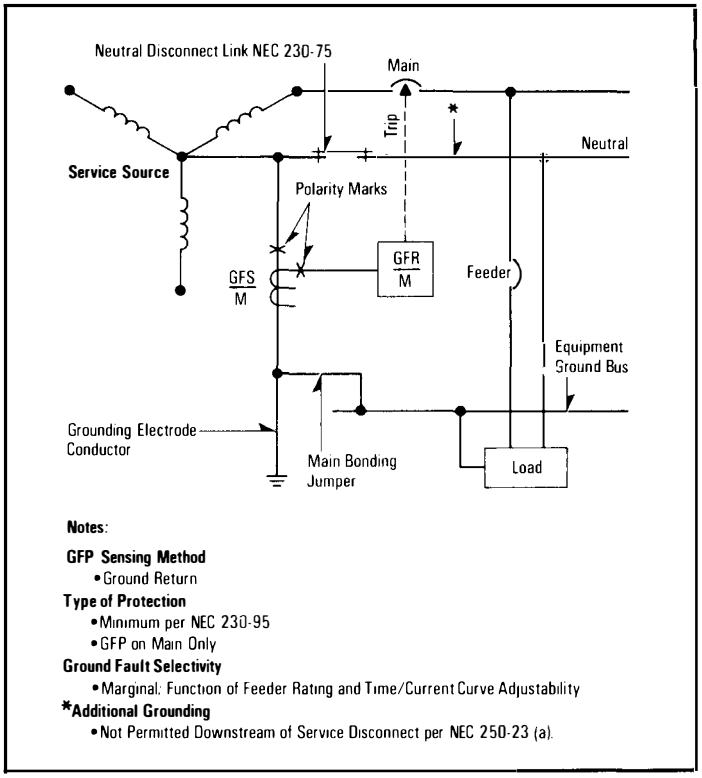


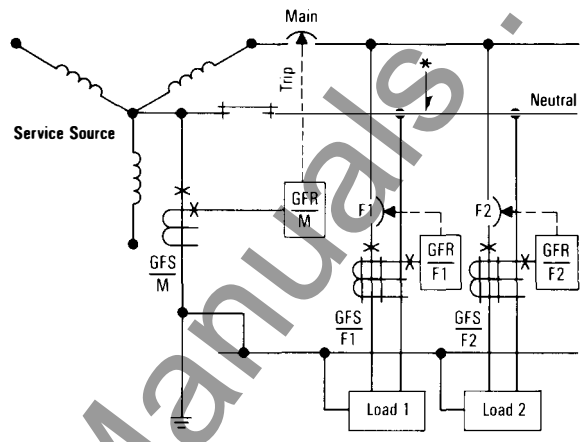
Fig. 8A: Simple Radial System With GFR on Main Only-Ground Return Sensing

Conversely, with "M2" and "T" closed and "M1" open, and with a ground fault in Zone 1, GFR (M1) will not operate to trip "M2" but GFR (M2) will operate to trip "T".

For properly co-ordinated main, tie and feeder interrupting devices, the feeder relays will always react to clear a downstream ground fault prior to operation of either the main or tie devices.

Zone interlock wiring between upstream and downstream devices can be included as shown. For this scheme, no cross interlocking with "T" auxiliary contacts is required.

This scheme may be expanded to additional alternate sources as long as interrupting devices are available to isolate any potential ground fault on each side of the fault.



Notes:

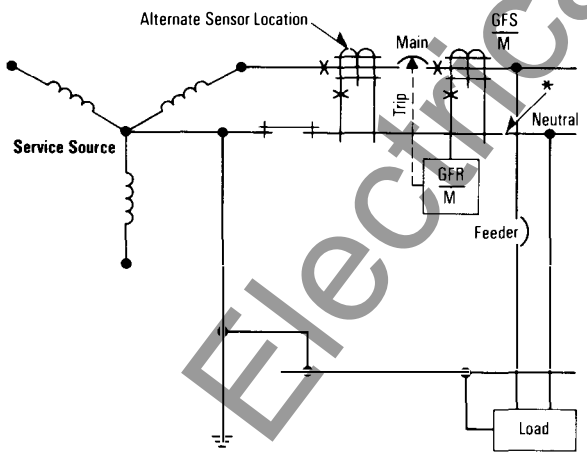
GFP Sensing Method
- Main-Ground Return
- Feeders-Zero Sequence

Type of Protection
- Two Level for Improved Service Continuity as Suggested by NEC 230-95 (b).

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders
- Feeder Trips Before Main for Downstream Faults

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a)

Fig. 8C: Simple Radial System With GFR on Main and Feeders-Ground Return Sensing on Main



Notes:

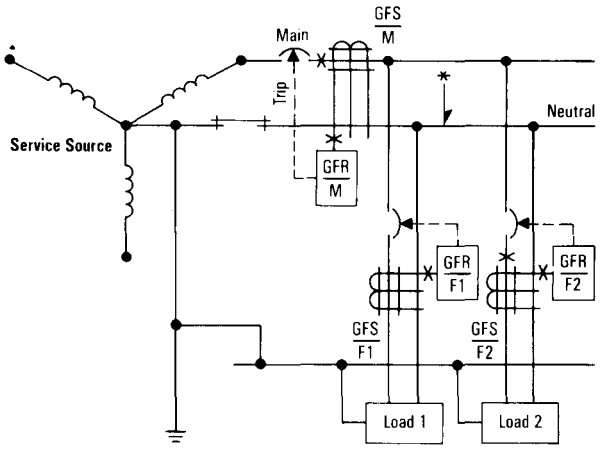
GFP Sensing Method
- Zero Sequence.

Type of Protection
- Minimum per NEC 230-95.
- GFP on Main Only.

Ground Fault Selectivity
- Marginal; Function of Feeder Time/Current Curve Adjustability.

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a).
- Must Not be on Downstream Side of Ground Fault Sensor.

Fig. 8B: Simple Radial System With GFR on Main Only-Zero Sequence Sensing



Notes:

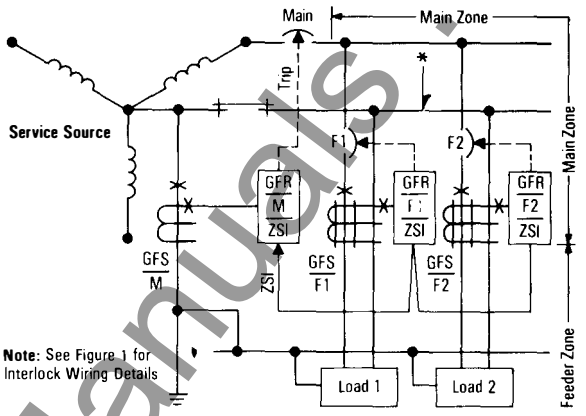
GFP Sensing Method
- Main and Feeders-Zero Sequence.

Type of Protection
- Two Level for Improved Service Continuity as Suggested by NEC 230-95 (b).

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders.
- Feeder Trips Before Main for Downstream Faults.

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a).
- Must Not be on Downstream Side of Ground Fault Sensor.

Fig. 8D: Simple Radial System With GFR on Main and Feeders-Zero Sequence Sensing on Main



Notes:

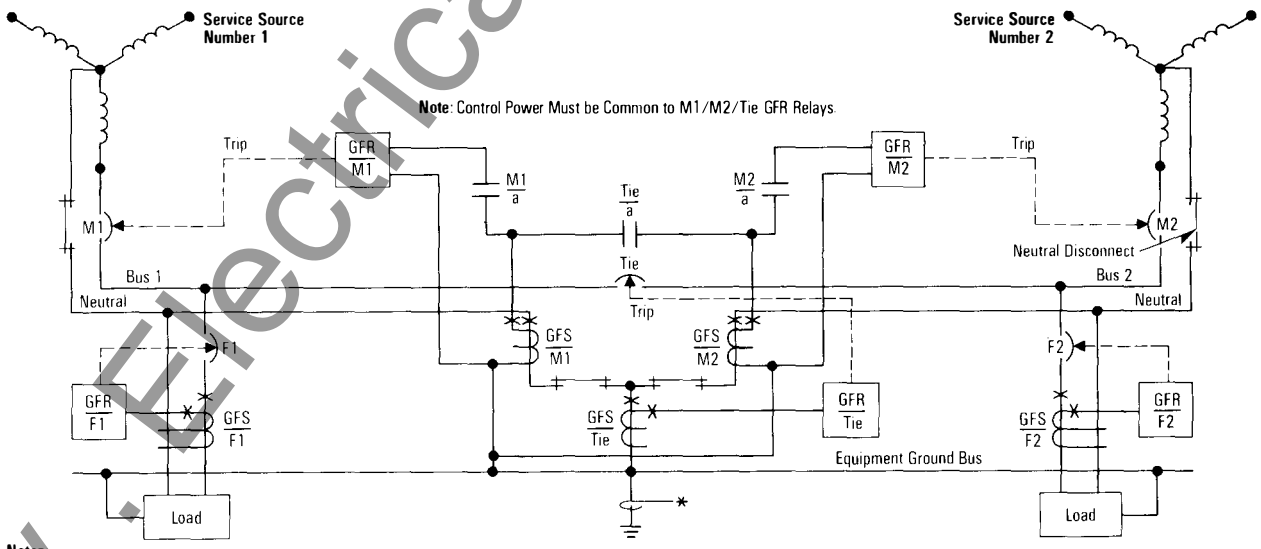
GFP Sensing Methods
- Main-Ground Return
- Feeders-Zero Sequence.

Type of Protection
- Two Level for Improved Service Continuity.
- Zone Selective Interlocking for Minimum Arcing Fault Damage

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders.
- Feeder Trips Before Main for Fault in Feeder Zone
- Main Trips Without Pre-set Time Delay for Fault in Main Zone

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a).

