Ground Fault Circuit Interrupter Solutions

For Commercial Facilities







Neutral Bar

Shunt Trip Operating Solenoid

Circuit Breaker



Ground Fault Protection for Your Applications

From a Company with a History of Innovation

Ground faults can be costly if not checked. They can cause a fire to erupt, damage equipment, or even shock or electrocute personnel. Numerous safety regulations and electrical codes exist to prevent and protect against ground faults. These and so much more can be found in this guide to ground fault protection for commercial facilities.



Meets intent of 2020 & 2023 NEC 210.8 defined term ground fault circuit interrupter.

With one of the broadest product portfolios in the industry, NK Technologies provides reliable, ground fault protection products designed to add value and exceed our customers' expectations. "From semiconductor wafer fabrication to commercial kitchens and electrical heating systems, NK Technologies has a family of ground fault relays to meet your application needs."

— Phil Gregory, President

Wet Environments

Agriculture & Aquaculture

Irrigation pumping systems, filter pumps

Biotech and Biopharma

Laboratory environments that use electrical equipment tied to pumping or processing fluids, or electrically powered heating processes

Chemical Processing

Chemical pumps and mixers, heat trace cables

Food/Beverage, Bottling/Canning

Filling machinery, equipment in washdown/hygienic locations

Marinas

Docking facilities (see Ground Fault Detection for High Current Circuits at Marina Docking Facilities)

Ground Fault Protection Applications

Electrical Heating Systems

Furnaces and Kilns

Heat treating and annealing

Manufacturing

Heat trace systems, process heating, annealing, drying, curing, overhead cranes

Semiconductors

Process heating (see Ground Fault Protection in Semiconductor Fabrication Equipment)

Commercial Kitchens

Steamers, grills, ovens (see Adjustable Ground Fault Detection for Commercial Kitchens)

Snow Melt

Snow melt cable to clear sidewalks, driveways and roof gutters

General Equipment Protection

Entertainment

Amusement park rides, ski lifts, electrified theater chairs, stage lighting and portable power supplies

Petrochemicals

Process control equipment, pumping systems, heat trace cables

Refrigeration and Compressors

Pumping systems, cooling towers, compressor motors

Timber and Logging

Debarking, sawing, drying, cranes

Utilities and Power Generation

Control systems, transformers, generators, solar panels, wind generators

For up-to-date product information, applications, engineering resources and more: www.nktechnologies.com

COMMERCIAL FACILITIES

5 mA Ground Fault Circuit Interrupter Solutions for Single or Three Phase Circuits up to 100 Amps

Cost Effective, Readily Available, Designed and Assembled in the USA



NK Technologies 5 mA Ground Fault Circuit Interrupter Solution Benefits

- Meets intent of 2020 & 2023 NEC 210.8 defined term ground fault circuit interrupter.
- Compact relay size allows for multiple mounting opportunities anywhere from the breaker to the appliance.
- Inventory and unrivaled in-house expertise within the USA.
- When you call or email, our application support team will answer promptly.
- Industry leading 5-year warranty.

For Resources & Downloads On-line: Go To Commercial Facilities Overview >>>

CONTENTS OF THIS GUIDE:

What are GFCI & GFPE Solutions?	4
2023 NEC Impact on the Market	5
What is a 5 mA Ground Fault Interrupter Solution?	6
How to Select a Ground Fault Relay	7
Choose a Ground Fault in 4 Easy Steps	8
Ground Fault Relay Part Number Selection	9
Shunt Trip Breaker Selection	10
Frequently Asked Questions	11

 $\mathbf{*}$ Click on the topics above to go directly to that page.



3511 Charter Park Drive • San Jose, CA 95136 800.959.4014 • www.nktechnologies.com • sales@nktechnologies.com



What are GFCI and GFPE Solutions?

Understanding GFCI, GFPE, and Class A Solutions

Electrical safety is paramount in residential, commercial, and industrial settings. Class A Ground Fault Circuit Interrupters (GFCIs) and Ground Fault Protection for Equipment (GFPE) solutions are critical components designed to enhance safety by mitigating risks associated with ground faults. While these devices share a common goal of preventing electrical hazards, they differ significantly in their applications, sensitivity levels, and compliance with the National Electrical Code (NEC).

