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Introduction

Welcome to another course in the STEP series, **S**iemens **T**echnical **E**ducation **P**rogram, designed to prepare our distributors to sell Siemens Energy & Automation products more effectively. This course covers **Basics of Panelboards**.

Upon completion of **Basics of Panelboards,** you will be able to:

- Explain the role of panelboards in a power distribution system
- Define a panelboard according to the National Electrical Code ®
- Distinguish between a lighting and appliance panelboard and a power panelboard
- Explain the need for circuit protection
- Distinguish between a main breaker panelboard and a main lug only panelboard
- Identify the most common power supply systems for panelboards
- Explain the use of panelboards as service-entrance equipment
- Describe the proper grounding techniques of service entrance and downstream panelboards
- Describe the five Siemens P series panelboard models
- Identify key ratings of Siemens P series panelboards
- Identify Siemens P series panelboard options

This knowledge will help you better understand customer applications. In addition, you will be better able to describe products to customers and determine important differences between products. You should complete **Basics of Electricity** and **Basics Circuit Breakers** before attempting **Basics of Panelboards**. An understanding of many of the concepts covered in **Basics of Electricity** and **Basics of Circuit Breakers** is required for **Basics of Panelboards**.

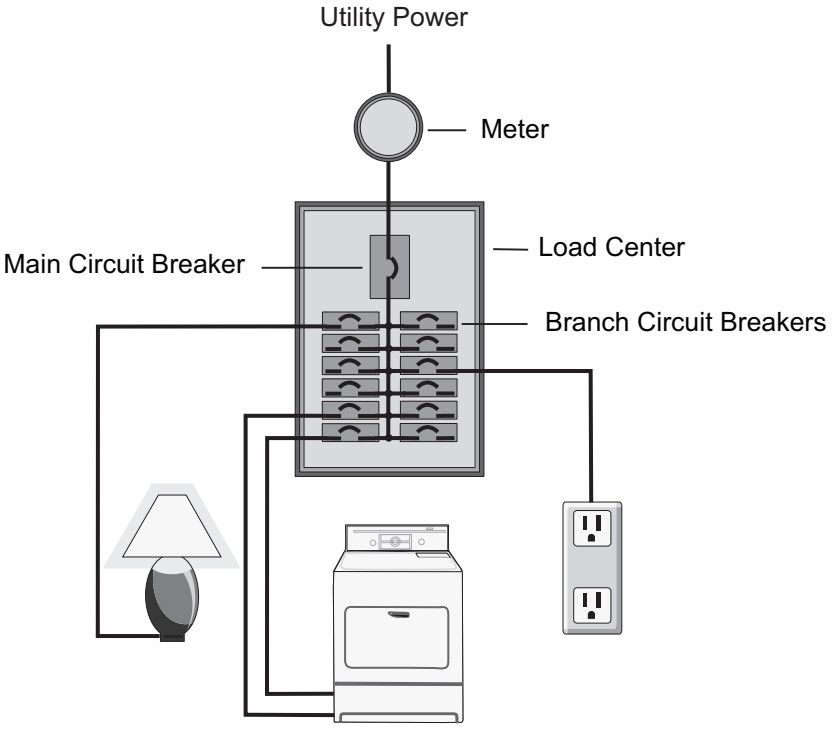
If you are an employee of a Siemens Energy & Automation authorized distributor, fill out the final exam tear-out card and mail in the card. We will mail you a certificate of completion if you score a passing grade. Good luck with your efforts.

Distribution Systems

Power distribution systems are used in every residential, commercial, and industrial building to safely control the distribution of electrical power throughout the facility.

Residential Power Distribution

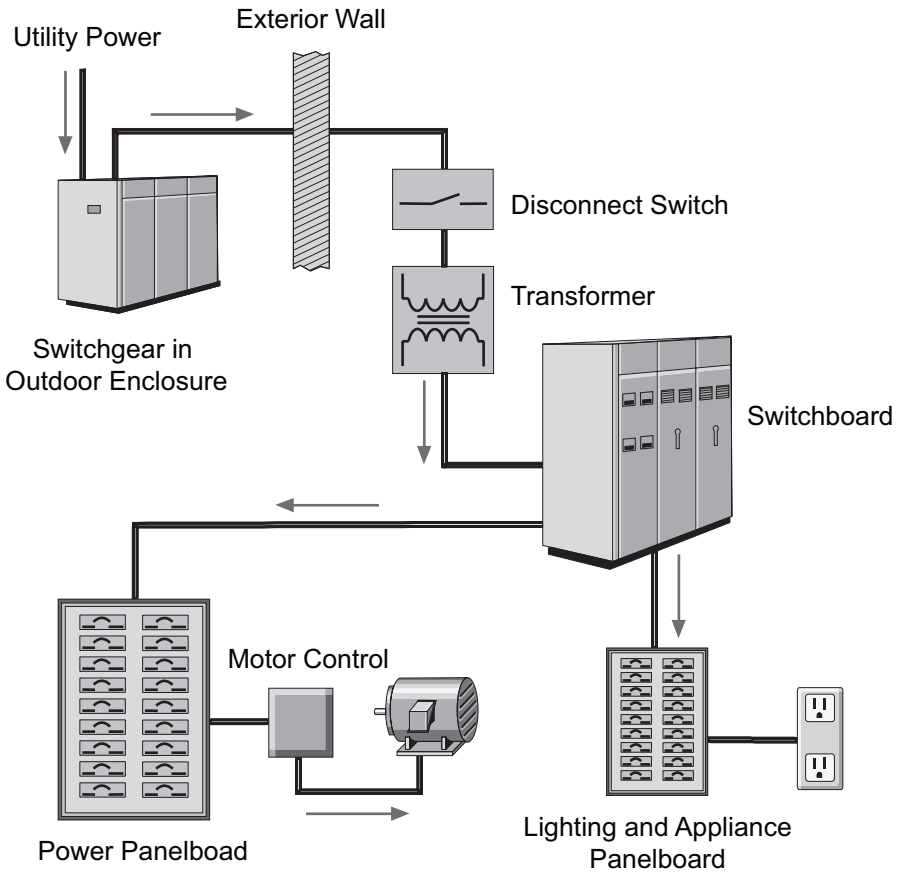
Most of us are familiar with the power distribution system found in the average home. Power, purchased from a utility company, enters the house through a metering device. The power is then distributed from a load center to various branch circuits for lighting, appliances, and electrical outlets.



Commercial and Industrial Power Distribution

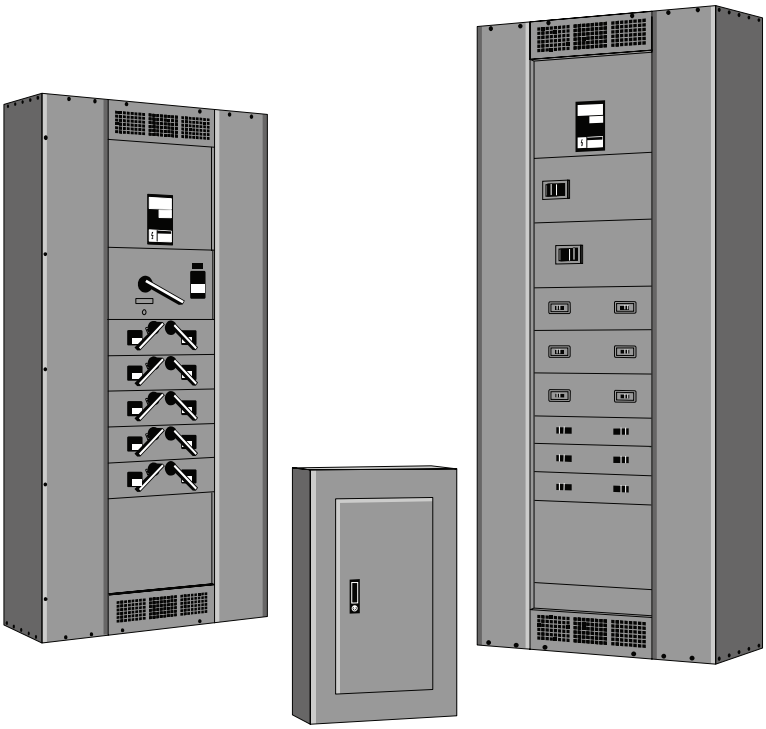
Power distribution systems used in multi-family, commercial, and industrial facilities are more complex. A power distribution system consists of metering devices to measure power consumption, main and branch disconnects, protective devices, switching devices to start and stop power flow, conductors, and transformers. Power may be distributed through various switchboards, transformers, and panelboards.