Fig. 8E: Simple Radial System With GFR on Main and Feeders-With Zone Selective Interlocking



Notes:

GFP Sensing Method
- Main-Ground Return With Polarities Arranged to Avoid Neutral Unbalance
- Tie-Ground Return
- Feeders-Zero Sequence

Type of Protection
- Multiple Level for Improved Service Continuity
- Zone Selective Interlocking May be Added for Minimum Arcing Fault Damage. (See Figure 8G).

Ground Fault Selectivity
- Time/Current Coordination Between Main, Tie and Feeders
- Feeder Trips Before Main or Tie for Downstream Faults
- Tie Trips Before Main to Sectionalize Main Bus

***Additional Grounding**
- Any Additional Grounding Points Must be Avoided

Fig. 8F: Dual Source System Using Center Point Grounding (NEC 250-23A, Exception No. 4)

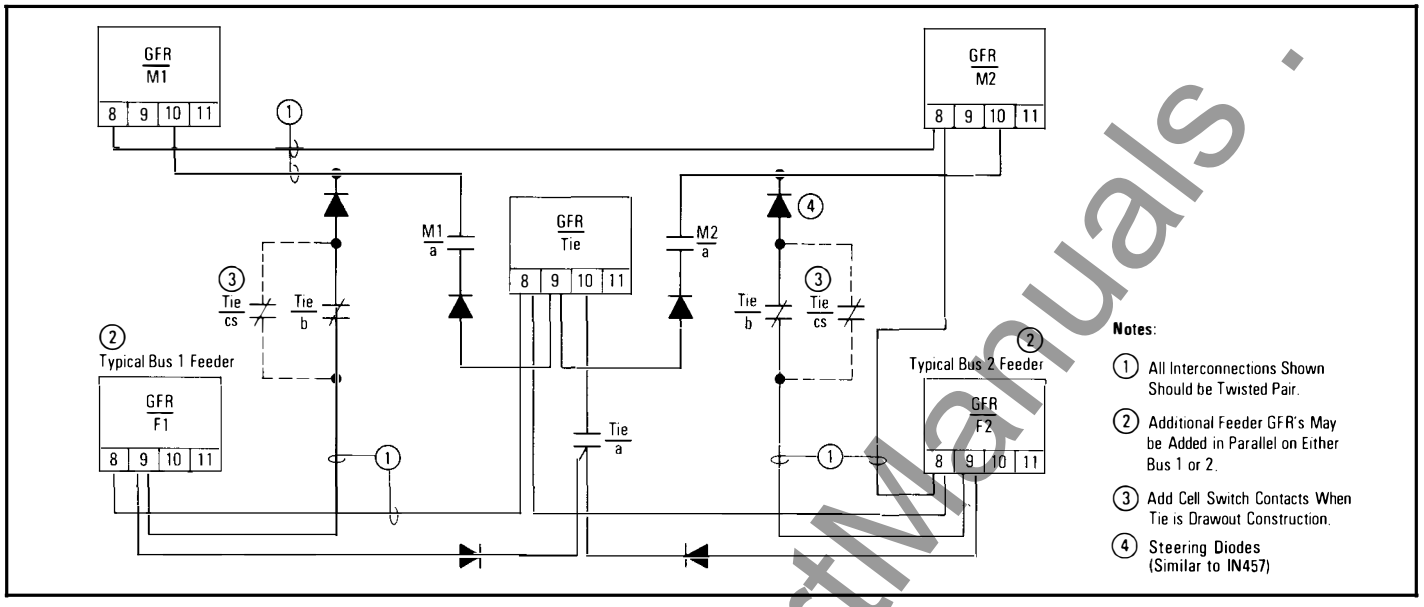


Fig. 8G: Special Zone Interlocking Wiring that May Be Used With Dual Source System Using Center Point Grounding (See Fig. 8F)

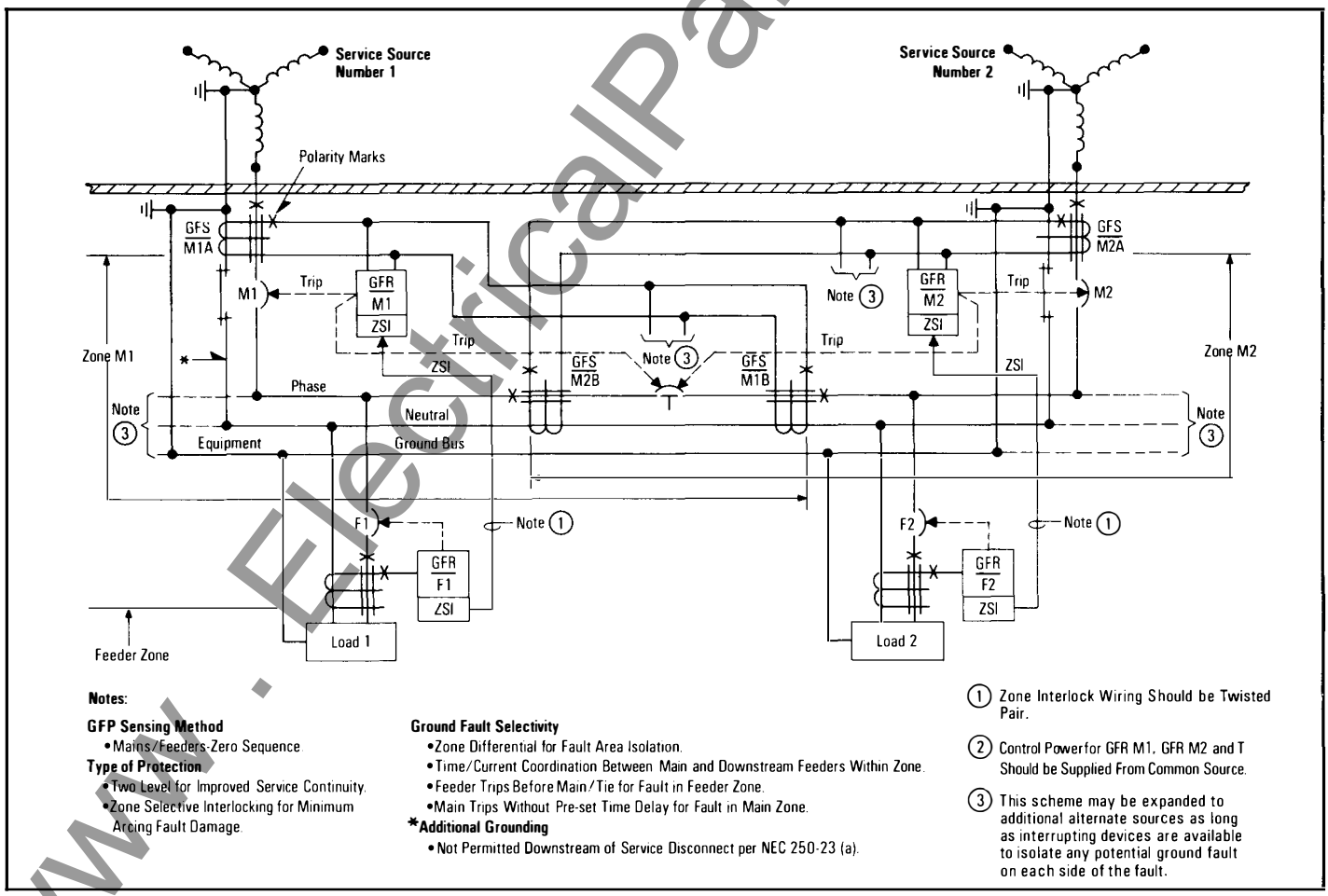


Fig. 8H: Multiple Source, Multiple Grounded System Using Zone Differential Sensing

Westinghouse Electric Corporation
Distribution and Control Business Unit
Electrical Components Division
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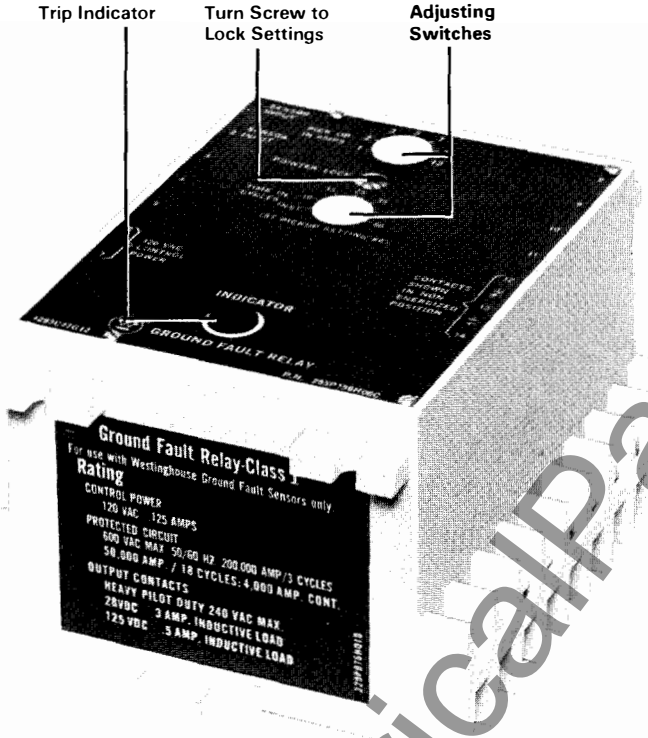
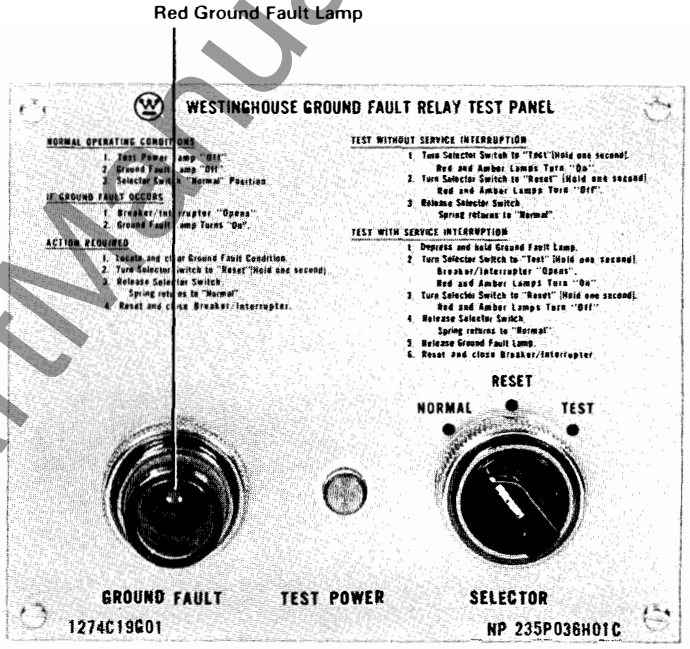
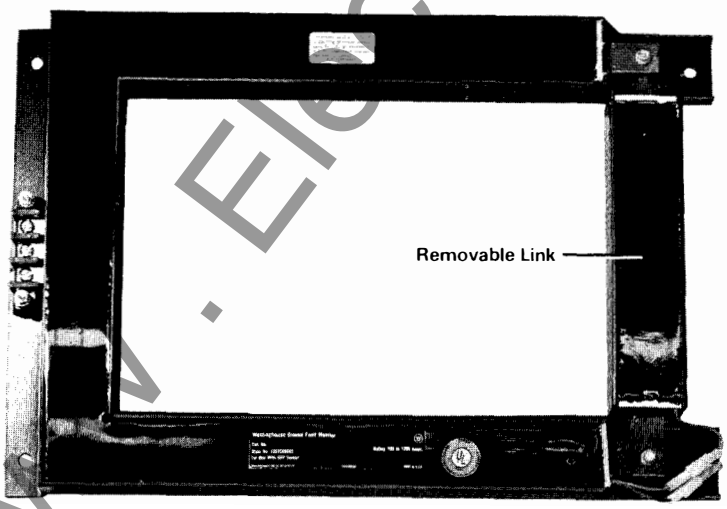
Type GFR Ground Fault Protection System



