

## 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.

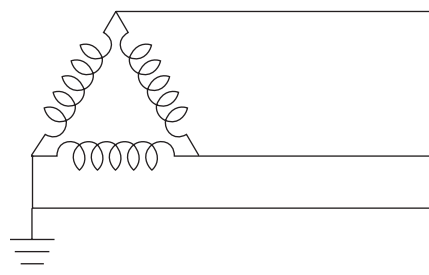
#### Grounded System

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, 3Ø3W Ground BØ 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 240 V or 480 V, 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 three-phase, corner-grounded delta circuit unless the circuit breaker is marked 1Ø–3Ø to indicate such suitability.**

A circuit breaker with a slash rating, such as 120/240 V or 480Y/277 V, 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.

Proper application of molded case circuit breakers on three-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the circuit breaker's 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- and Four-Way Switches. Three- 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 “1Ø–3Ø”.

## 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 three-phase load shall be marked “1Ø–3Ø” 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 “1Ø–3Ø”.

**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 electrical distribution equipment manufactured in North America 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 below 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<sup>2</sup> 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 <sup>1</sup> |
|-------------------------|-------------------------------|-----------------------------------------------|
| 800                     | Yes                           | 480 Vac                                       |
| 1200                    |                               |                                               |
| 1600                    |                               |                                               |
| 2000                    |                               |                                               |
| 2500                    |                               |                                               |

<sup>1</sup> For 240 V grounded B phase systems, use only 480 V BP switches listed in the table above.

<sup>2</sup> 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 <sup>1</sup> |
| E1                    | 30                           | N/A                    | Yes           | Yes          | Yes          | Yes      | Yes                     |
|                       | 60                           |                        |               |              |              |          |                         |
|                       | 100                          | Yes                    |               |              |              |          |                         |
|                       | 200                          |                        |               |              |              |          |                         |
|                       | 400                          |                        |               |              |              |          |                         |
|                       | 600                          |                        |               |              |              |          |                         |
|                       | 800                          |                        |               |              |              | N/A      |                         |

<sup>1</sup> 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<br>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<br>or<br>480     | Two- or three-pole<br>neutral installed<br>e.g., H223N | 1, 3R, 4, 4X, 5,<br>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 <sup>1</sup> |                      |                                                        |                             |                                                                                                                            |
|                 | 400              |                      |                                                        |                             |                                                                                                                            |
|                 | 600              |                      |                                                        |                             |                                                                                                                            |

<sup>1</sup> 200 A switch is limited to 100,000 A short circuit current rating when used with Class R, J, or T fuses.

## 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. of Poles <sup>1</sup> | 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 <sup>2</sup>            | 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            |                           | 150–250       |                                                     |
| FH-FHL <sup>4</sup>       | 2 <sup>3</sup>            | 15–100        | 42,000                                              |
| KH-KHL                    |                           | 70–250        | 42,000                                              |
| LH, LHL <sup>4</sup>      |                           | 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     |                                                     |
| RL Micrologic             |                           | 600–2500      | 125,000                                             |

<sup>1</sup> The grounded phase should be connected to the center pole only.

<sup>2</sup> Standard labeling includes grounded B phase.

<sup>3</sup> Built using three-pole module.

<sup>4</sup> 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. of Poles <sup>1</sup> | 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 <sup>2</sup>                                 |
| KH-KHL                           |                           | 70–250        | 35,000 <sup>2</sup>                                 |
| LH-LHL                           |                           | 125–400       |                                                     |
| MH                               |                           | 300–1000      | 65,000 <sup>2</sup>                                 |
| PH                               |                           | 2000          | 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                                             |

<sup>1</sup> The grounded phase should be connected through the center pole only.<sup>2</sup> 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 3Ø3W, 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 3Ø3W, 240 Vac grounded B phase systems with rated main circuit breakers installed (see Table 7 on following page).

**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            |                                | No  |
| FH                        |                                |     |
| 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). 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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