Data Bulletin

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Corner-Grounded Delta (Grounded B Phase) Systems
Class 2700

Retain for future use.

INTRODUCTION

Corner-grounded delta systems are not recommended for new installations. However, some utilities still provide this system, and many old installations still exist. Schneider Electric has tested equipment for use on corner-grounded delta systems to provide Underwriters Laboratories Inc.® (UL®) Listed products for this application.

This document outlines the background of the corner-grounded delta systems and lists the equipment rated for use on these systems.

Background

In the past, delta-delta connected transformers were extensively used in electrical distribution systems. With this type of system, it was practical to continue distributing three-phase power while performing maintenance on one unit of the three-phase transformer bank. Now, with the advent of more reliable modern transformers and the popularity of three-phase units, the delta-delta connected transformer no longer has the advantage it once had.

One of the disadvantages of the delta-delta system is the absence of an intentional connection to ground on the transformer secondary. To obtain a grounded system, one of the corners of the delta secondary is grounded.

With decreased usage of the delta-delta connected transformer, and increased usage of delta-wye connected transformers, the corner-grounded delta is rarely applied in modern systems.

Definitions

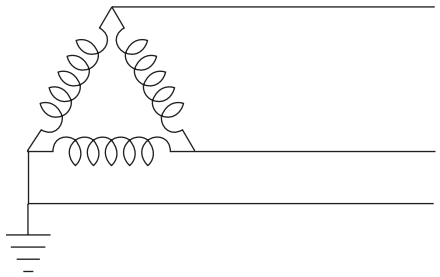
Corner-Grounded Delta System — A system in which the transformer secondary is delta-connected with one corner of the delta solidly grounded. Corner-grounded delta systems are also referred to as grounded B phase systems, grounded phase services, and end-grounded delta systems.

Ungrounded System — A system without an intentional connection to ground, except through potential indicating or measuring devices.

Grounded System — A system that has at least one conductor or point intentionally connected to ground, either solidly or through an impedance.

Solidly Grounded — An intentional connection made directly to ground without inserting any resistor or impedance.

Figure 1: System Diagram, 3ϕ3W Ground Bϕ Delta



STANDARDS

This section contains a list of standards that are applicable to corner-grounded delta systems. These standards address three basic points:

1. Any two-pole circuit breaker intended for use on corner-grounded delta systems shall be tested and rated for such use.
2. No overcurrent device is permitted to be used to disconnect the grounded conductor, unless this device simultaneously disconnects all conductors of the circuit, including the ground.
3. If the system is a corner-grounded delta system and fuses will be used for motor overload protection, a fuse must be installed in the grounded conductor, but only at the motor controller.

NEMA Standards Publication No. PB 1

PB 1–7.7 Corner-Grounded (Grounded B Phase) Three-Phase Delta Applications

Two-pole circuit breakers intended to be installed on corner-grounded (grounded B phase) delta systems to supply three-phase loads shall be marked “1 phase - 3 phase.”

NEMA Standards Publication No. PB 2

PB 2–7.9 Corner-Grounded (Grounded B Phase) Three-Phase Delta Applications

Two-pole circuit breakers intended to be installed on corner-grounded (grounded B phase) delta systems to supply three-phase loads shall be marked “1 phase–3 phase.”

National Electrical Code® (NEC®)

240.85 Applications

A circuit breaker with a straight voltage rating, such as 240V or 480V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker’s voltage rating. **A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked 1ϕ–3ϕ to indicate such suitability.**

A circuit breaker with a slash rating, such as 120/240V or 480Y/277V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker’s voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker’s voltage rating.

FPN: Proper application of molded case circuit breakers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the circuit breakers’ individual pole-interrupting capability.

Article 230.90 (B) Not in Grounded Conductor

No overcurrent device shall be inserted in a grounded service conductor except a circuit breaker which simultaneously opens all conductors of the circuit.

Article 240.22 Grounded Conductor

No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions are met:

(1) The overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently.

(2) Where required by Sections 430.36 or 430.37 for motor overload protection.

Article 404.2 Switch Connections

(A) Three-Way and Four-Way Switches. Three-way and four-way switches shall be wired so that all switching is done only in the ungrounded circuit conductor. Where in metal raceways or metal-armored cables, wiring between switches and outlets shall be in accordance with 300.20(A).
Exception: Switch loops shall not require a grounded conductor.