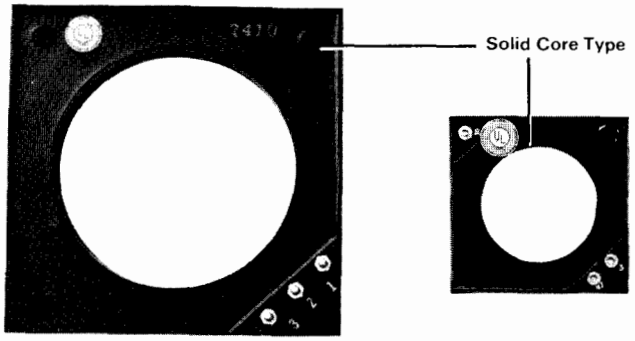
Ground Fault Relay



Test Panel



Removable Link Type



Typical Ground Fault Sensors

Description
A basic Type GFR ground fault protection system consists of a ground fault relay, a ground fault current sensor and a disconnect device equipped with a shunt trip device. This disconnect device can be a molded case circuit breaker, a power circuit breaker, a bolted pressure switch or other fusible disconnect device, suitable for application with UL Class I Ground Fault Sensing and Relaying equipment.

Type GFR ground fault relays, current sensors, test panels and accessory devices are listed by Underwriters' Laboratories, Inc. in accordance with their standard for Ground Fault Sensing and Relaying Equipment, UL 1053, under File E48381.

A Type GFR ground fault protection system, when properly installed on a grounded electrical system, will sense phase to ground fault currents. When the level of fault current is in excess of the pre-selected current pick-up and time delay settings, the GFR relay will initiate a trip action of a disconnect device, which will open the faulted circuit and clear the fault.

The GFR devices are UL Class I devices designed to protect electrical equipment against extensive damage from arcing ground faults.

Ground Fault Signal Memory
Arcing ground fault currents are, erratic in nature being caused by the intermittent striking and restriking of an arcing ground fault. To avoid the instantaneous resetting of the solid state timing circuitry every time the fault current drops to zero, Type GFR ground fault relays are equipped with a memory response, which integrates these intermittent faults with time using a seven second time constant.

Application

General
Type GFR ground fault protective devices are designed to be used primarily on solidly grounded electrical distribution systems rated up to a maximum of 600 volts, 50/60 Hz, to provide for rapid clearing of arcing ground faults.

When properly applied, these devices will satisfy the requirements for ground fault protection of service entrance equipment as outlined in Sections 230-95 and 517-14 of the National Electrical code. When these devices are added to downstream feeder and branch circuits as well as the main service disconnecting devices as suggested in 230-95 and to the downstream feeders as required in 517-14, additional protection will be provided.

There are two basic methods of achieving selective coordination between different levels of ground fault protective devices in a distribution system.

The first method employs adjustable time delay and current pick-up settings to achieve selectivity between upstream and downstream devices. When properly coordinated, downstream detection devices will use a time-current band setting that will initiate a downstream tripping operation and clear the faulted circuit before any upstream interrupting device tripping action can be initiated. This type of coordination necessarily requires the longest time delay settings to be placed on the upstream devices. This type of coordination is fine if the faults are always downstream.

The second method is zone selective interlocking in a system employing zone selective interlocking type devices, selective coordination is still achieved for downstream faults by the use of time-current band settings. With appropriate settings, downstream interrupting devices will clear the faulted circuit before any upstream device can operate. However, with zone selective interlocking, additional intelligence is automatically programmed into the time-current coordination scheme to allow for variations in the pre-established tripping sequence to allow for alternate locations of the arcing ground fault. A zone selective interlock coordinated system provides for fast tripping of the nearest interrupting device upstream of the arcing ground fault regardless of the pre-set time delay settings. With this type of protection, the resulting systems damage level is the lowest possible because the interrupting devices are allowed to clear the fault as quickly as they can respond.

Zone interlock wiring is only applicable to Type GFR relays equipped with zone selective interlocking. These relays are equipped with four additional terminals

To make the relays function in a zone interlocking mode, all relays must be of the interlocking type and additional wiring connections are required. Typical connections for a main with multiple feeders and multiple branch circuits is illustrated in Fig. 1.

As shown by Note 1 in Fig. 1, twisted pair wiring must be used for interlock wiring to reduce the influence of stray magnetic fields in switchboards with high ampacity bus systems. Interlock wiring must be routed away from bus bars and separate from concentrated control wire groupings.

Up to 50 – Type GFR relays may be wired in parallel to transmit a single signal to upstream device. No supplementary relaying is required for this function.

Regardless of the time delay setting, any interlocking Type GFR relay will respond near instantaneously unless a restraint signal – which is indicative of a ground fault further downstream in the next protective zone – acts to change the mode of operation to the preset time delay. On downstream circuits, it is frequently desired that a short time delay be observed before a tripping action is initiated. This can be accomplished by adding a jumper between terminals 9 and 10 on the downstream relay as indicated by Note 2 on Fig. 1. This jumper should not be used on any upstream relay as it will defeat the zone interlocking function.

Relay Settings
The exact individual relay time/current settings will vary between system installations depending upon the type of protection and level of selectivity desired. The Specifying Engineer can best make these decisions for any specific installation for general applications, settings as described in the following conditions may be considered.

Single Zone Level of Protection
Minimum Pick-up: 20% of disconnect rating. Increase to maximum pick-up setting (1200 Amp) where maximum service continuity is desired.

Minimum Time Delay: 10 cycles. Any faster time will invite nuisance trips. Increase time when more than minimum damage level can be tolerated.

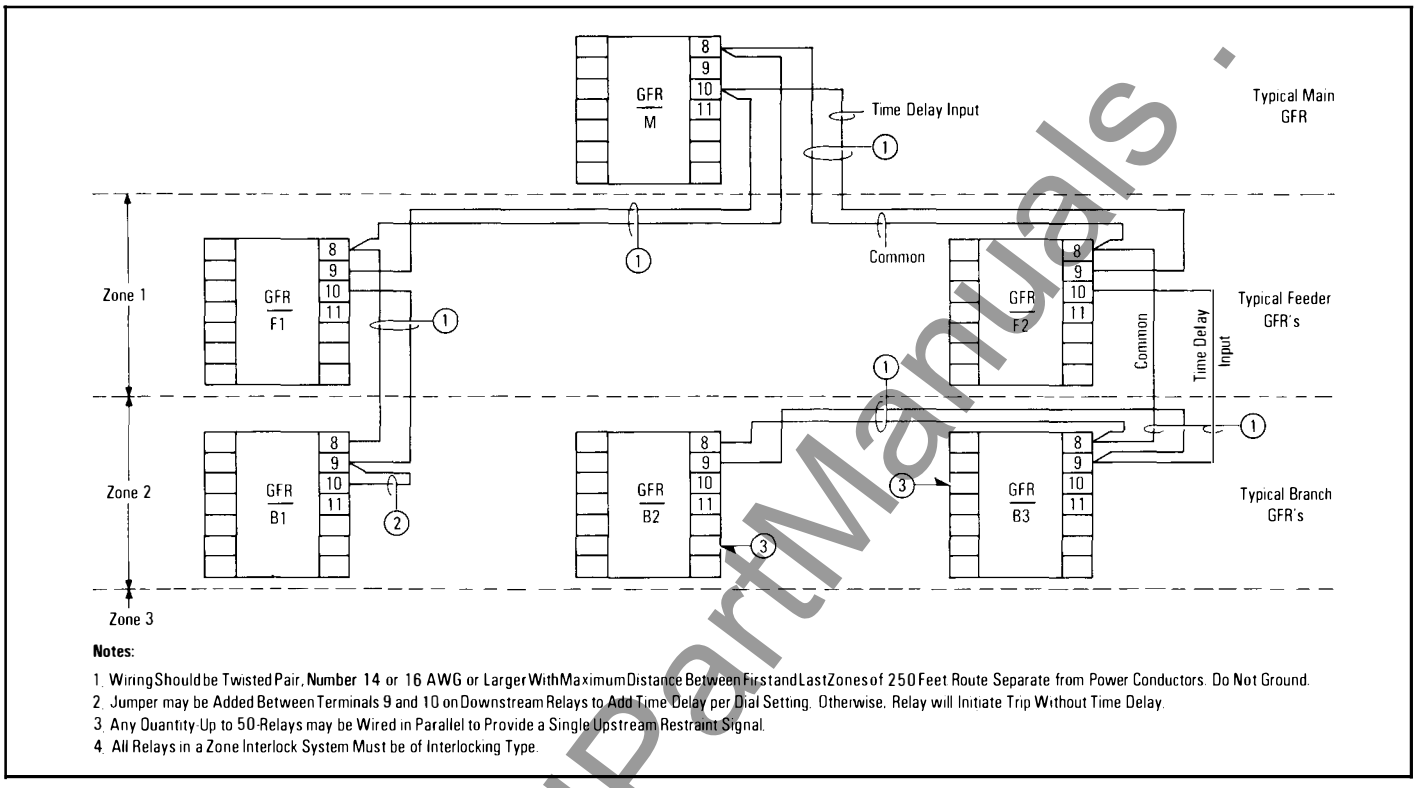
Multiple Zones of Protection Without Zone Interlocking
Minimum Pick-up: The pick-up setting of the downstream device should still be no less than 20% of the disconnect rating. Successive upstream settings should be approximately 200% greater than the nearest downstream device pick-up setting.