Good distribution systems don't just happen. Careful engineering is required so that the distribution system safely and efficiently supplies adequate electric service to existing loads and has expansion capacity for possible future loads.



Panelboards

Electrical distribution systems, whether simple or complex, typically include **panelboards**, the focus of this course.

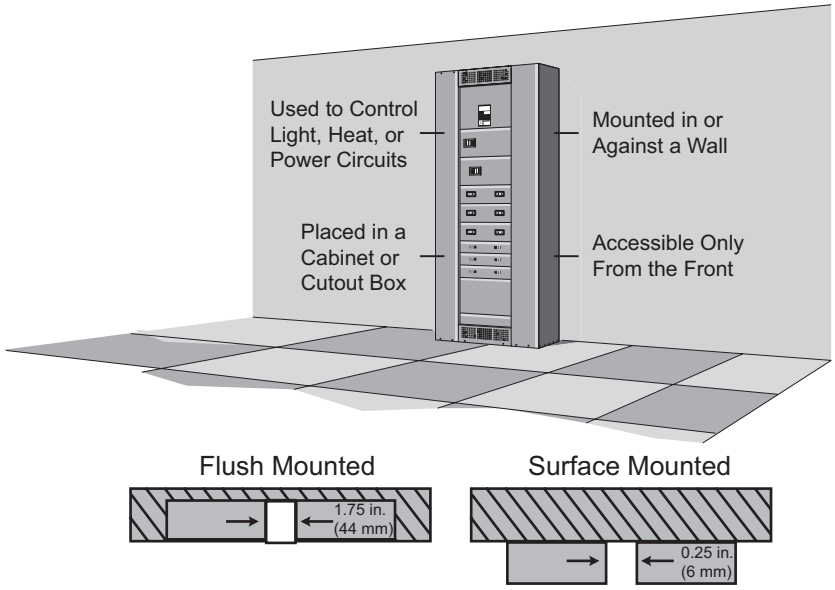


Panelboard Definition

T*he National Electrical Code*® (*NEC*®) defines a panelboard as *a single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front* (Article 100-Definitions).

In summary, according to the *NEC*® definition, panelboards are:

- Used to control light, heat, or power circuits
- Placed in a cabinet or cutout box
- Mounted in or against a wall
- Accessible only from the front



For additional information, refer to *National Electrical Code*® Article 408, Switchboards and Panelboards.

Panelboards are frequently divided into two categories:

- **Lighting and appliance branch-circuit panelboards**
- **Power panelboards** (also called **distribution panelboards**)

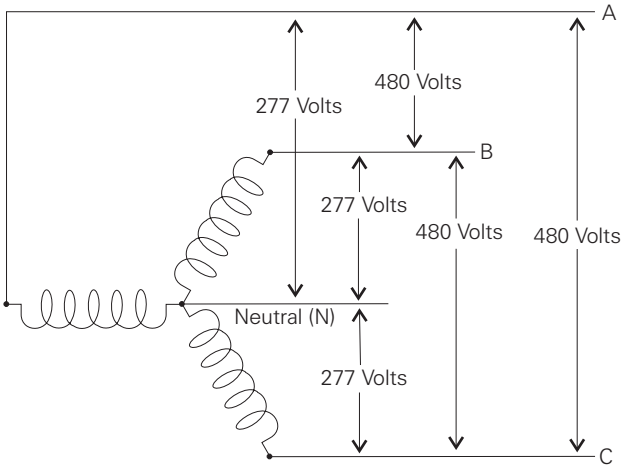
Prior to the publication of the 2008 *National Electrical Code*®, the distinction between these two panelboard types was described in Articles 408.34 and 408.35. These articles have been removed from the 2008 code. However, it will take time for the industry to adapt to this change. Therefore, Articles 408.34 and 408.35 of the 2005 *National Electrical Code*® still warrant discussion.

Lighting and Appliance Branch-circuit Panelboard

In order to understand the difference between a lighting and appliance branch-circuit panelboard and a power panelboard, you must first understand the term **lighting and appliance branch-circuit.**

2005 *National Electrical Code®* *Article 408.34 states that a lighting and appliance branch circuit is a branch circuit that has a connection to the neutral of the panelboard and has overcurrent protection of 30 amperes or less in one or more conductors.*

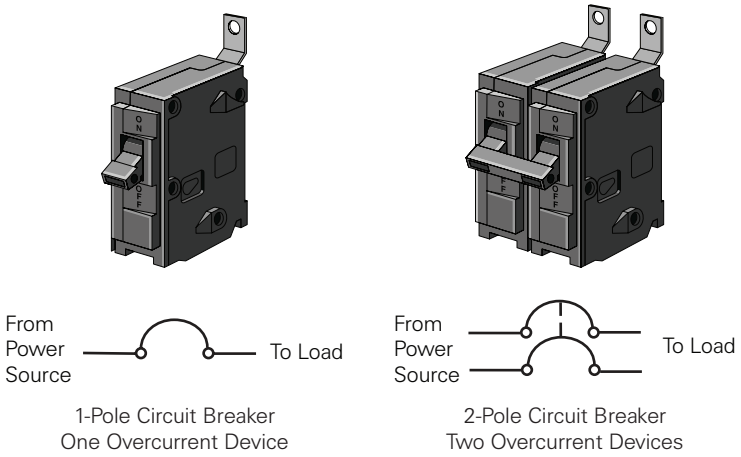
A **neutral** is a current-carrying conductor that is connected to the third wire of a single-phase, three-wire system or the fourth wire of a three-phase, four-wire system. For example, the following illustration shows the secondary of a 480 volt, wye-connected, three-phase transformer. Although the voltage between any two phases in this example is 480 volts, the voltage between any phase and neutral (N) is 277 volts.



2005 *National Electrical Code®* Article 408.34 goes on to state that a lighting and appliance branch-circuit panelboard must have more than 10% of its overcurrent protective devices protecting lighting and appliance branch circuits.

Overcurrent Devices

For the purpose of this definition, each pole of a circuit breaker is considered one overcurrent device. Therefore, a 1-pole breaker is one overcurrent device and a 2-pole breaker is two overcurrent devices.



1-Pole Circuit Breaker
One Overcurrent Device

2-Pole Circuit Breaker
Two Overcurrent Devices

Number of Overcurrent Protection Devices

An additional condition that a lighting and appliance panelboard must meet is added in the 2005 *NEC®* Article 408.35, which limits this type of panelboard to no more than 42 overcurrent protection devices (poles) in any one cabinet or cutout box.

2005 *NEC®* *Article 408.35 also states that a lighting and appliance branch-circuit panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated, and approved.*

Class CTL

Class CTL is a designation used by Underwriters Laboratories, Inc. (UL 67), to indicate panelboards and circuit protection devices which meet the 2005 *NEC®* circuit limitation requirements. Class CTL panelboards incorporate physical means that prevent the installation of more overcurrent devices than the panelboard is designed and rated to include.

Example

In the following example, a three-phase, four-wire (the fourth wire is neutral) distribution system is used to supply a panelboard. The panelboard has five 1-pole, 15 A breakers; twenty-one 1-pole, 20 A breakers; and eight 2-pole, 40 A breakers for a total of 42 overcurrent devices. However, for this panelboard to be considered a lighting and appliance, branch-circuit panelboard (according to the 2005 *NEC®*), ten percent or more of these overcurrent devices must be rated for 30 amps or less, for which neutral connectors are provided. Because there are 26 overcurrent devices rated at 30 amps or less, this is a lighting and appliance branch-circuit panelboard.

Number of Circuit Breakers	Description	Number of Overcurrent Devices
5	1-Pole, 15 A	5
21	1-Pole, 20 A	21
8	2-Pole, 40 A	16
		42

Power Panelboards

2005 *NEC®* *Article 408.34 defines a power panelboard as one having 10 percent or fewer of its overcurrent devices protecting lighting and appliance branch circuits.*

More broadly, it can be said that panelboards that are not lighting and appliance branch-circuit panelboards are power panelboards.