Ground Fault Circuit Interrupters (GFCIs)

GFCIs are designed to protect individuals from electrical shock by detecting ground faults and interrupting the circuit. According to the NEC, GFCIs are required for specific appliances and locations where water and electricity are likely to come into contact, such as bathrooms, kitchens, and outdoor receptacles (NEC Article 210.8). These devices monitor the current flowing through the hot and neutral wires and trip the circuit if an imbalance is detected.

Class A

The NEC (2020/2023) explicitly defines Class A GFCIs in article 100, which narrows the GFCI behavior to values established by a Class A device. Class A devices trip when ground fault currents exceed 6 mA but do not trip below 4 mA. These devices are specifically designed for personnel protection and function to de-energize a circuit within an established period of time.

This sensitivity ensures that even minor ground faults are promptly addressed, reducing the risk of severe injuries or fatalities. Class A GFCIs are widely used in residential and commercial applications. They're the standard for most GFCI applications, ensuring compliance with safety regulations and providing reliable protection against ground faults.

Ground Fault Protection for Equipment (GFPE)

GFPE devices are designed to protect electrical equipment rather than personnel and are commonly used in industrial and commercial settings. They operate at higher trip thresholds, typically 30 mA or greater, depending on the application. The NEC mandates the use of GFPE in specific scenarios, such as protecting feeders and branch circuits in large installations (NEC Article 215.10). Unlike GFCIs, GFPE devices are not intended to prevent electrical shock but to safeguard equipment and maintain operational continuity.

Key Differences Between Class A GFCI and GFPE

Feature	Class A GFCI	GFPE			
Purpose	Protects personnel from shock	Protects equipment from damage			
Trip Threshold	Trip Threshold4-6 mA≥30 mA to 1200 A				
Application	Residential and commercial	Industrial and commercial			
NEC Reference	Article 100 Article 210.8	Article 215.10			
Primary Use Case	Bathrooms, kitchens, outdoors Large installations, feeders				
Sensitivity	sitivity High Low to medium				

GFCI vs GFPE Conclusion

In summary, Class A GFCIs and GFPE solutions play distinct roles in enhancing electrical safety. Class A GFCIs prioritize personnel protection and are the standard for most applications. GFPE devices, on the other hand, focus on safeguarding equipment in industrial and commercial environments. Understanding these differences is crucial for ensuring compliance with the NEC and selecting the appropriate device for each application.

By adhering to NEC guidelines and leveraging these devices' unique capabilities, we can create safer electrical systems that protect individuals and equipment from the dangers of ground faults.







2020 & 2023 NEC Impact to the Market

The 2020 and 2023 editions of the National Electric Code (NEC) have expanded the GFCI regulations to include additional locations and appliances that require GFCI protection in commercial settings.

Section 210.8(B) expanded GFCI regulations to include areas with sinks and permanent provisions for food preparation and cooking, significantly impacting commercial kitchens.

Section 210.8(D) expanded the list of appliances that require protection, including electric ranges, wall-mounted ovens, and counter-mounted cooking units.

These updates extend GFCI protection requirements to personnel in non-residential settings and apply to kitchen appliances operating on 3-phase power (e.g., line-to-line connections under 250V AC, typically 208V AC).



5 mA Ground Fault Solutions for Single or 3-Phase up to 100 Amps

With each update, the NEC has continued to increase GFCI requirements in more locations. As a result, architects, designers, electricians, general contractors, and program managers face a growing year over year demand for GFCI protection.

Summary of 2023 Code Changes

2023 Edition NEC article 210.8 (B) related to spaces "other than dwellings" has been rewritten to clarify and expand GFCI requirements.

NEC 2023 Article	Change
Article 210.8(B)(2)	Includes "Kitchens," requiring GFCI protection for single-phase (\leq 50A) and 3-phase (\leq 100A) plug-in appliances.
Article 210.8(B)(4)	Covers buffet and break areas in commercial settings, requiring GFCI protection for receptacles and appliances. This includes areas with provisions for food or beverage service, as well as cooking areas.
Article 210.8(B)(7)	Requires GFCI protection for stationary appliances within 1.8 m (6 ft) of a sink.
Articles 210.8(D)(8)-(12)	Update the appliance list for hardwired outlets (≤60A), addressing shock hazards. Shock hazards exist whether the appliance is energized from an outlet (hardwired) or from a receptacle (cord and plug).