Minimum Time Delay: The shortest time possible should be used on the branch circuit downstream. Increase the time delay on upstream devices in increments of 10 cycles for molded case breakers and 20 cycles for other slower operating type devices.

Multiple Zones of Protection With Zone Selective Interlocking
Establish time/current coordination for multiple zones with zone interlocking. This is done on the basis that most faults occur downstream and that the most downstream device should be set to clear the fault first leaving upstream devices for back-up fault protection.

Add zone interlocking to provide fast tripping of upstream devices regardless of pre-set time delay for faults in the upstream zones.

Where desired, nearly instantaneous operation of downstream devices can be defeated where time delayed operations are adequate.



Notes:

1. Wiring Should be Twisted Pair, Number 14 or 16 AWG or Larger With Maximum Distance Between First and Last Zones of 250 Feet Route Separate from Power Conductors. Do Not Ground.
2. Jumper may be Added Between Terminals 9 and 10 on Downstream Relays to Add Time Delay per Dial Setting. Otherwise, Relay will Initiate Trip Without Time Delay.
3. Any Quantity Up to 50 Relays may be Wired in Parallel to Provide a Single Upstream Restraint Signal.
4. All Relays in a Zone Interlock System Must be of Interlocking Type.

Fig. 1: Connection Diagram for Typical Zone Selective Interlocking System

Available Relay Types

The GFR ground fault relays are available in two basic types, ie., with and without zone selective interlocking. Each type relay must be reset following a trip operation. Each of the basic type relays is available with either an electrically held or mechanically latched output relay. The electrically held type must be electrically reset remotely – usually via a normally closed, momentary pushbutton in the control power circuit. In this type, a red lamp is provided for visual ground fault trip indication. The mechanically latched type must be manually reset by depressing the pushbutton on the face of the GFR relay. This manual reset button also serves as a mechanical pop-up trip indicator.

Table 1: GFR Relays

GFR Relay Types	Catalog Number		
	Pick-up Amperes		
	1-12	5-60	100-1200
Electric Reset with Zone Interlocking	GFR12EI	GFR60EI	GFR1200EI
Electrical Reset without Zone Interlocking	GFR12E	GFR60E	GFR1200E
Mechanical Reset with Zone Interlocking	GFR12MI	GFR60MI	GFR1200MI
Mechanical Reset without Zone Interlocking	GFR12M	GFR60M	GFR1200M

Setting Adjustments

Each type relay is provided with two switches that are adjustable over the range selected. The top adjusting knob, adjusts the pick-up level of the ground fault current. The Bottom adjusting knob adjusts the time delay range. After the desired values have been pre-set, the adjusting knobs can be locked in position.

Table 2: Setting Adjustments

Pick-up Amperes	Dial Marking①						
1-12	1	2	3	5	7	9	12
5-60	5	10	15	25	35	45	60
100-1200	100	200	300	500	700	900	1200
Time Delay Cycles	1	10	15	25	35	45	60

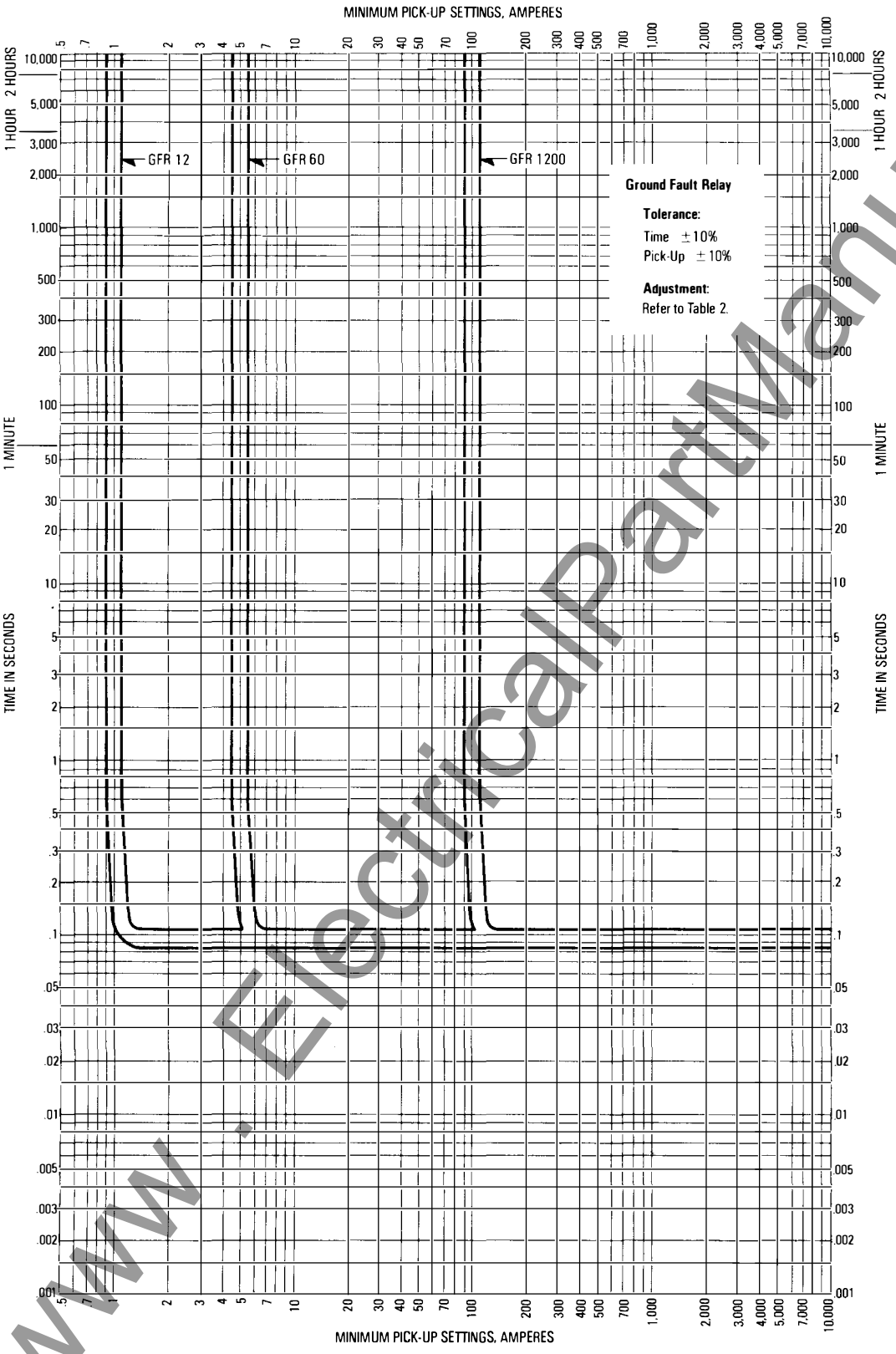
① All adjustments are in discrete steps.

Relay Selection

General

The specific type and pick-up range of relay selected is a factor of its intended application, which the specifying engineer can best determine. In general, the ratings may be selected on the following general basis:

Fig. 2: GFR Relay Time-Current Curve



Type of Selectivity
Relays without zone interlocking are best suited for single level applications where it is desired to only satisfy the minimum requirements of the National Electrical Code. Zone selective interlocking type relays should be selected for multi-level system applications where only the minimum amount of system damage can be tolerated following an arcing ground fault.

Type of Operation
Electrically held relays will satisfy most applications where reliable control power is available following a fault interruption. Where control power is derived from the load side of the disconnect device and a visual trip indication is desired, the mechanically held relay should be selected. Also, in applications where the control power is less than reliable and where an automatic reset could affect interlocking circuitry, the mechanically held relay should be selected.

Time/Current Curves
The time/current performance curve of a Type GFR relay has a flat response, ie., the operating time of any given fault current above its pick-up setting is essentially constant. There is some small variation in the lower ranges, but very little. The pick-up and time delay tolerances, are ±10%.

Ground Fault Sensors
Ground Fault Current Sensors (GFS) are available in a variety of physical sizes and current ratings to match the application requirements of the distribution system. Sensors should be selected to match the ampere rating of the specified GFR relay. The physical size should be selected to properly encompass the required conductor configuration with space allowed for minimum clearances as shown in the applicable outline mounting figure.

Sensors are available with solid cores having round conductor openings, and in split core designs with various size rectangular openings. On the split core designs, one core leg is removable to permit ease of installation around existing conductor assemblies.

Ground Fault Current Sensors are special rated current transformers and must be applied only with Type GFR relays shown in Table 1. Sensors cannot be used with any other equipment.

Sensors are insulated with cast epoxy and can be mounted directly to enclosure surfaces. Ideally, they should be installed so that all conductors passing through the sensor opening are physically centered in the window opening. Minimum clearances are specified in the applicable outline, but greater clearances will help reduce any possible error signals. Rectangular configurations are provided with compensating windings to reduce potential error signals.