Example

In the following example, the panelboard has 42 devices, but there are only four overcurrent devices which are rated at 30 amps or less. Since four is less than 10% of 42, this panelboard does not qualify as a lighting and appliance branch-circuit panelboard (according to the 2005 *NEC®*); therefore, it is a power panelboard.

Number of Circuit Breakers	Description	Number of Overcurrent Devices
4	1-Pole, 30 A	4
22	1-Pole, 40 A	22
8	2-Pole, 40 A	16
		42

Review 1

1. A _____ system safely controls the distribution of electrical power throughout a facility.

2. Which of the following descriptions is not correct according to the *NEC*® definition for a panelboard?

   a. Controls light, heat, or power circuit
   b. Accessible from the front or rear
   c. Mounted in or on a wall
   d. Placed in a cabinet or cutout box

3. 2005 *National Electrical Code*® Article _____ explains the difference between a lighting and appliance branch-circuit panelboard and a power panelboard.

4. Assuming that other requirements are met, why would a panelboard with the following branch circuit devices be classified as a lighting and appliance branch-circuit panelboard according to the 2005 *NEC*®?

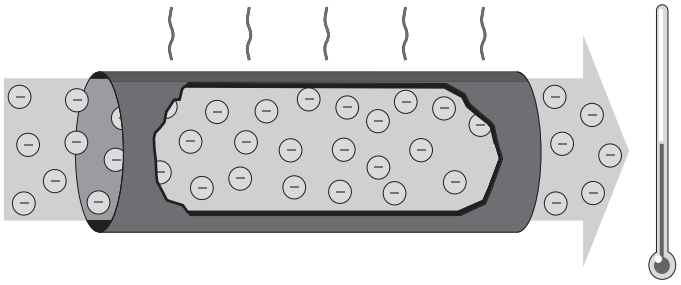
Number of Circuit Breakers	Description	Number of Overcurrent Devices
2	3-Pole, 60 A	6
4	2-Pole, 30 A	8
4	1-Pole, 15 A	4
		18

Overcurrent Protective Devices

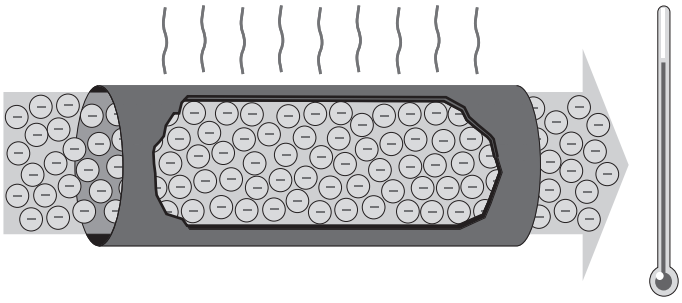
Excessive current is referred to as **overcurrent**.

The National Electrical Code® defines overcurrent as *any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault* (Article 100-Definitions).

Current flow in a conductor always generates heat. The greater the current flow, the hotter the conductor. Excess heat is damaging to electrical components. For that reason, conductors have a rated continuous current carrying capacity or **ampacity**. Overcurrent protection devices are used to protect conductors from excessive current flow. These protective devices are designed to keep the flow of current in a circuit at a safe level to prevent the circuit conductors from overheating.



Normal Current Flow



Excessive Current Flow

Circuit protection would be unnecessary if overcurrents could be eliminated. Unfortunately, overcurrents do occur. To protect a circuit against these currents, a protective device must automatically disconnect the electrical equipment from the voltage source when an overcurrent is sensed. In addition, an overcurrent protection device must be able to recognize the difference between slight overcurrents and short circuits and respond in the proper way. Slight overcurrents can be allowed to continue for some period of time, but as the current magnitude increases, the protection device must open faster. Short circuits must be interrupted instantly.

Fuse

A **fuse** is one type of overcurrent protection device. The heat produced by an overcurrent causes the current carrying element in a fuse to melt open, disconnecting the load from the source voltage.

Fuse During Fault

Fuse After Fault

Non-time-delay Fuses

Non-time-delay fuses provide excellent short circuit protection. When an overcurrent occurs, heat builds up rapidly in the fuse. Non-time-delay fuses usually hold 500% of their rating for approximately one-fourth second, after which the current-carrying element melts. This means that these fuses cannot be used in motor circuits, which often have large in-rush currents when a motor starts.

Time-delay Fuses

Time-delay fuses provide overload and short circuit protection. Time-delay fuses used in motor applications are designed usually allow several times the rated current for a short time to allow motors to start without blowing the fuse.

Fuse Classes

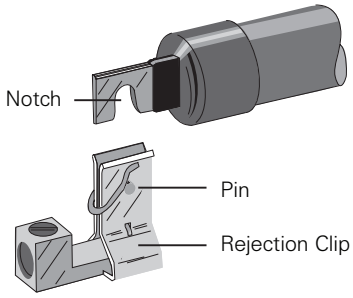
Fuses are grouped into classes based on their operating and construction characteristics. Each class has an **interrupting rating** or **ampere interrupting rating (AIR)** which is the amount of fault current they are capable of interrupting without destroying the fuse casing. Fuses are also rated according to the maximum continuous current and maximum voltage they can handle.

Underwriters Laboratories (UL) establishes and standardizes basic performance and physical specifications to develop its safety test procedures. These standards have resulted in distinct classes of low voltage fuses rated at 600 volts or less.

Class	Interrupting Rating
H	10,000 A
K	50,000 A
R	200,000 A
J	200,000 A
L	200,000 A

Class R Fuseholder

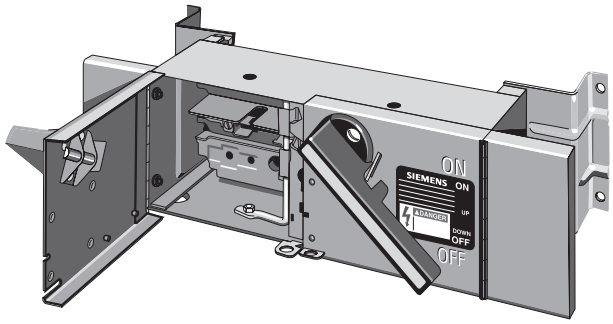
An optional **Class R fuseholder** can be used to prevent any other type of fuse from being used. The Class R rejection clip contains a pin that permits only the notched Class R fuse to be inserted. This prevents a lower rated fuse from being used.



Optional Class R Fuseholder

Fusible Disconnect Switch

A **fusible disconnect switch** is one type of device used on panelboards to provide overcurrent protection. Properly sized fuses located in the switch open when an overcurrent condition exists.

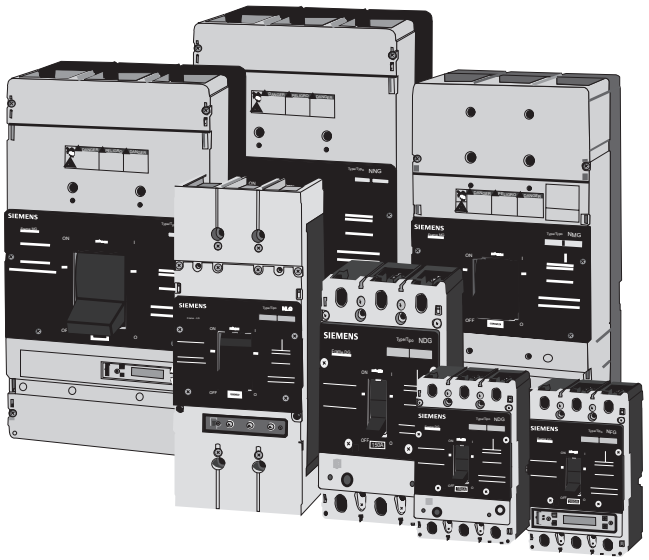


Circuit Breakers

Another device used for overcurrent protection is a **circuit breaker**.

The *National Electrical Code*® defines a circuit breaker as *a device designed to open and close a circuit by nonautomatic means, and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating* (Article 100-Definitions).

Circuit breakers provide a manual means of energizing and de-energizing a circuit. In addition, circuit breakers provide automatic overcurrent protection of a circuit. A circuit breaker allows a circuit to be reactivated quickly after a short circuit or overload is cleared. Unlike fuses which must be replaced when they open, a simple flip of the breaker's handle restores the circuit.