(B) Grounded Conductors. Switches or circuit breakers shall not disconnect the grounded conductor of a circuit.
Exception: A switch or circuit breaker shall be permitted to disconnect a grounded circuit conductor where all circuit conductors are disconnected simultaneously, or where the device is arranged so that the grounded conductor cannot be disconnected until all the ungrounded conductors of the circuit have been disconnected.

Article 430.36 Fuses—In Which Conductor

Where fuses are used for motor overload protection, a fuse shall be inserted in each ungrounded conductor and also in the grounded conductor if the supply system is three-wire, three-phase ac with one conductor grounded.

Schneider Electric adds the following clarification note to Article 430.36:

NOTE: It is prohibited to fuse the grounded conductor on service or distribution disconnects.

Article 430.85 In Grounded Conductors

One pole of the controller shall be permitted to be placed in a permanently grounded conductor, provided the controller is designed so that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

UL Standard 67

Paragraph 13.2.4

A two-pole circuit breaker, used in a panelboard marked for use on a corner-grounded delta system, shall be marked "1ϕ–3ϕ."

Paragraph 13.5.2

An overcurrent device shall not be connected in the permanently grounded wire of any circuit unless opening of the overcurrent device simultaneously opens all the conductors in that circuit.

UL Standard 891

Paragraph 8.6.11.3

A two-pole circuit breaker intended for use on a 3-phase load shall be marked "1ϕ – 3ϕ" when installed in a switchboard for use on a corner grounded delta system.

Paragraph 8.6.6.3

No overcurrent device shall be placed in any permanently grounded conductor unless it simultaneously opens all conductors of the circuit.

UL Standard 489

Paragraph 7.1.11.3.1.4

Two-pole circuit breakers are to be tested on a single-phase circuit with the load terminals short circuited. An additional two-pole sample shall be tested on a three-phase circuit if the circuit breaker is marked "1ϕ–3ϕ"

VOLTAGES

Table 1: Possible Low Voltage Corner-Grounded Delta Systems

System Voltage	Phase-to-Phase Voltage	Description
120 V	120 V	The ungrounded phases, generally A and C phases, have the same phase-to-ground voltage, while B phase is solidly grounded.
240 V	240 V	
480 V	480 V	
600 V	600 V	

THEORY

A corner-grounded delta system has the following characteristics:

- Grounding one phase stabilizes the voltage of the other two phases to ground.
- High fault currents may flow on the first ground fault, requiring the immediate clearance of this first fault.
- The voltage to ground in this system will be the system voltage, usually 240 or 480 volts.

Corner-grounded delta systems are not recommended for new installations because more suitable and reliable systems are available today. Even though this system is not recommended, it is encountered today for several reasons:

- As mentioned in the “Background” section on page 1, nearly all low voltage systems in the past were supplied from transformers with delta-connected secondaries. Grounding one of the phases provided a means of obtaining a grounded system. In this way, a grounded system could be obtained at a minimum of expense where existing delta transformer connections did not provide access to the system neutral.
- The recommended practice for most systems involves grounding one conductor of the supply.
- Possibly, customers wanted to avoid installing equipment ground fault protection as required by the NEC on solidly grounded wye electrical services.
- This system could result in the use of less expensive equipment, since two-pole switches and a neutral could be used for three-pole applications.

Corner-grounded delta systems have several advantages and disadvantages, as listed below.

Advantages

Corner-grounded delta systems:

- Stabilize voltages of the ungrounded phases to ground.
- Reduce the generation of transient overvoltages.
- Provide a method for protecting electrical distribution systems when used in combination with equipment grounding.

Disadvantages

Due to its disadvantages, the corner-grounded delta system has little reason for modern day use:

- The system is unable to supply dual-voltage service for lighting and power loads.
- It requires a positive identification of the grounded phase throughout the system.
- A higher line-to-ground voltage exists on two phases than in a neutral-grounded system.
- Most manufacturers’ electrical distribution equipment is not rated for use on this system.
- Fault switching (opening) is much more severe for the clearing device, and ratings may be greatly reduced.

Testing

Why isn’t more equipment rated for corner-grounded delta systems? Testing is required to get equipment rated for this system. Since the system is no longer frequently specified, most manufacturers do not test for its use.

APPLICATION

Schneider Electric has tested and obtained a UL listing for equipment to be used on grounded B phase systems. The “Devices” section on page 5 lists devices on unassembled and factory assembled distribution equipment that is suitable for such use. It is recommended to provide some type of equipment ground fault protection when the equipment is used on grounded B phase systems, due to the potential high fault currents on the first ground fault.

When ordering factory assembled equipment for use on grounded B phase systems, the order should be clearly identified as such on the order entry paperwork, because of the special requirements. Merchandised equipment must be properly selected and ordered from the Digest.