All sensors are provided with integral test winding for use under simulated ground fault test conditions. With an input of 1.2 amps into terminals 2-3, a rated output of 240 MA should be produced in terminals 1-3 with a tolerance of ±15%.

Electrical Ratings

Relay Electrical Ratings
Control Power Required:
120 Volts, 50/60 Hz., 0.125 Amps

Output Contacts:
UL Heavy Duty Pilot Rating:
240 Volts, 50/60 Hz., 3.0 Amps Continuous
120 Volts, 50/60 Hz., 6.0 Amps Continuous
28 Volts, Dc, 3.0 Amps, Inductive Load
125 Volts, Dc, 0.5 Amps, Inductive Load

Zone Interlock, Contacts 8-9:
Output Voltage, 6 Volts Dc
Rated Amps, .01 Amps, Dc

Maximum Dielectric:
Terminals to mounting screw 3000 Volts

Sensor Electrical Ratings
Maximum System Voltage
600 V. @ 50/60 Hz.

Withstand:

Primary Amps	Time Seconds
200KA	0.05
50KA	0.3
4KA①	Continuous

● Except 1 KA on 12 A. Solid Core Sensors

Dielectric Withstand:
Windings to Mounting Holes: 3KV
Windings to Inner Core Surface: 3KV
Mounting Surface to Inner Core Surface: 3KV

Maximum Error Signal With Bolted Phase Through Fault:
12 Amp Solid Core Sensors 1.0 A @ 144A
60 Amp Solid Core Sensors 5.0 A @ 720A
1200 Amp Solid Core Sensors 100 A @ 14.4KA
60/1200 Amp Split Core Sensors 100 A @ 15KA

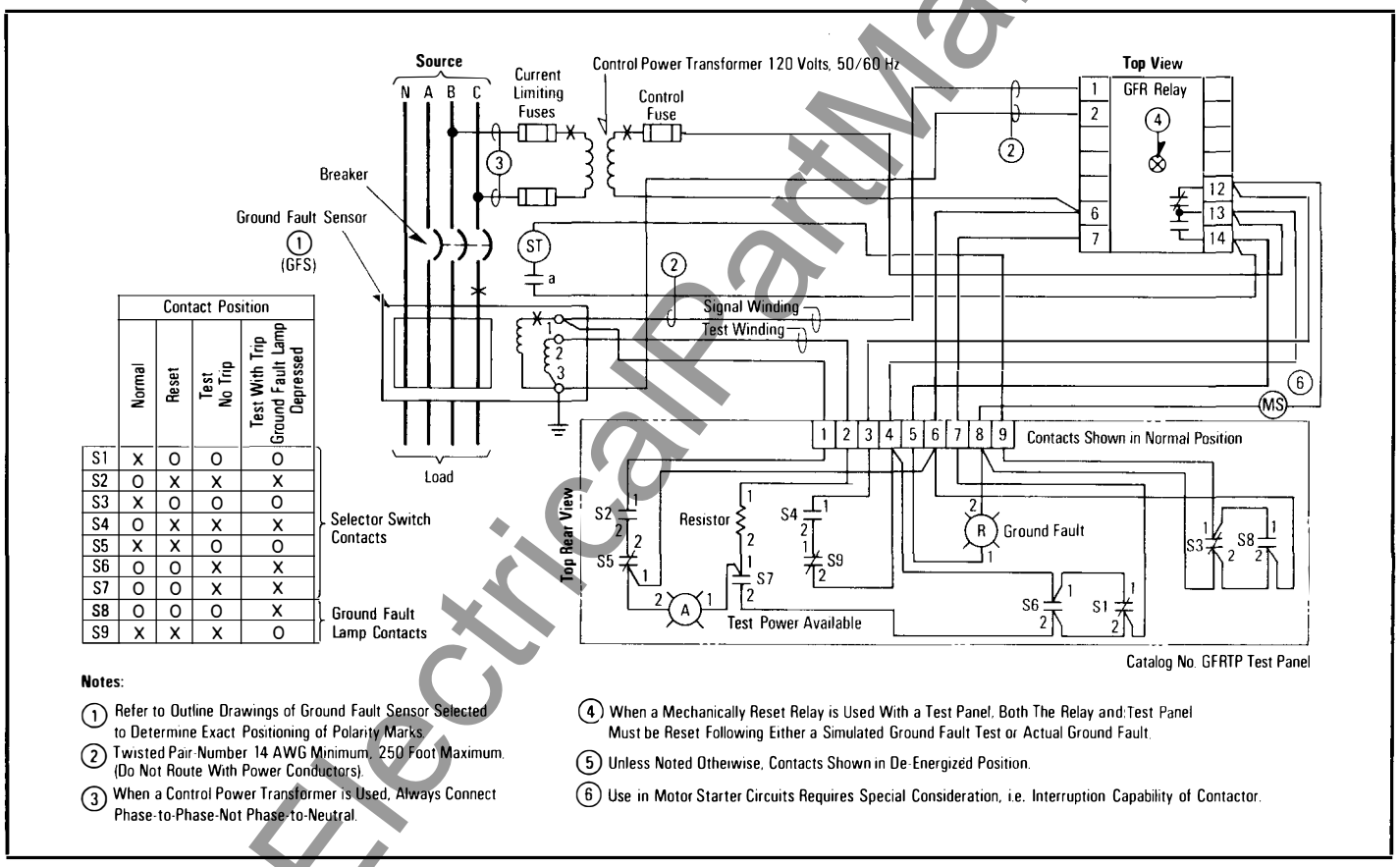
Ground Fault Test Panel

The test panel is designed to test the ground fault circuitry in the Type GFR Ground Fault Relay along with its associated disconnect with a simulated, low-level test current from a location remote from the disconnect using a separate power source. Provisions are available to conduct a test in either of two operational modes: By opening the disconnect or by not opening the disconnect.

The test panel provides the easiest and most inexpensive method to conduct ground fault tests on a repeat basis. Tests can be conducted by qualified maintenance personnel during routine maintenance schedules.

The test panel is available only as a semi-flush, cover mounted assembly under Cat. No. GFR TP as illustrated on page 1. It is provided with a selector switch for initiating the desired test sequence, a red lamp to signify a ground fault trip operation, an amber light to indicate the availability of test power to the test panel, and an instruction nameplate.

The assembly requires a 120 Volt, 50/60 Hz. Control power source for operation. The total maximum burden on the test panel is 300 VA.



Contact Position	Normal	Reset	Test No Trip	Test With Trip Ground Fault Lamp Depressed	
S1	X	O	O	O	Selector Switch Contacts
S2	O	X	X	X	
S3	X	O	O	O	
S4	O	X	X	X	
S5	X	X	O	O	
S6	O	O	X	X	
S7	O	O	X	X	
S8	O	O	O	X	Ground Fault Lamp Contacts
S9	X	X	X	O	

Notes:

1. Refer to Outline Drawings of Ground Fault Sensor Selected to Determine Exact Positioning of Polarity Marks.
2. Twisted Pair-Number 14 AWG Minimum, 250 Foot Maximum. (Do Not Route With Power Conductors).
3. When a Control Power Transformer is Used, Always Connect Phase-to-Phase-Not Phase-to-Neutral.
4. When a Mechanically Reset Relay is Used With a Test Panel, Both The Relay and Test Panel Must be Reset Following Either a Simulated Ground Fault Test or Actual Ground Fault.
5. Unless Noted Otherwise, Contacts Shown in De-Energized Position.
6. Use in Motor Starter Circuits Requires Special Consideration, i.e. Interruption Capability of Contactor.

Fig. 3: Connection Diagram for Ground Fault Relay Used With Test Panel

Alternate Test Diagrams
Where desired, alternate test schemes can be utilized for periodic testing of the Type GFR relay and associated disconnect using a simulated ground fault test current. Two such test schemes are illustrated in Figures 4 and 5. Figure 4 illustrates the connections required for an electrically reset ground fault relay. Figure 5 is for a mechanically reset relay.

In each of the alternate test diagrams, the suggested test resistor rating is 50 ohms, 70 watts. Using a 120 Volt control power source, this will produce a test current of approximately 200% of the maximum pick-up setting of the GFR relay. Simulated field test methods should not be used as a calibration check of the relay. Functional testing only should suffice.

The National Electrical Code under Article 230-95-C requires that any ground-fault protection system be performance tested when first installed. The test shall be conducted in accordance with approved instructions provided with the equipment. A written record of this test shall be made and shall be available to the authority having inspection jurisdiction.