Voltage Rating

Circuit breakers are rated according to the maximum voltage they can handle. The **voltage rating** of the circuit breaker must be at least equal to the circuit voltage. The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower. For example, a 480 VAC circuit breaker could be used on a 240 VAC circuit. A 240 VAC circuit breaker could not be used on a 480 VAC circuit. The voltage rating is a function of the circuit breaker's ability to suppress the internal arc that occurs when the circuit breaker's contacts open.

Some circuit breakers have what is referred to as a "slash" voltage rating, such as 120/240 volts. In such cases, the breaker may be applied in a circuit where the nominal voltage between any conductor and ground does not exceed the lower rating and the nominal voltage between conductors does not exceed the higher rating.

Continuous Current Rating

Every circuit breaker has a **continuous current rating** which is the maximum continuous current a circuit breaker is designed to carry without tripping. The current rating is sometimes referred to as the **ampere rating** because the unit of measure is amperes, or, more simply, amps.

The rated current for a circuit breaker is often represented as I_n. This should not be confused with the current setting (I_r) which applies to those circuit breakers that have a continuous current adjustment. I_r is the maximum continuous current that circuit breaker can carry without tripping for the given continuous current setting. I_r may be specified in amps or as a percentage of I_n.

Conductors are rated for how much current they can carry continuously. This is commonly referred to as the conductor's **ampacity**. In general, the ampere rating of a circuit breaker and the ampacity of the associated conductors must be at least equal to the sum of any noncontinuous load current plus 125% of the continuous load current.

Siemens circuit breakers are rated on the basis of using 60° C or 75° C conductors. This means that even if a conductor with a higher temperature rating were used, the ampacity of the conductor must be figured on its 60° C or 75° C rating.

Frame Size

The circuit breaker frame includes all the various components that make up a circuit breaker except for the trip unit. For any given frame, circuit breakers with a range of current ratings can be manufactured by installing a different trip unit for each rating. The breaker **frame size** is the highest continuous current rating for a breaker with a given frame.

Interrupting Rating

Circuit breakers are also rated according to the maximum level of current they can interrupt. This is the **interrupting rating** or **ampere interrupting rating (AIR**). Because UL and IEC testing specifications are different, separate UL and IEC interrupting ratings are usually provided.

When designing a power distribution system, a main circuit breaker must be selected that can interrupt the largest potential fault current that can occur in the selected application. The interrupting ratings for branch circuit breakers must also be taken into consideration, but these interrupting ratings will depend upon whether series ratings can be applied.

The interrupting ratings for a circuit breaker are typically specified in **symmetrical RMS amperes** for specific rated voltages. As discussed in **Basics of Electricity**, RMS stands for root-mean-square and refers to the effective value of an alternating current or voltage. The term symmetrical indicates that the alternating current value specified is centered around zero and has equal positive and negative half cycles. Siemens circuit breakers have interrupting ratings from 10,000 to 200,000 amps.

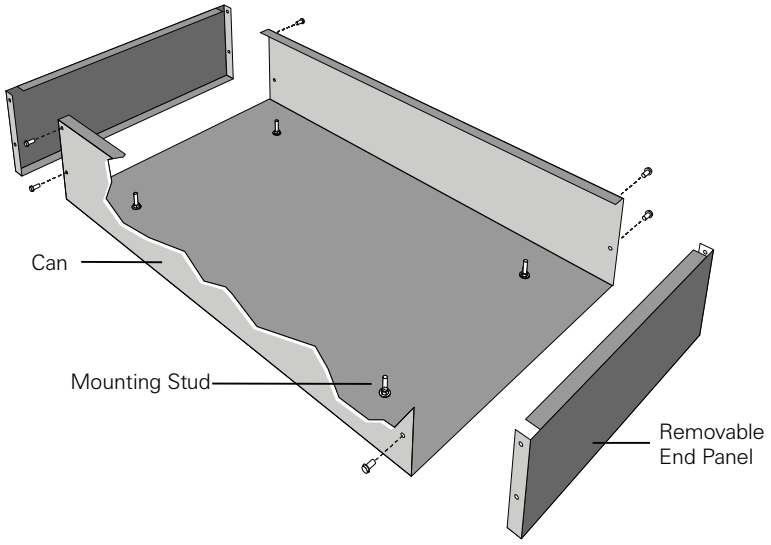
These and other ratings for Siemens circuit breakers can be found in the SPEEDFAX catalog which is available in print form as well as on the Siemens Energy & Automation web site.

Panelboard Construction

Panelboards are available in different sizes with variations in construction. The components that make up a panelboard, however, are similar. Panelboards contain a can, interior, circuit protection devices, label, and trim.

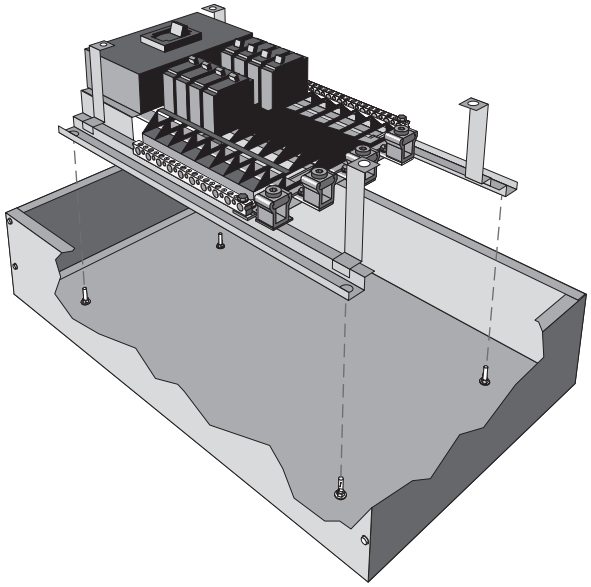
Can

The **can** is typically constructed of galvanized steel and houses the other components. The can is also referred to as a box or enclosure. It is designed to provide component and personnel protection. Removable blank end panels allow the user to cut whatever conduit holes are necessary. Pre-stamped knockouts are available as an option. Mounting studs are used to support the interior or group mounted devices.



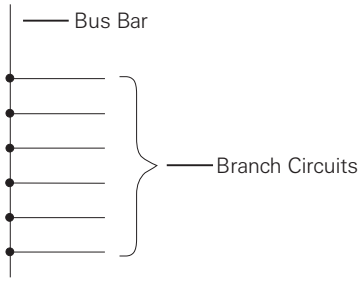
Interior

The **interior** consists of several components, including overcurrent protection devices, bus bars and insulated neutral bus bars. The interior is mounted to the four mounting studs in the can. Jacking screws (not shown) allow adjustment of the interior within the enclosure.



Bus Bars

A **bus bar** is a conductor that serves as a common connection for two or more circuits. It is represented schematically by a straight line with a number of connections made to it.

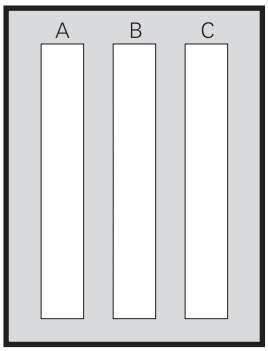


NEC® article 408.3(A)(1) states that bus bars shall be located so as to be free from physical damage and shall be held firmly in place.

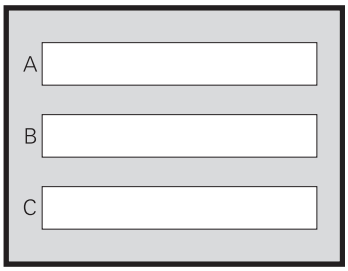
Standard bus bars on Siemens panelboards are made of aluminum, but copper bus bars are available as an option.

NEMA Arrangement

Bus bars are required to have **phases** in sequence so that an installer can have the same fixed phase arrangement for each termination point in any panelboard or switchboard. This is established by NEMA (National Electrical Manufacturers Association). A panelboard can have a non-NEMA phase sequence, providing phases are clearly marked on the panelboard. Unless otherwise marked, bus bars are arranged according to NEMA. The following diagram illustrates accepted NEMA phase arrangements.