It is also recommended for engineers to specify that equipment is UL-labeled as suitable for use on grounded B phase systems, when applicable. This will ensure that our competitors quote and supply equipment rated for use on corner-grounded systems.

DEVICES

NOTE: All equipment listed in this document is rated for use on systems with a grounded B phase.

BP Fusible Switches

BP switches can be used on corner-grounded delta systems in manually or electrically operated, upright or inverted mount, and two- or three-pole[2] versions. The short-circuit current rating of BP switches on this system is 200,000 ampere interrupting rating (AIR) with Class L fuses installed.

Table 2: BP Switches

BP Switch Ampere Rating	Grounded B Phase System Rated	Maximum Grounded B Phase Voltage [1]
800 1200 1600 2000 2500	Yes	480 Vac

[1] For 240 V grounded B phase systems, use only 480 V BP switches listed in the table above.

[2] Three-pole switches have a copper link inserted in the center phase to restrict insertion of a fuse into the grounded conductor.

QMB and QMJ Switches

Table 3 lists QMB and QMJ switches that are UL Listed in File E34358, Vol. 2, Section 1 for grounded B phase systems. Two- and three-pole switches listed in Table 3 are rated for grounded B phase. However, only two-pole switches are marked to indicate a grounded B phase rating. The short-circuit current rating for 30–200 A Series E1 switches is 200,000 AIR. The short-circuit current rating for Series E1 400–800 A switches is 50,000 AIR.

Table 3: QMB and QMJ Switches

QMB/QMJ Switch Series	QMB/QMJ Switch Ampere Rating	Grounded B Phase Rated					
		Main Switch	Branch Switch	240 Vac Unit	480 Vac Unit	Two-pole	Three-pole[11]
E1	30	N/A	Yes	Yes	Yes	Yes	Yes
	60						
	100	Yes					
	200						
	400						
	600						
	800					N/A	

[1] Three-pole switches have a copper link inserted in the center phase to restrict insertion of a fuse into the grounded conductor. The rating is not shown on the wiring diagram of three-pole switches.

Safety Switches

Table 4 lists two-pole safety switches that are UL Listed for use on 240 and 480 Vac grounded B phase systems. Refer to the Digest, CAD drawings, or device wiring diagram(s) for complete information.

Table 4: Safety Switches

Safety Switches	Ampere Rating	System Voltage (VAC)	Type Construction	NEMA Types	Short Circuit Rating
General Duty	30	120	Neutral installed, *e.g.*, D223N	1, 3R	10,000 A
	60	240			10,000 A when used in conjunction with Class H or K fuses. 100,000 A when used in conjunction with Class R, J, or T fuses.
	100				
	200				
Heavy Duty	30	240 or 480	Two-pole or three-pole, neutral installed, *e.g.*, H223N	1, 3R, 4, 4X, 5, 12, 12K	10,000 A when used in conjunction with Class H or K fuses. 200,000 A when used in conjunction with Class R, J, or T fuses.
	60				
	100				
	200				
	400				
	600				

Molded Case Circuit Breakers

Table 5 lists molded case circuit breakers that are UL Listed for 240 Vac grounded B phase systems. Table 6 on page 7 lists UL Listed ratings available for use on 480 Vac grounded B phase systems.

Table 5: 240 Vac UL Listed Grounded B Phase Interrupting Ratings

Catalog Number Prefix	No. Poles[1]	Ampere Rating	UL Listed 240 Vac Grounded B Phase RMS Sym. Amperes
Q0-H, Q0B-H	2	15–100	5,000
QB, QD, QG, QJ	2[2]	100–225	10,000
EDB, EGB, EJB		15–125	18,000, 35,000, 65,000
HD, HG, HJ, HL		15–150	25,000, 35,000, 65,000, 100,000
JD, JG, JJ, JL	2[3]	150–250	
FH-FHL[4]		15–100	42,000
KH-KHL		70–250	42,000
LH, LHL[4]		125–400	30,000
MG, MJ Electronic		300–800	65,000
PG, PJ, PK, PL Electronic		600–1200	
RG Electronic		1200-2500	
RJ Electronic		1200–2500	100,000
RL Electronic		1200–2500	125,000
MG, MJ Electronic	3	300–800	65,000
PG, PK Electronic		600–1200	
PG, PK Micrologic®		250–1200	
PJ, PL Electronic		600–1200	100,000
PJ, PL Micrologic		250–1200	
RG, RK Electronic		1200–2500	65,000
RG, RK Micrologic		600–2500	
RJ Electronic		1200–2500	100,000
RJ Micrologic		600–2500	
RL Electronic		1200–2500	125,000
RL Micrologic		600–2500	

1 The grounded phase should be connected to the center pole only.

2 Standard labeling includes grounded B phase.

3 Built using three-pole module.

4 Add suffix 5861 to the catalog number for grounded B phase labeling.

NOTE: Electronic = ET1.01 electronic trip system. Micrologic = 3.0, 5.0, 3.0A, 5.0A, 6.0A, 5.0P, 6.0P, 5.0H, and 6.0H Micrologic trip system.