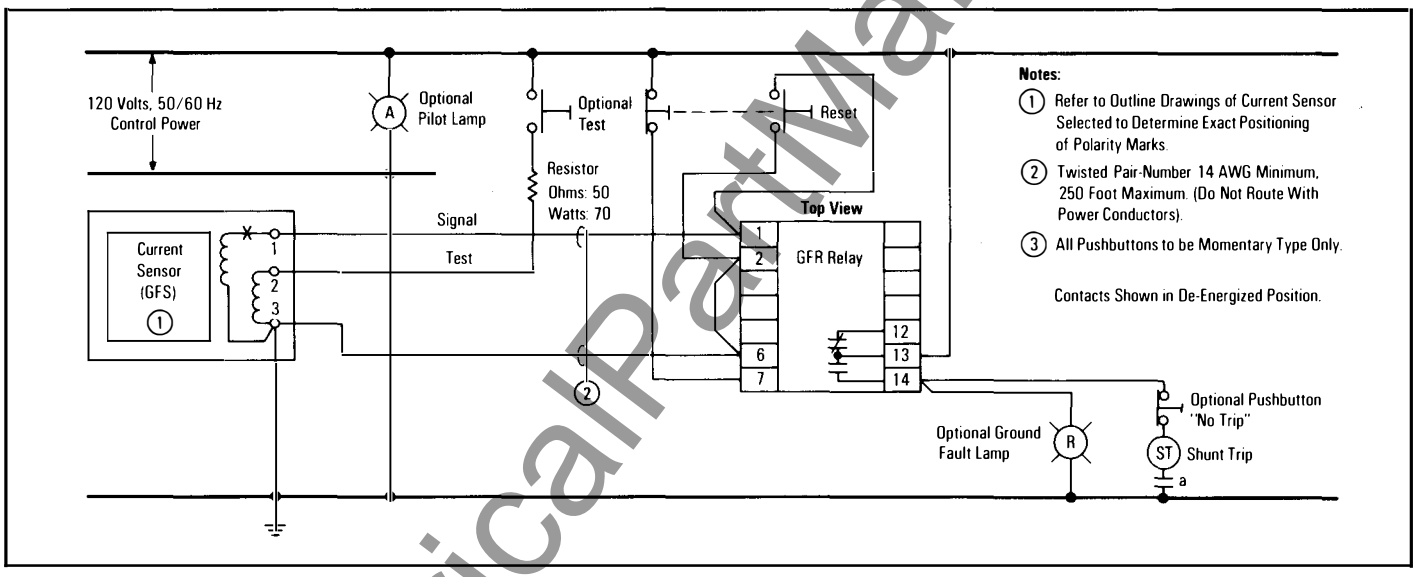


Fig. 4: Connection Diagram for Electrical Reset Ground Fault Relay With Separate Test and Reset Devices

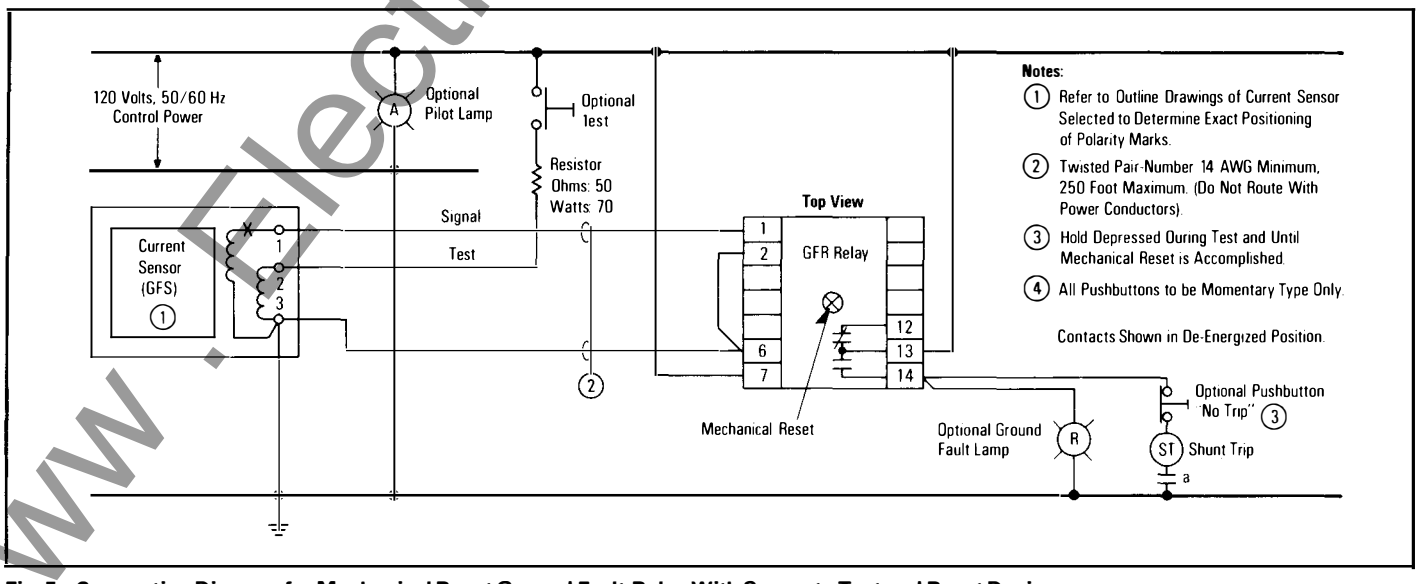


Fig. 5: Connection Diagram for Mechanical Reset Ground Fault Relay With Separate Test and Reset Devices

Ground Fault Warning Indicator Relay

This relay can be used to initiate a remote audio or visual warning of a low level ground fault condition. The non-adjustable relay is set to pick-up at 30-50% of the pick-up setting of the associated Type GFR relay. Thus, a warning of a slow progressing, high resistance type of arcing ground fault can be triggered prior to the circuit clearing actions initiated by the Type GFR relay. The relay requires a 120 volt, 60 Hz., control power source and must be used with a Type GFR relay equipped with zone selective interlocking.

The Warning Indicator Relay is UL listed and available in two types. One type is self-reset following a diminished pick-up signal. The other type requires an electrical reset of control power normally accomplished by a pushbutton in the control power circuit.

① The amber light turns "On" only during a test sequence.

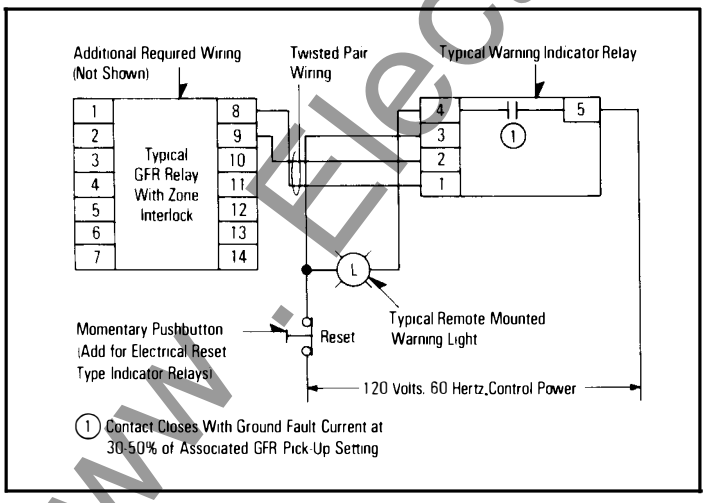
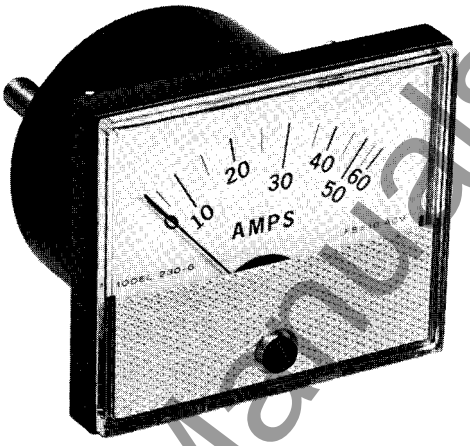


Fig. 6: Connection Diagram for Typical Panel Mounted Ground Fault Warning Indicator Relay

Ground Fault Indicating Ammeter ①



This ammeter, can be used to visually monitor the actual value of a low level ground current in the distribution circuit. The ammeter, suitable for semi-flush panel mounting, is available in three styles. The ammeter scale rating selected must agree with the maximum ampere rating of the ground fault sensor that it is applied with. The ammeter is used in connection with a momentary contact pushbutton.