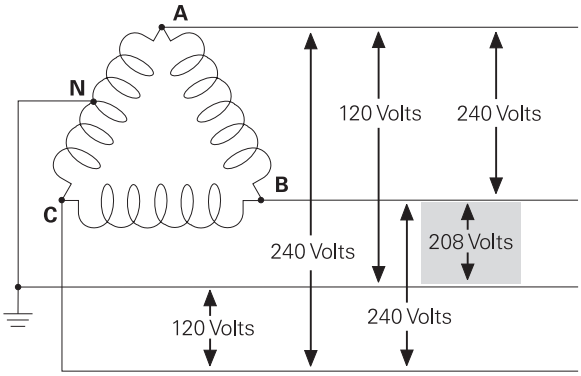
Vertical
(Left-to-Right)



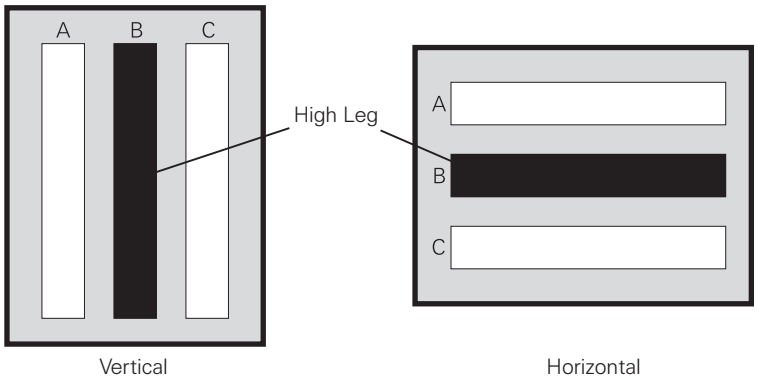
Horizontal
(Top-to-Bottom)

High Leg

Some power supply systems use a transformer with a three-phase, four-wire (3Ø4W), delta-connected secondary with grounded, center-tap connection on one phase. The following illustration shows an example of such a system with 240 volts phase-to-phase. The midpoint of one phase winding is grounded to provide 120 volts between phase A and neutral and 120 volts between phase C and neutral. Between phase B and neutral, however, the voltage is 208 volts. This is referred to as the **high leg**.

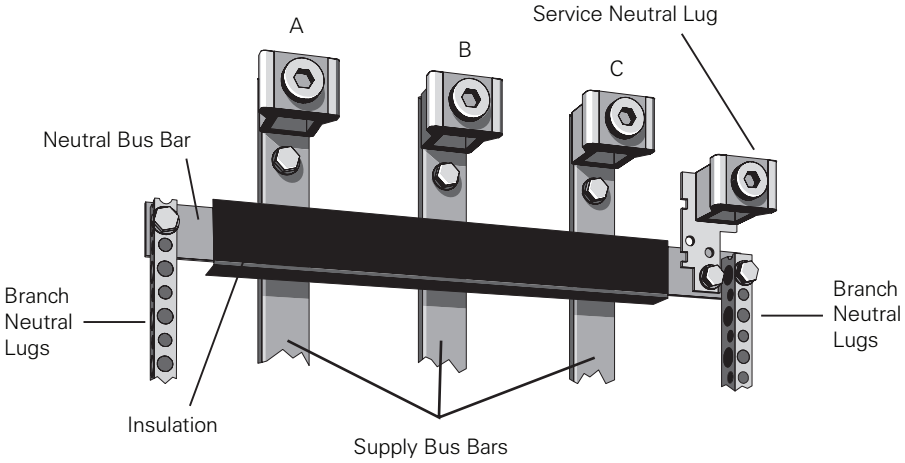


NEC® Article 110.15 requires that the high leg conductor or bus bar be permanently marked with an orange finish "or by other effective means." In addition, *NEC*® Article 408.3(E) states the **B phase** should be the high leg. Other bus bar arrangements are permitted for existing installations, but these arrangements must be marked. More information on calculating the value of the high leg, as well as connecting loads, is discussed later in the course.



Split Neutral

Siemens panelboards feature a **split neutral design** which means that neutral connections are available on both sides of the panelboard. Split neutrals are connected by means of an insulated neutral bus bar.

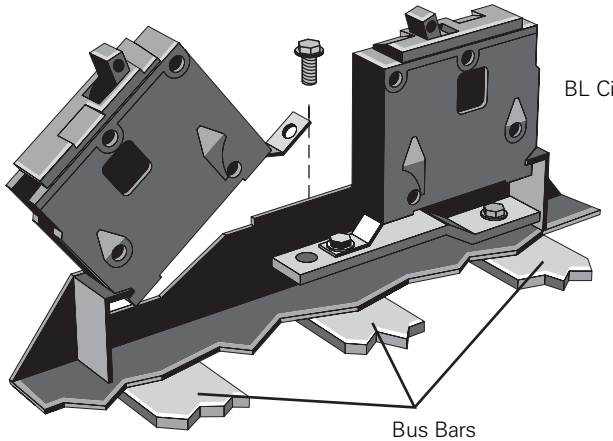


200% Neutral

Some loads can cause harmonics and non-linear loading on a distribution system. This requires special consideration when ordering a panelboard. One way to deal with non-linear loads is to double the capacity of the panelboard neutral. A **200% neutral** is an available option on Siemens panelboards.

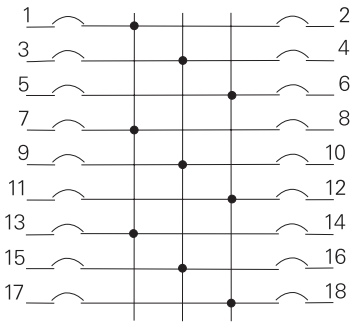
Circuit Protection Devices

While it is common for load centers to have plug-in branch circuit breakers, circuit breakers used in panelboards for commercial and industrial applications typically bolt on to the bus bars. For example, the following illustration, shows two BL circuit breakers, one is mounted to the panelboard bus and the other is being mounted.

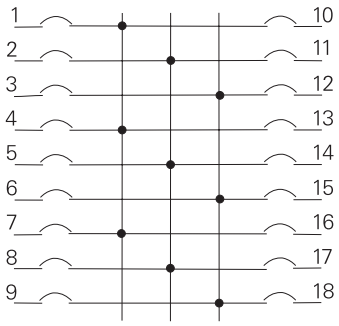


Circuit Identification

Specifications typically require panelboard circuit terminals to be labeled or for a wiring diagram to be provided. One approach for numbering terminals is to use odd numbers for poles on the panelboard's right (your left as you face the panelboard) and even numbers on the panelboard's left. This is sometimes referred to as NEMA numbering. For some specifications, vertical numbering is required.



NEMA Numbering



Vertical Numbering

Panelboard Label

The **label** identifies the panelboard's type, voltage rating, and ampacity.

SIEMENS

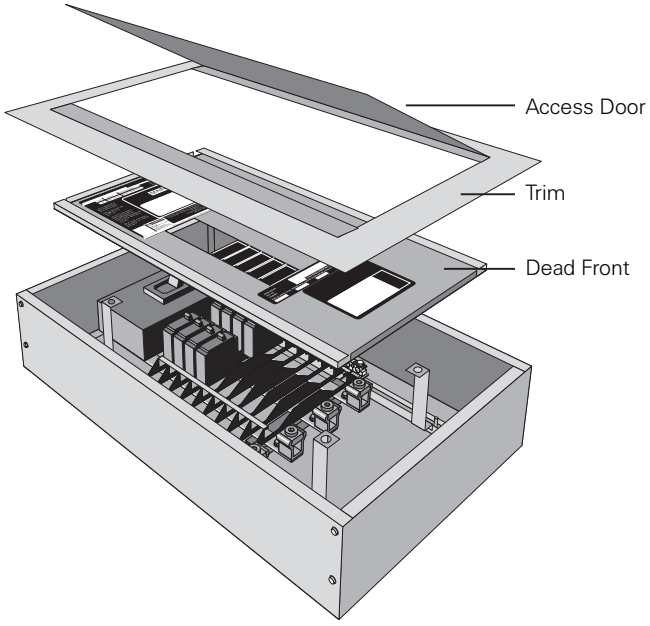
Panel Type	System
P1	208Y/120 V
250 Amps Max (see main device or breaker)	

Provisions are for device types:
100 A max: BL BLH HBL BLF BLHF BLE BLEH LG BAF BAFH BQD
Minimum size UL listed cabinet or cut-out box for this panel: 20"W x 5.75"DP x 56"H

Siemens Energy & Automation, Inc. Atlanta, Ga. USA
For emergency service call 1-800-241-4453 15-A-1034-01 Rev.2

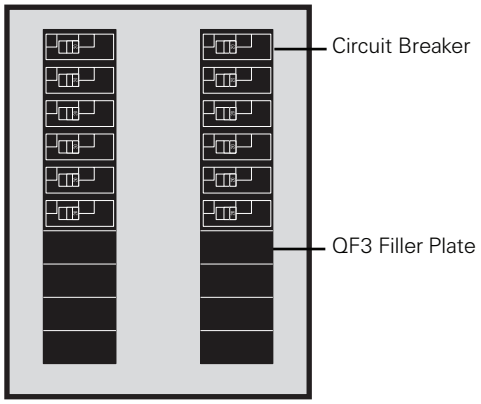
Dead Front and Trim

The **dead front** and **trim** are the front surfaces of the panelboard that cover the interior. The trim includes an access door. These components provide access to the overcurrent devices while sealing off the bus bars and internal wiring from contact.