A Class A (5 mA) Ground Fault Protection System

Many GFCI solutions are available for low-amperage (15/20A) single-phase branch circuits, often as an "all-in-one" GFCI Circuit Breaker. However, for three-phase power, GFCI protection often requires a shunt trip circuit breaker combined with a ground fault relay, especially for amperage of 60A or higher.

A Class A (5 mA) ground fault protection system includes a breaker with a shunt trip option and an AC ground fault sensor. NK Technologies offers ground fault relays with various options to ensure compatibility with any shunt trip breaker (MCB or MCCB), relay, or contactor. Our ground fault sensors are compact and easily installed within the panelboard. A shunt trip breaker with a ground fault sensor protects 15 A to over 100 A branch circuits from both overload and ground fault currents exceeding 5 mA.

When combined with a shunt trip breaker, the AGU Series provides a cost-effective, compact ground fault protection system that is <u>easy to install and set up</u> and compatible with all OEM panel boards. It meets NEC requirements that state GFCI protection must be provided for up to 50 A single-phase (120 VAC to 240 VAC) or up to 100 A three-phase (208 VAC or 240 VAC) branch circuits.

For wire bundles larger than 0.75" diameter, use the AGL-005 Series instead.

For more information on how to calculate the correct wire bundle size, see our "Calculating A Wire Bundle Size" Application Note.





What is a 5 mA Ground Fault Protection System

Two base models are offered:

AGU Ground Fault Relav for wire bundle diameter sizes up to 0.75" diameter

AGL Ground Fault Relay for wire bundle diameter sizes up to 1.76" diameter





A ground fault relay, combined with a shunt trip circuit breaker provides a ground fault circuit interrupter (GFCI) solution that meets the intent of 2020 & 2023 National Electric Code (NEC) Article 210.8 (B) - (F), ground fault protection for branch circuits within wet locations. The system includes an AC ground fault relay that trips at 5 mA and separate circuit interrupter device.

A shunt trip breaker combined with a ground fault relay is a common configuration widely adopted across multiple market segments with decades of reliable operation. The GFCI solution is suitable for single or three-phase, 15 A to 100 A branch circuits and will protect against both overload current and ground fault currents greater than 5 mA.



A cost effective, compact ground fault circuit interrupter solution can be installed in, or adjacent to the existing panelboard. Depending on the relay used, the relay can be either panel mounted or DIN Rail mounted with easy installation and setup and is compatible across all OEM panel boards. The GFCI solution can service the NEC GFCI requirements for branch circuits, including:

Single phase 120 VAC to 240 VAC (30 A to 50 A)

3-Phase 208 VAC to 240 VAC (15 A to 100 A)

Our Ground Fault Relay Selection Guide provides additional guidance.

When a ground fault current exceeds 5 mA, the NK Technologies AGU or AGL ground fault relay will respond "within an established period of time" (refer to Figure 2). When the circuit interrupter (CI) receives a fault signal from the relay, it will de-energize the branch circuit or portion thereof.

When a shunt trip breaker is manually reset and the ground fault current incidence has not been cleared, then the ground fault relay will command the CI to again de-energize the branch circuit.

ESTABLISHED PERIOD OF TIME AG SERIES -VS- UL943









OVE YEAD

How to Select a Ground Fault Relay

Two base models are offered:

AGU Ground Fault Relay

for wire bundle diameter sizes up to 0.75 " diameter



AGL Ground Fault Relay for wire bundle diameter sizes up to 1.76" diameter



Choosing the correct AC ground fault relay is based on whether all current carrying conductors will fit through the relay's aperture window. Configuring the ground fault relay order code is dependent upon the circuit-interrupter type. **The Ground Fault Relay Selection Guide** provides a table for most common field configurations and also includes shunt trip breaker models from various vendors. To use the Ground Fault Relay Guide table the following details are needed:

- 1) Branch circuit specifications: (example: 50A, 208 VAC, 3-Phase, Delta (3+1))
 - A. Amperage capacity (30A, 40A, 50A, 60A, 80A, 90A, or 100A)
 - Defines the required wire gauge
 - B. Load configuration (Single Phase, 3-Phase Delta (3+1) or 3-Phase Wye (4+1)) Defines the number of wires that must run through the aperture

2) Circuit-Interrupter type:

- A. Shunt trip breaker (recommended)
- B. Contactor
- C. Relay

Note: For commercial kitchens, a shunt trip breaker is the most common method for interrupting the branch circuit when a ground fault is detected by the ground fault relay.