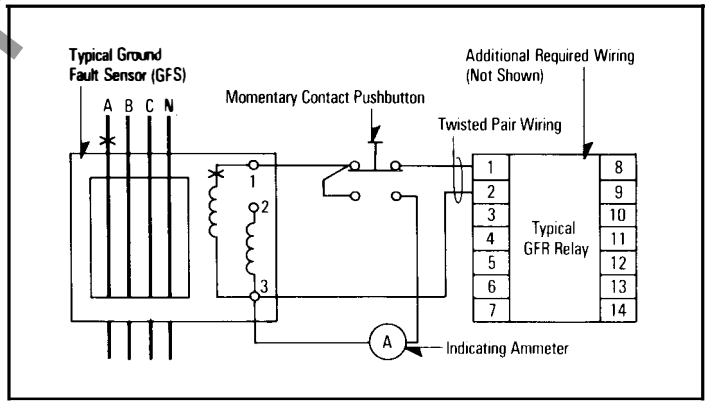


Fig. 7: Connection Diagram for Indicating Ammeter

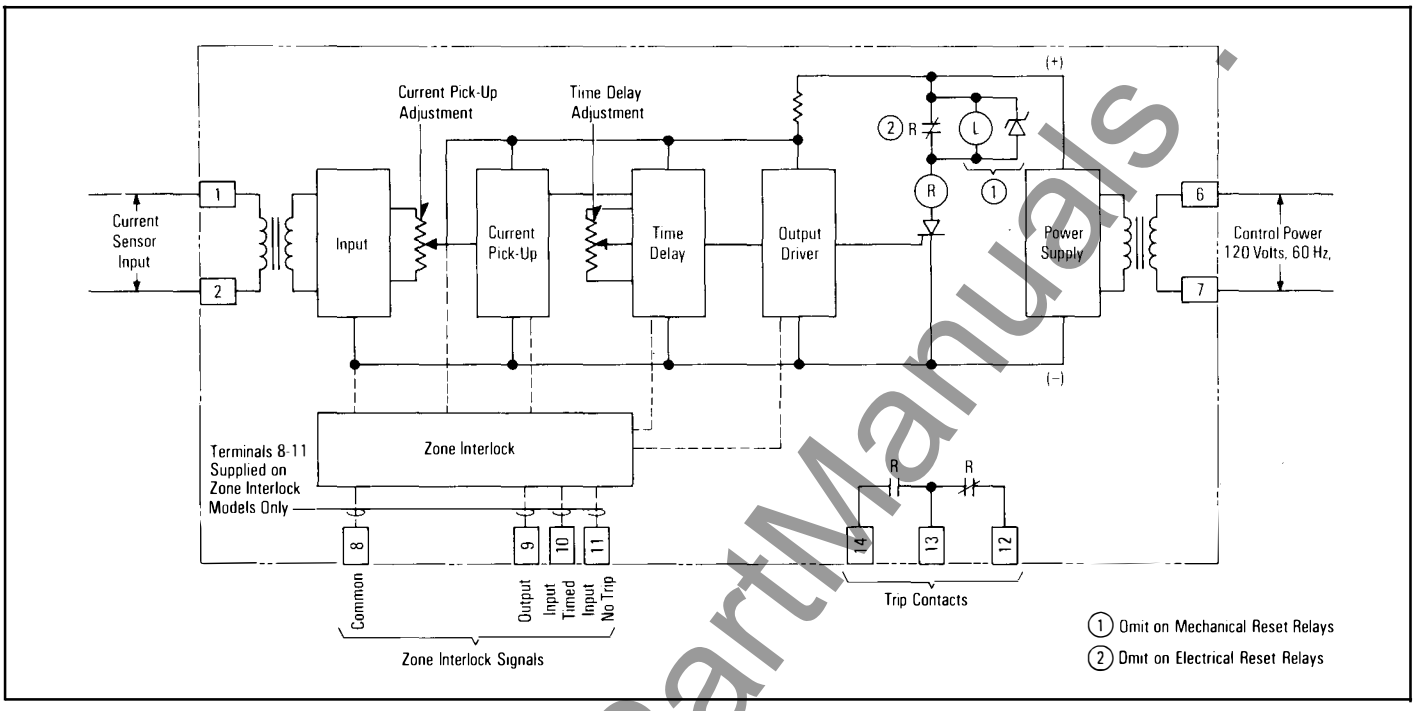


Fig. 8: Block Diagram for Typical GFR Ground Fault Relay

Typical System Diagrams
Basic, typical radial distribution system diagrams are provided for guidance; refer to Figs. 8A, 8B, 8C, 8D and 8E.

Two multiple source distribution systems are illustrated in Figs. 8F and 8H. Fig. 8F illustrates a dual source distribution system with center point grounding as allowed in the National Electrical Code under Artical 250-23a, Exception No. 4. Fig. 8H illustrates a multiple source, multiple ground distribution system with zone differential ground fault sensing methods employed.

Zone Differential GFP Operation Principles – See Fig. 8H
In general, GFR (M1) will operate only for ground faults within Zone 1, and GFR (M2) for Zone 2. This includes ground faults for feeders located in these respective zones.

With "M1" and "T" closed and "M2" open, and with a ground fault in Zone 2, GFR (M1) will not operate to trip "M1" but, GFR (M2) will operate to trip "T".

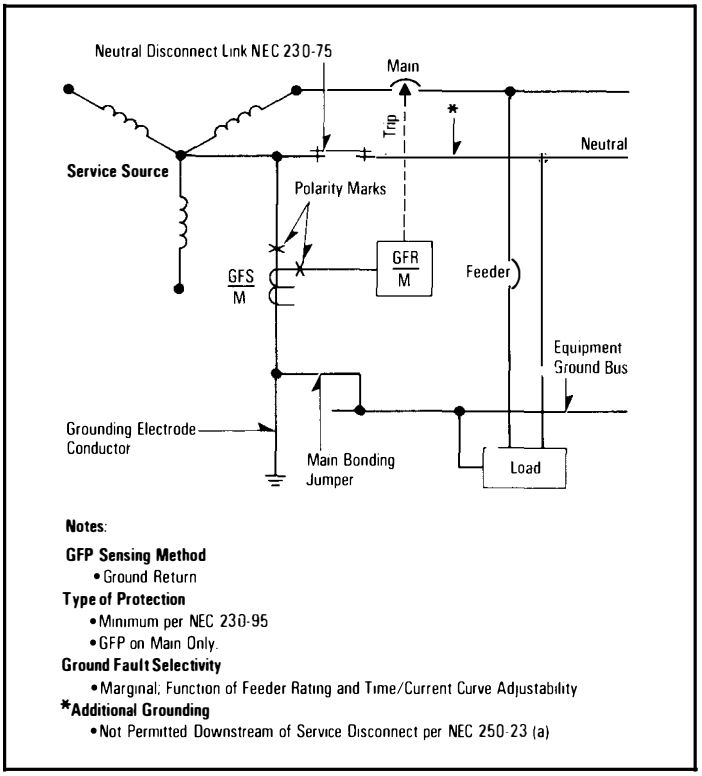


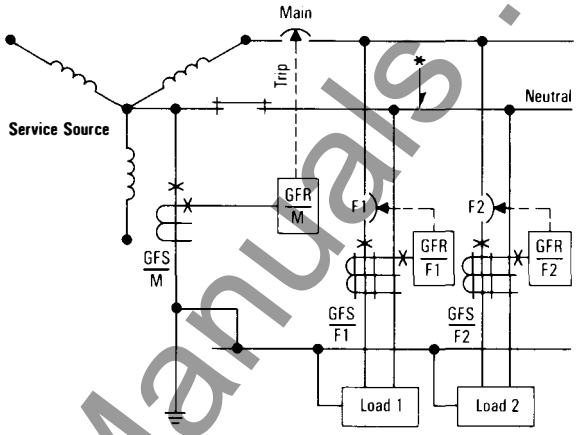
Fig. 8A: Simple Radial System With GFR on Main Only-Ground Return Sensing

Conversely, with "M2" and "T" closed and "M1" open, and with a ground fault in Zone 1, GFR (M1) will not operate to trip "M2" but GFR (M2) will operate to trip "T".

For properly co-ordinated main, tie and feeder interrupting devices, the feeder relays will always react to clear a downstream ground fault prior to operation of either the main or tie devices.

Zone interlock wiring between upstream and downstream devices can be included as shown. For this scheme, no cross interlocking with "T" auxiliary contacts is required.

This scheme may be expanded to additional alternate sources as long as interrupting devices are available to isolate any potential ground fault on each side of the fault.



Notes:

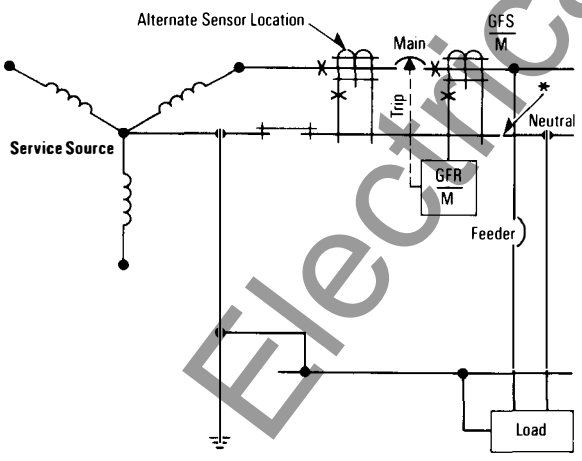
GFP Sensing Method
- Main-Ground Return
- Feeders-Zero Sequence

Type of Protection
- Two Level for Improved Service Continuity as Suggested by NEC 230-95 (b)

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders
- Feeder Trips Before Main for Downstream Faults

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a)

Fig. 8C: Simple Radial System With GFR on Main and Feeders-Ground Return Sensing on Main



Notes:

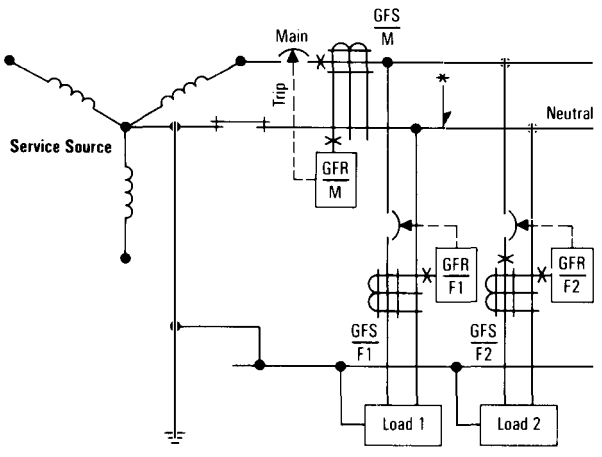
GFP Sensing Method
- Zero Sequence

Type of Protection
- Minimum per NEC 230-95.
- GFP on Main Only.

Ground Fault Selectivity
- Marginal; Function of Feeder Time/Current Curve Adjustability.

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a).
- Must Not be on Downstream Side of Ground Fault Sensor.

Fig. 8B: Simple Radial System With GFR on Main Only-Zero Sequence Sensing



Notes:

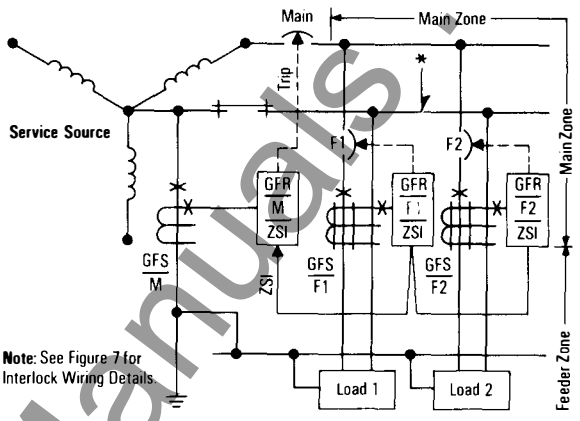
GFP Sensing Method
- Main and Feeders-Zero Sequence

Type of Protection
- Two Level for Improved Service Continuity as Suggested by NEC 230-95 (b)

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders.
- Feeder Trips Before Main for Downstream Faults.

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a)
- Must Not be on Downstream Side of Ground Fault Sensor

Fig. 8D: Simple Radial System With GFR on Main and Feeders-Zero Sequence Sensing on Main



Note: See Figure 7 for Interlock Wiring Details.