Filler Plates

QF3 filler plates are used to cover any unused pole spaces not filled by a circuit breaker.



Enclosures

The National Electrical Manufacturers Association (NEMA) has established guidelines for electrical equipment enclosures. Siemens panelboards are supplied as standard in a **NEMA Type 1 enclosure** intended for general purpose indoor use.

The following enclosures are available as an option:

Type 3R Enclosures are intended for outdoor use primarily to provide a degree of protection against rain, sleet and damage from external ice formation.

Type 4X Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

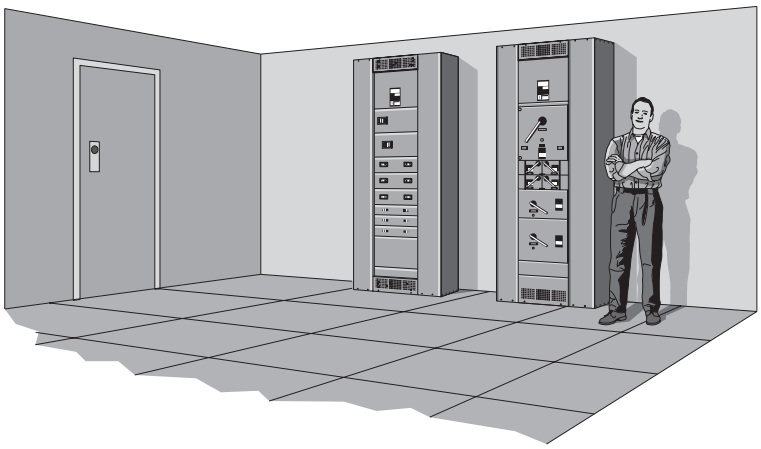
Type 3R/12 Enclosures are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.

Installation

Panelboard installation requires careful planning to ensure a safe environment for personnel and equipment. Article 110.26 of the *National Electrical Code®* covers spaces about electrical equipment, such as panelboards.

The intent of Article 110.26 is to provide enough **working space** for personnel to examine, adjust, service, and maintain energized equipment. Article 110.26 sets requirements for depth, width, and height of a working space.

In addition, Article 110.26 discusses entrance requirements to the working space as well as requirements for dedicated equipment space for indoor and outdoor applications. Refer to this article if you have questions about working space requirements.



Review 2

1. A _____ is a conductor that serves as a common connection for two or more circuits.

2. Circuit protection devices are designed to keep the flow of _____ at a safe level to prevent the circuit conductors from overheating.

3. Three causes of overcurrent are:

   a. _____

   b. _____

   c. _____

4. A Class K fuse has an interrupting rating of _____ amps.

5. A Class ___ fuse has a notch to fit a rejection clip.

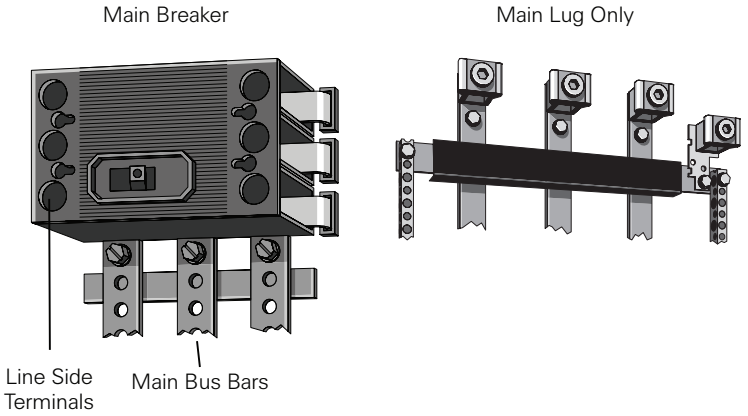
6. Circuit breakers have a continuous _____ rating. This is sometimes referred to as the circuit breaker's ampere rating.

7. The panelboard components designed to seal off the bus bars and internal wiring from contact are the _____ and _____ .

8. The standard enclosure for Siemens panelboards is a NEMA Type ___ enclosure.

Panelboards Main Configurations

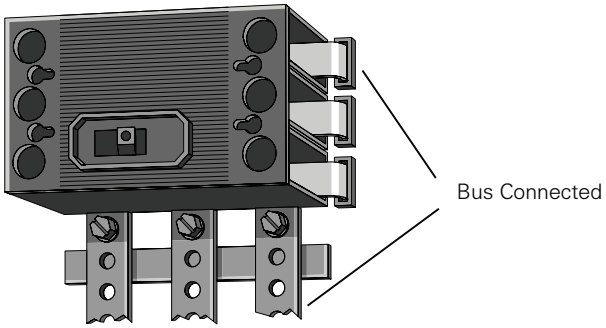
There are three types of panelboard main configurations: **main switch**, **main breaker,** and **main lug only**. In this context, the term switch refers to a fusible switch. Fusible switches are sometimes used as a main device in power panelboards and are discussed later in this course.



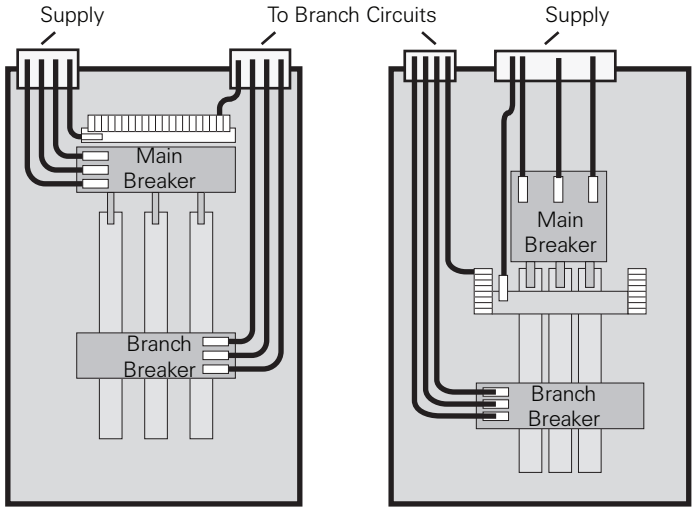
Main Breaker Panelboard

The incoming supply cables of a **main breaker type panelboard** are connected to the line side of the main breaker, which, in turn, feeds power to the panelboard and its branch circuits. The main breaker disconnects power from the panelboard and protects the system from short circuits, overloads, and ground faults (if equipped with ground fault protection).

Siemens main breakers are **bus connected** to the main bus bars. This means there are no cable connections required from the main circuit breaker to the lugs on the main bus bars. Bus connecting provides a higher degree of circuit integrity because there is less chance for loose connections which lead to overheating.



Depending on the panelboard, the main breaker can either be mounted horizontally or vertically.