Depending on the required aperture size either the AGU or the AGL Series is recommended for commercial kitchens and other wet locations per **2020 & 2023 Edition National Electric Code** (NEC) 210.8 (B) - (F), and 422.5 special appliances. The best relay for a given branch circuit is dependent upon whether the required wire bundle passes through the aperture of the ground fault relay.

Check out our new easy to use guide for **Choosing a Ground Fault Relay in Four Easy Steps**. The guide walks you through the decision making process of choosing the correct relay for your application.

A more detailed guide is also provided. The **Ground Fault Relay Selection Guide** is provided to ease the selection process and recommendations are based on using a shunt trip breaker and THHN wire. Given numerous wire and local code variants, the Guide is for reference only.

When using other than THHN wire and/or non-NEC cable correction factors, use application note **How to Calculate Bundle Diameter** to confirm whether the required wire bundle will pass through aperture of either the AGU or AGL ground fault relay.

After verifying that all current carrying conductors pass through the relay's aperture, Click here for How to Wire a Shunt Trip Connection.





Ground Fault Relay Selection — For Commercial Electrical Panel Applications

- Combine 5 mA ground fault relay with a shunt trip circuit breaker for GFCI solution
- Meets intent of NEC 210.8 for commercial kitchens & applications requiring 4-6 mA ground fault detection.
- This solution guide is for most common single-phase 120 VAC & 3-phase 240 VAC applications. NK Technologies offers a full line of ground fault relays.
- Contact NK Technologies for other use cases. sales@nktechnologies.com





	1 GFCI Protection Level		2 Listed UL 508 Preferred?		3 Choose Aperture Diameter Based on Wire Bundle Diameter					<mark>4</mark> Pair with Shunt Trip Circuit Breaker	
	Personnel GFCI	Process & Equipment GFPE	Listed UL 508	Recognized UL 1053	Aperture	Single Phase	<u><</u> 50A	3-PI 60	nase A	> 60 A	Use 120 or 240 or 480 VAC circuit breaker with 120 VAC rated shunt trip solenoid
AGL Series AGL1-SDT1-120-DEN-005					1.76"				4-wire Wye	YES	AGL & AGU are UL Listed to UL 508 for applications where code requires a "listed
AGU Series AGU1-SDT-120-DEN-005-FL	5 mA		CUL)US		0.75″	YES	YES	Delta			Factory calibrated for 5 mA (Class A) trip point.
AG3 Series AG3-SDT1-120-DEN-TR3		10 mA & 30 mA		c AL ° us	0.75″	YES	YES	3-wire			AG3 provides field adjustable settings for personnel (5 mA) and process/equipment protection (10 mA & 30 mA)
	NEC re 4-6 mA for prote	equires personnel ection	All model	s UL tested	Monitored wire bundle must pass through relay aperture. AGL offers larger diameter than AGU/ AG3 for 3-phase >60 A						

Choose a GF Relay in 4 Easy Steps

For the full line of NK Ground Fault Solutions, go to: https://www.nktechnologies.com/ground-fault-protection