Table 6: 480 Vac UL Listed Grounded B Phase Interrupting Ratings

Catalog Number Prefix	No. Poles[1]	Ampere Rating	UL Listed 480 Vac Grounded B Phase RMS Sym. Amperes
HD, HG, HJ, HL	3	15–150	18,000, 35,000, 65,000, 100,000
JD, JG, JJ, JL		150–250	
FH-FHL		15–100	25,000[2]
KH-KHL		70–250	35,000[2]
LH-LHL		125–400	
MH		300-1000	65,000[2]
PH		2000A	100,000
MG, MJ Electronic, PG Micrologic		300-800	35,000,
PG Electronic		600–1200	
PG Micrologic		250–1200	
PK Electronic		600–1200	65,000
PK Micrologic		250–1200	
PJ Electronic/		600–1200	65,000
PJ Micrologic		250–1200	
PL Electronic		600–1200	100,000
PL Micrologic		250–1200	
RG Electronic		1200–2500	35,000
RG Micrologic		600–2500	
RJ, RK Electronic		1200–2500	65,000
RJ, RK Micrologic		600–2500	
RL Electronic		1200–2500	100,000
RL Micrologic		600–2500	
NT		800–1200	100,000
NW		800–6000	150,000

[1] The grounded phase should be connected through the center pole only.

[2] UL pending

NOTE: Electronic = ET1.01 electronic trip system. Micrologic = 3.0, 5.0, 3.0A, 5.0A, 6.0A, 5.0P, 6.0P, 5.0H, and 6.0H Micrologic trip system.

UNASSEMBLED AND ASSEMBLED EQUIPMENT

Panelboards

QMB Panelboards

QMB panelboards are UL Listed for use on grounded B phase systems 240 or 480 Vac with appropriately rated switches installed.

I-Line® Circuit Breaker Panelboards, 240 Vac

I-Line panelboards are UL Listed to indicate a 3ϕ3W, 240 Vac grounded B phase rating with appropriately rated circuit breakers installed (see Table 5 on page 6 for 240 Vac circuit breakers).

I-Line Circuit Breaker Panelboards, 480 Vac

I-Line panelboards are UL Listed for use on 480 Vac grounded B phase systems with the appropriately rated circuit breakers installed when using the B phase as grounded.

NQOD and NF Circuit Breaker Panelboards

NQOD and NF panelboards are UL Listed and can be used on 3ϕ3W, 240 Vac grounded B phase systems with rated main circuit breakers installed (see Table 7).

Table 7: NQOD and NF Circuit Breaker Panelboards

Main Circuit Breaker Type	240 Vac Grounded B Phase Rated	
	NQOD	NF
QB, QD, QG, QJ	Yes	No
EDB, EGB, EJB	No	Yes
HD, HG, HJ, HL	Yes	Yes
JD, JG, JJ, JL		
FH		No
KH		Yes
LH		
Main lugs only		
Branches for NF include EDB, EGB, and EJB. Branches for NQOD include QO-H and QOB-H.		

Switchboards

QED custom switchboards are UL Listed for use on grounded B phase systems when properly rated devices are installed (see the “Devices” section beginning on page 5 for details about these devices). QED switchboards can be rated up to 480 Vac as shown in Table 8.

Table 8: Switchboard Voltages

Type of Switchboard	Grounded B Phase System Rating
Circuit breaker switchboards	240 Vac, 480 Vac
Fusible switchboards	240 Vac, 480 Vac

REFERENCES

- IEEE Standard 142, 1991: “IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.”
- IEEE No. 241, 1990: “Electrical Systems for Commercial Buildings.”
- National Electrical Code, 2002.
- NEMA Standards: Publication No. PB1, 2000.
- NEMA Standards: Publication No. PB2, 2001.
- Underwriters Laboratories Standard 67, 2003.
- Underwriters Laboratories Standard 891, 2003.
- Underwriters Laboratories Standard 489, March 2003.

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