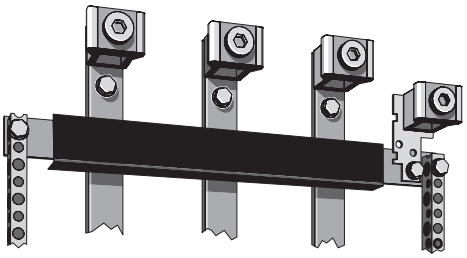


Main Breaker Mounted Horizontally

Main Breaker Mounted Vertically

Main Lug Only Panelboard

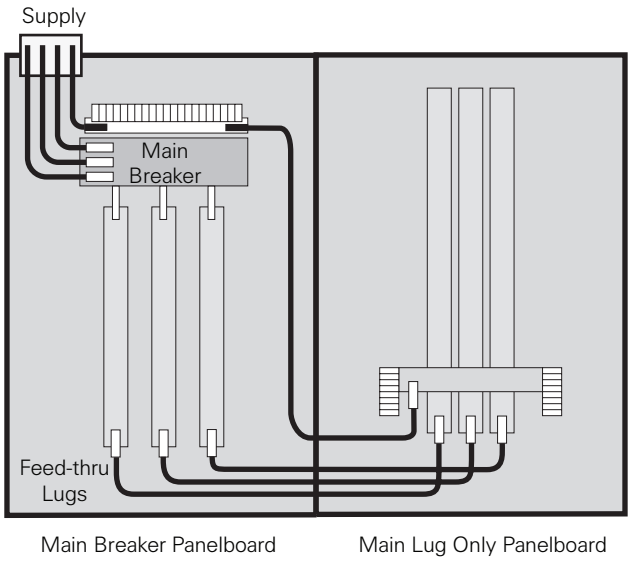
A **main lug only type panelboard** does not have a main circuit breaker. The incoming supply cables are connected directly to the bus bars. Primary overload protection for the panelboard is not provided as an integral part of the panelboard.



Feed-thu Lugs

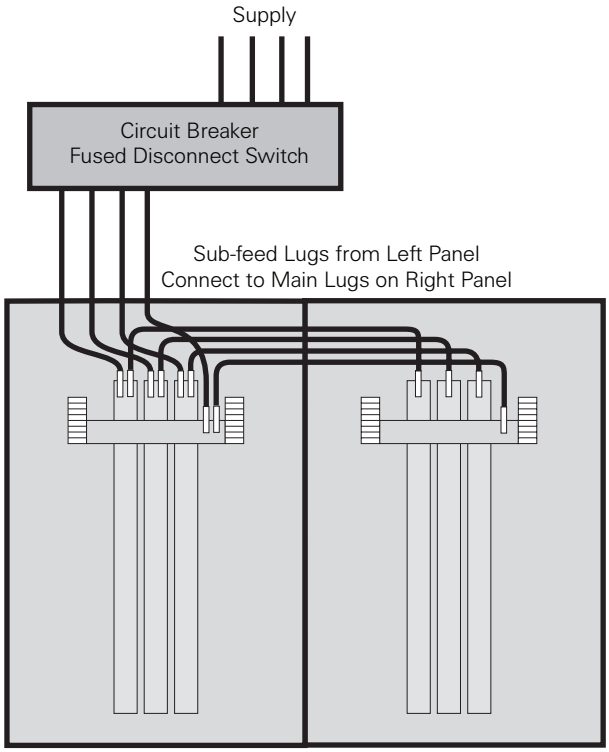
There are a variety of ways a main breaker or main lug only panelboard might be used in the same application. For example, **Feed-thru lugs,** mounted on the opposite end of the main bus from the main breaker, could be used to connect a main breaker panelboard to a main lug only panelboard.

The feed-thru lugs mounted on the main bus of the main breaker panelboard are connected to the main lug only panelboard. The main breaker protects both panelboards from overcurrent.



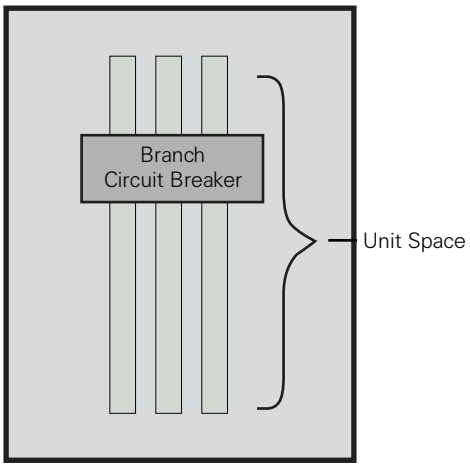
Sub-feed Lugs

Sub-feed lugs are mounted directly beside the main incoming lugs on a panelboard and are used to connect one or more additional panelboards to the same feeder. In the example shown below, two adjacent main lug only panelboards are connected to the feeder through a fusible switch or circuit breaker. Power supplied by the overcurrent protection device is routed to the panelboard on the left and through sub-feed lugs to the panelboard on the right.

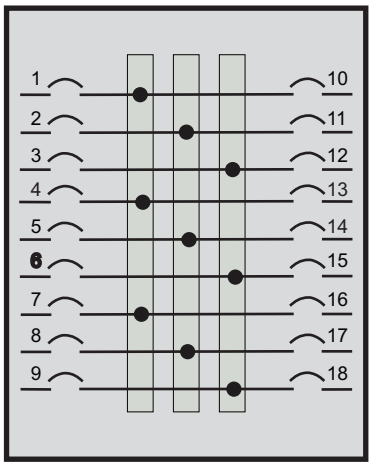


Unit Space and Number of Circuits

Unit space is the area that accommodates the branch circuit breakers in most power panelboards. The number of branch circuits determines the panel dimensions in lighting and appliance branch-circuit panelboards.



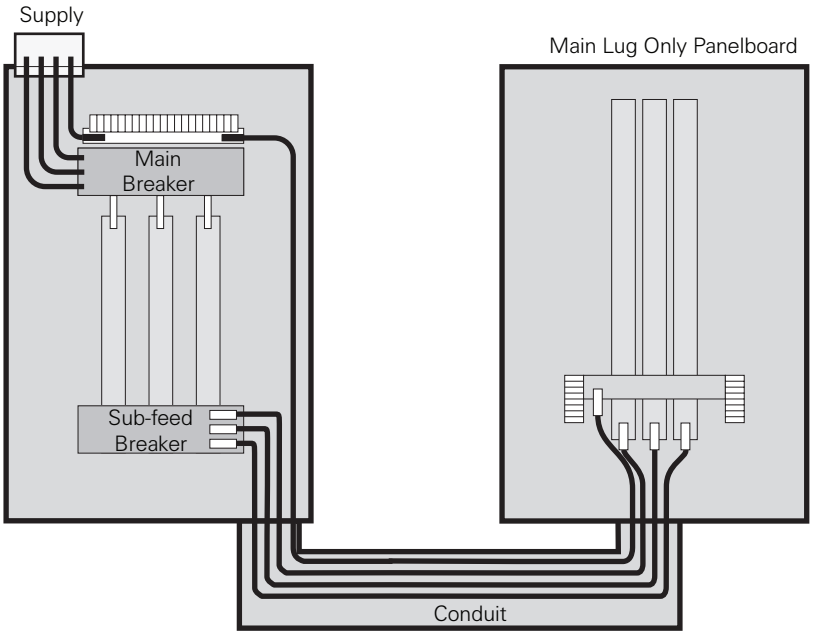
Power Panelboard Unit Space



Lighting and Appliance
Branch Circuit Panelboard
Number of Circuits

Sub-feed Breaker

When an application requires a circuit breaker that is a larger frame size than the branch circuit breakers available and will not fit in a branch circuit location, a **sub-feed breaker** can be used. One possible application is to supply a second panelboard located some distance from the first panelboard. This is, however, is not the only application. A sub-feed breaker can supply any load that a branch circuit breaker can supply.

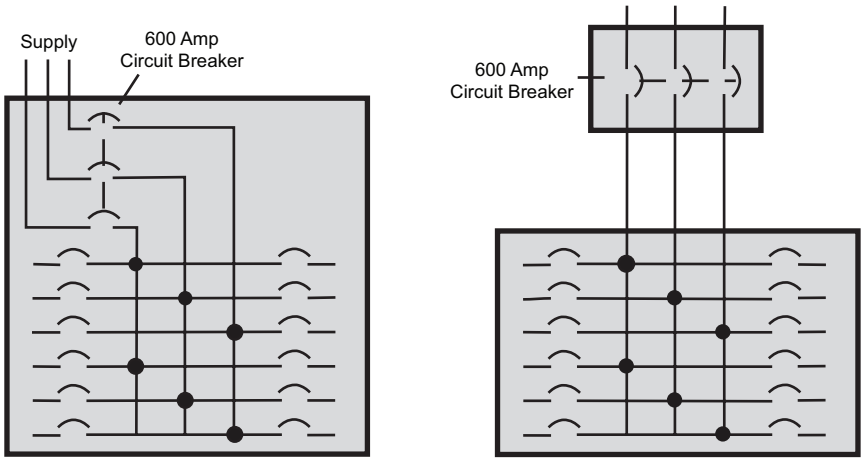


Individual Overcurrent Protection

The *National Electrical Code*® Article 408.36 requires a panelboard to be individually protected against overcurrent and for the overcurrent device to be rated less than or equal to the rating of the panel.