WARRAN

Ground Fault Relay Part Number Selection Guide

Branch Circuit Specifications & Details			ons & Details	Recommendation for all appliances			
Breaker Rating ¹	Wire Size ² AWG	Corrected ³ Conductor Amperage Capacity (A)	Calculated Wire Bundle Diameter⁴	Branch Circuit Configuration ⁵	AGU1-SDT-120-DEN-005-FL	AGL1-SDT1-120-DEN-005	
	10	36	0.353	3 Phase, Delta, up to 480 V (3+1)	Х		
30 A	10	29	0.396	3 Phase, Wye, up to 480 V (4+1)	Х		
	10	36	0.328	1 Phase, up to 240 V (2+1)	Х		
	8	50	0.474	3 Phase, Delta, up to 480 V (3+1)	Х		
40A	8	40	0.531	3 Phase, Wye, up to 480 V (4+1)	Х		
	8	50	0.440	1 Phase, up to 240 V (2+1)	Х		
	8	50	0.474	3 Phase, Delta, up to 480 V (3+1)	Х		
50A	6	55	0.618	3 Phase, Wye, up to 480 V (4+1)	Х		
	8	50	0.440	1 Phase, up to 240 V (2+1)	Х		
	6	68	0.552	3 Phase, Delta, up to 480 V (3+1)	Х		
60A	4	69	0.785	3 Phase, Wye, up to 480 V (4+1)		Х	
	6	68	0.512	1 Phase, up to 240 V (2+1)	Х		
	4	86	0.700	3 Phase, Delta, up to 480 V (3+1)		Х	
80A	3	84	0.852	3 Phase, Wye, up to 480 V (4+1)		Х	
	4	86	0.650	1 Phase, up to 240 V (2+1)	Х		
	3	105	0.761	3 Phase, Delta, up to 480 V (3+1)		Х	
90A	2	95	0.932	3 Phase, Wye, up to 480 V (4+1)		Х	
	3	105	0.706	1 Phase, up to 240 V (2+1)	Х		
	3	105	0.761	3 Phase, Delta, up to 480 V (3+1)		Х	
100A	1	106	1.168	3 Phase, Wye, up to 480 V (4+1)		X	
	3	105	0.706	1 Phase, up to 240 V (2+1)	Х		

Note(s)

1. Ground fault relay recommendations based on mating with a shunt trip breaker only

2. Wire type: CU | THHN

3. Corrected conductor amperage capacity @ +40°C ambient temperature and as required correction factor for more than 3 conductors in raceway, reference NEC Tables: 310.15(B)(1), 310.15(C)(1) & 310.16

4. Reference How to Calculate Wire Bundle Diameter Application Note

5. Configurations: Live Wire & Neutral plus Ground (2+1). 3-wire Delta plus Ground (3+1). 4-wire Wye plus Ground (4+1)







AC Ground Fault Relay Relevant Features and Options

A properly configured NK Technologies AC ground fault relay will trip in the range of 4 mA to 6 mA and trips within an established period-of-time, meeting the intent of the 2020 & 2023 National Electric Code.

Standard features:

- Manual ground fault push-to test.
- Two visual indicators: power status and ground fault trip status.
- Normally Open/Normally Closed mechanical relay outputs.

User selectable output options (available choices vary by model):

• Normally energized or normally de-energized contacts.





by Phone or Email.

Shunt Trip Breaker Options

A Shunt Trip Breaker is required along with a NK Technologies AGU or AGL Ground Fault Relay to complete a 5mA Ground Fault Interrupter Solution. NK Technologies does not sell Shunt Trip Breakers. To make it easier for you to complete your solution, see the table below showing the correct part number for



MPN MPN # # MFR Voltage MFR Voltage Amperage Amperage Poles (10K AIC) Poles (10K AIC) THQL32020ST1 Q31500S01 20 15 30 THQL32030ST1 25 Q32500S01 40 THQL32040ST1 30 Q33000S01 3 THQL32050ST1 50 35 Q33500S01 60 THOL32060ST1 45 O34500S01 3 100 THQL32100ST1 50 Q35000S01 ABB (GE) 120/240 20 THQL2120ST1 60 Q36000S01 30 THOL2130ST1 70 O37000S01 35 THQL2135ST1 80 Q38000S01 Siemens 120/240 2 40 THQL2140ST1 90 Q39000S01 THOL2150ST1 O22000S01 50 20 25 60 THQL2160ST1 Q22500S01 100 THQL21100ST1 30 Q23500S01 CHP310ST* O23500S01 10 35 2 15 CHP315ST* 40 Q24000S01 20 CHP320ST* 45 Q24500S01 CHP325ST* Q25000S01 25 50 30 CHP330ST* 60 Q26000S01 3 CHP335ST* 35 15 OOU3151021 40 CHP340ST* 20 QOU3201021 45 CHP345ST* 30 QOU3301021 50 CHP350ST* 40 OOU3401021 CHP360ST* 60 3 50 QOU3501021 Eaton (Cutler-Hammer) 120/240 10 CHP210ST* 60 QOU3601021 15 CHP215ST* QOU3701042 70 20 CHP220ST* Square D 120/240 80 QOU3801042 25 CHP225ST* 100 QOU31001042 CHP230ST* QOU2201021 30 20 2 35 CHP235ST* 25 OOU2251042 CHP240ST* 40 30 QOU2301021 2 45 CHP245ST* 40 QOU2401021 50 CHP250ST* 50 QOU2501021 60 CHP260ST* 60 QOU2601021

many of the leading Shunt Trip Breaker manufacturers. If you need technical assistance contact our Engineers

* If you prefer a CH, simply replace the CHP in the model number.