Notes:

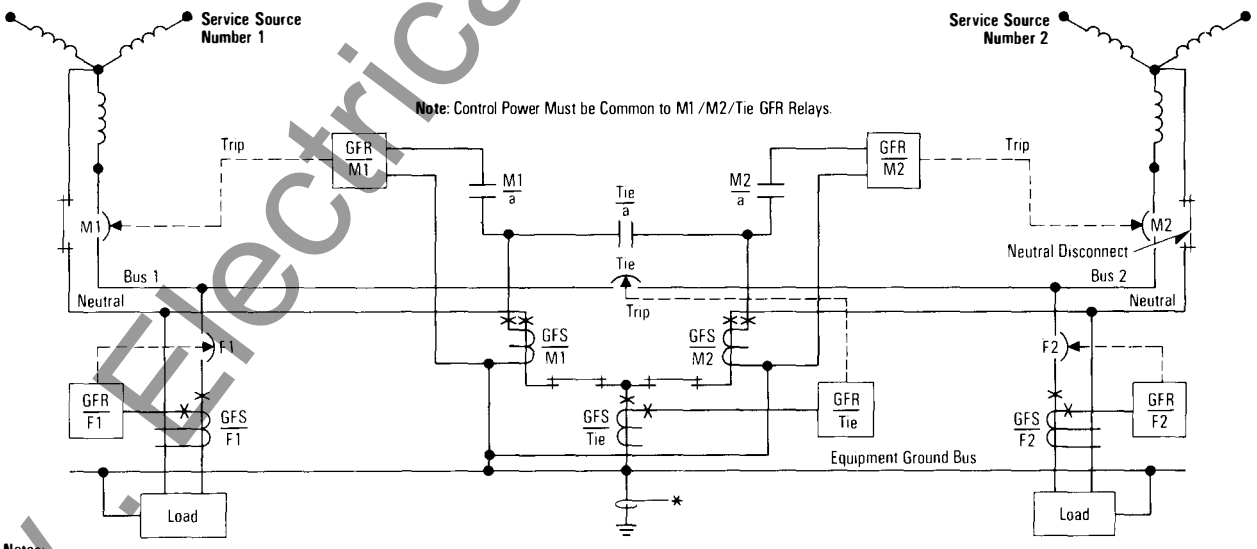
GFP Sensing Methods
- Main-Ground Return.
- Feeders-Zero Sequence.

Type of Protection
- Two Level for Improved Service Continuity.
- Zone Selective Interlocking for Minimum Arcing Fault Damage.

Ground Fault Selectivity
- Time/Current Coordination Between Main and Downstream Feeders.
- Feeder Trips Before Main for Fault in Feeder Zone.
- Main Trips Without Pre-set Time Delay for Fault in Main Zone

***Additional Grounding**
- Not Permitted Downstream of Service Disconnect per NEC 250-23 (a).

Fig. 8E: Simple Radial System With GFR on Main and Feeders-With Zone Selective Interlocking



Notes:

GFP Sensing Method
- Main-Ground Return With Polarities Arranged to Avoid Neutral Unbalance.
- Tie-Ground Return.
- Feeders-Zero Sequence.

Type of Protection
- Multiple Level for Improved Service Continuity.
- Zone Selective Interlocking May be Added for Minimum Arcing Fault Damage. (See Figure 11G).

Ground Fault Selectivity
- Time /Current Coordination Between Main, Tie and Feeders.
- Feeder Trips Before Main or Tie for Downstream Faults.
- Tie Trips Before Main to Sectionalize Main Bus.

***Additional Grounding**
- Any Additional Grounding Points Must be Avoided.

Fig. 8F: Dual Source System Using Center Point Grounding (NEC 250-23A, Exception No. 4)

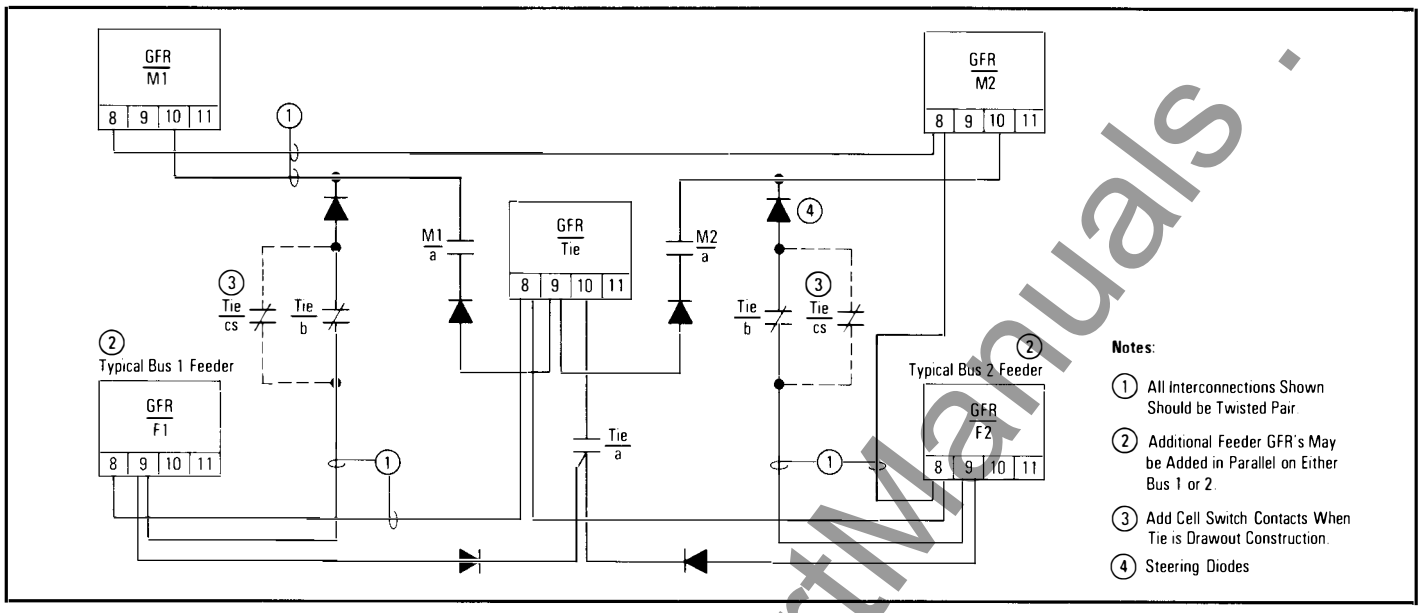


Fig. 8G: Special Zone Interlocking Wiring that May Be Used With Dual Source System Using Center Point Grounding (See Fig. 8F)

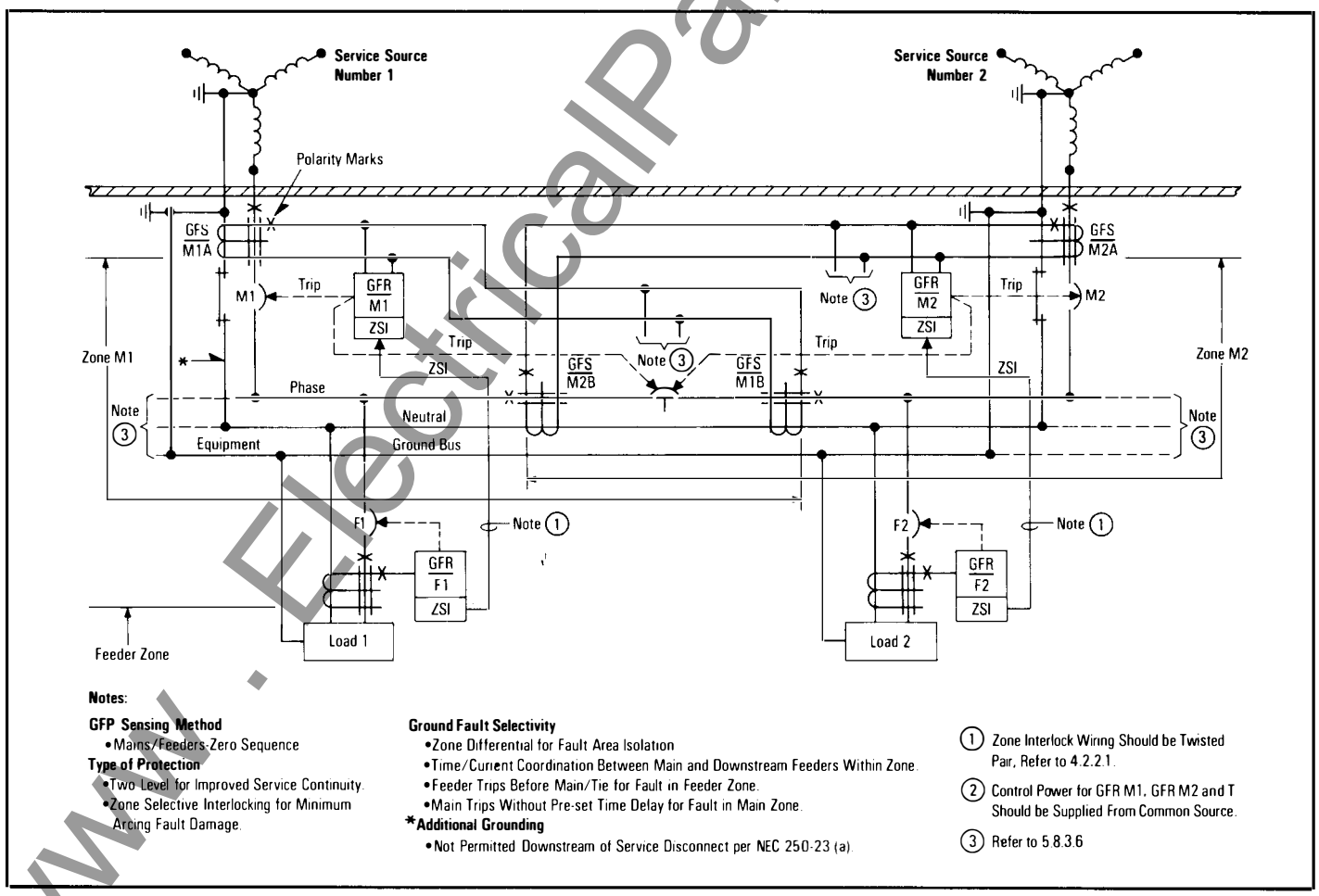


Fig. 8H: Multiple Source, Multiple Grounded System Using Zone Differential Sensing