FIVE YEAR

5 mA Ground Fault Protection — Frequently Asked Questions

What is the difference between the AGU and the AGL Series?

The AGU and AGL Series are UL Listed to UL 508. The main difference between the two ground fault relays is the aperture diameter. All current carrying conductors to the load must be able to pass through aperture. The AGU accommodates most wire bundles, so switch to the AGL for larger bundle sizes that exceed 0.75" diameter.

- AGU aperture diameter is 0.75"
- AGL aperture diameter is 1.76"

Which devices do I need to purchase?

The 5 mA ground fault circuit interrupter solution has two readily available devices.

- Quantity 1, AC ground fault relay; recommend AGU or AGL series
 - The AGU Series is a panel mount device and can be screwed directly to the panel.
 - ► AGU1-SDT-120-DEN-005-FL
 - Powered by 120 VAC
 - Mechanical Relay (SDT) with both NO & NC wiring options. 5 mA trip point.
 - The AGL Series is a DIN rail mount device, and attaches to an existing DIN rail within the electrical panel. If the panel does not have a DIN rail, we offer an optional DIN Rail Kit (Model #DINKIT) which includes a single 175 mm wide DIN rail and two end stops to keep the device from sliding on the rail.
 - ► AGL1-SDT1-120-DEN-005
 - Powered by 120 VAC
 - Mechanical Relay (SDT1) with both NO & NC wiring options. 5 mA trip point.
- Quantity 1, Circuit-Interrupter; choose MCB circuit breaker with shunt trip option suitable for required branch circuit amperage capacity.
 - NK's ground fault relays have user selectable options to ensure compatibility across all OEM's shunt trip breakers, contactors, and relays.

What is "established period of time" and do AGU and AGL comply?

"Established period of time" is a NEC undefined term. "Established period of time" is found within the NEC's defined term "GFCI". This definition refers to de-energizing the branch circuit within an "established period of time". NEC provides an informal note to clarify "established period of time" by referring to UL 943.

Yes, both the AGU and AGL series response time is within the response time requirement defined by UL 943. To learn more, review the application note **5 mA Ground Fault Circuit Interrupter Solution**.

Does AGU or AGL trip within ground fault current range 4 mA to 6 mA, per NEC defined term GFCI?

Yes.

The AGU1 comes from the factory with a 5 mA trip point.

The AGL1 comes from the factory at a fixed trip point. Order the -005 option for a 5 mA trip point.

► AGL1-SDT1-120-DEN-005





Does AGU or AGL trip have manual push to test feature and visual indicators?

Yes, both the AGU or and AGL have a user accessible manual push-to-test button to verify operation of the relay and two visual indicators for power and ground fault trip status.

Do you have more information on how to wire a ground fault relay with a shunt trip breaker?

Yes. See our guide for How to make a shunt trip connection.

What is the difference between the AG3 and the AGU Series?

The AGU is designed for GFCI applications with a 5 mA setpoint from the factory and is UL Listed to UL 508. The AG3 has a field selectable jumper for GFCI and Process/Equipment Protection (5 mA, 10 mA and 30 mA) and is UL Recognized to UL 1053. For a full comparison, see our guide.





FIVE YEAD

For the most current and up-to-date information...

www.nktechnologies.com

- Up-to-date Product Information
- Data Sheets & Instruction Sheets
- CAD Drawings
- Product Certifications
- Request for Quote
- Support
- Application Examples
- Engineering Resource Articles
- Sign up for Product Updates
- Distributor Information
- ... and so much more!

Visit our website for all the technical, application and support information that you could ever want or need!





3511 Charter Park Drive • San Jose, CA 95136 800.959.4014 • sales@nktechnologies.com www.nktechnologies.com