Individual Protection

The following illustration shows two ways individual panelboard overcurrent protection can be accomplished. A main overcurrent protection device, such as a circuit breaker, can be located as an integral part of the panelboard or located on the supply side of the panelboard. In this example, the main breaker and panelboard are both rated for 600 amps.



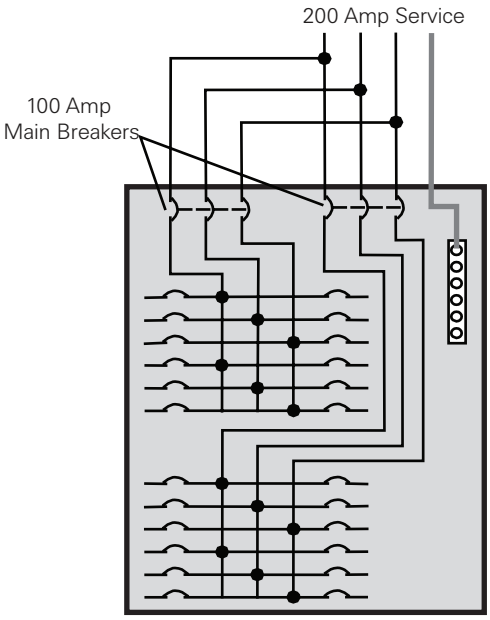
600 Amp Panelboard
Main Overcurrent Protection
is an Integral Part of the Panelboard

600 Amp Panelboard
Main Overcurrent Protection
is Remote from the Panelboard

NEC® Article 408.36 does provide for exceptions to this rule. Refer to the complete article and *NEC*® Article 230.71 for additional details.

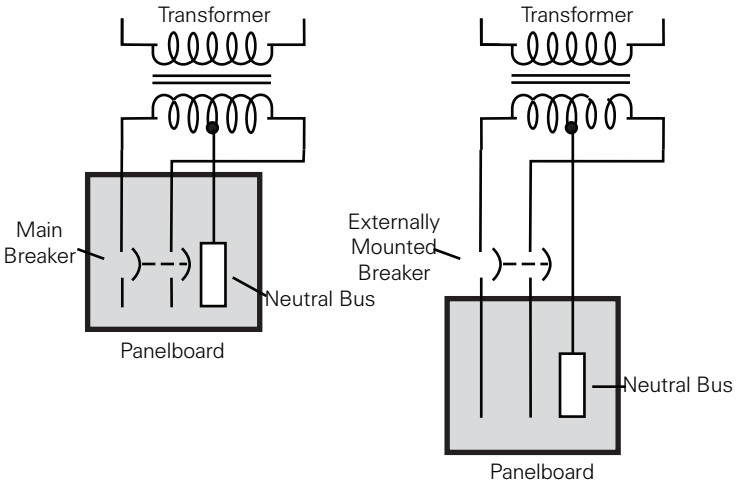
Split Bus

When two main circuit breakers are used in a panelboard, a **split bus** is used. Half of the branch circuits are protected by one main circuit breaker, and the other half are protected by the other main circuit breaker. Keep in mind that the combined ratings for these circuit breakers must be no greater than the panelboard rating.



Panelboard Supplied by a Transformer

Frequently a panelboard is supplied by the secondary of a transformer. According to *NEC*® Article 408.36 (B), individual protection for the panelboard must be provided on the secondary side of the transformer. The overcurrent protection device can be installed either ahead of or in the panelboard.



NEC® Article 408.36 (B) provides an exception to this rule. Refer to this article and Article 240.21 (C)(1) for additional details.

Review 3

1. The three types of panelboard main configurations are main switch, main _____ and main _____ only.

2. The main breaker of a main breaker panel can be mounted _____ or _____.

3. Primary overload protection for a main _____ only type panelboard is not provided as an integral part of the panelboard.

4. _____ lugs**,** mounted on the opposite end of the main bus from the main breaker, can be used to connect a main breaker panelboard to a main lug only panelboard.

5. _____ lugs are mounted directly beside a panelboard's main incoming lugs and are used to connect one or more additional panelboards to the same incoming feeder.

6. A _____ breaker can also be used to supply power to a second panelboard or a load that cannot be supplied by a branch breaker.

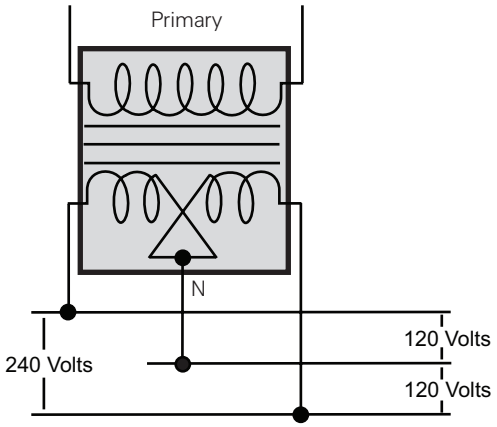
Power Supply Systems

Panelboards receive power from a variety of sources. For example, a downstream panelboard typically receives power from an upstream panelboard or switchboard. However, power for the distribution system originates from a utility power company. Power from the power company is stepped down through a transformer for distribution to a residential, commercial or industrial facility.

There are a number of ways that the transformer secondary windings providing service may be configured. In order to properly select a panelboard, you need to understand which voltage and system will be connected. The following examples show a few of the more common systems, but other systems and voltages are also common.

1Ø3W Power System

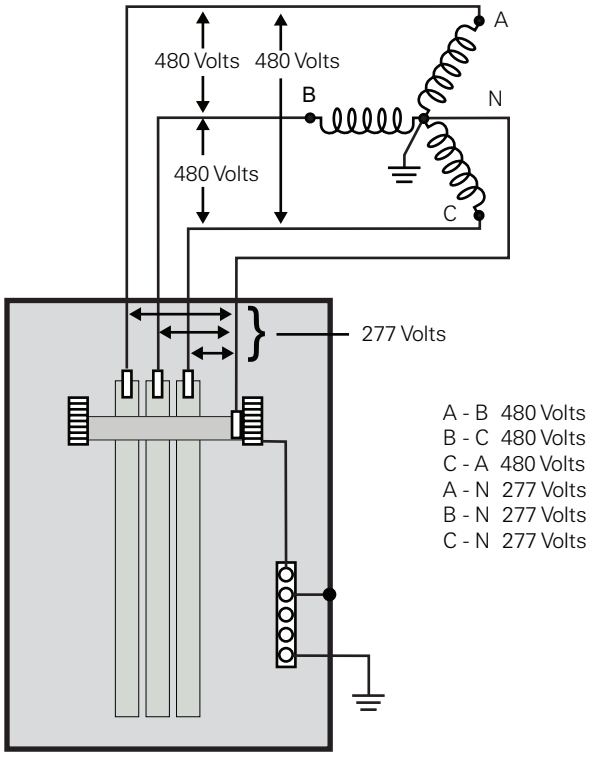
The following diagram illustrates a common single-phase, three-wire (**1Ø3W**) distribution system. As this diagram shows, the voltage between the neutral connection (N) of the transformer secondary and either side of the secondary is 120 V and the voltage across the entire secondary winding is 240 V.



3Ø4W Wye-connected Transformer

The following illustration shows the secondary of a 480 Y/277 V three-phase, four-wire (**3Ø4W**), wye-connected transformer. The "480 Y" indicates the transformer is wye-connected and has 480 volts between any two phases. The "277 V" indicates the voltage between any phase and neutral (N) is 277 V.

If you know the phase voltage for a system like this, you can calculate the phase-to-phase voltage by multiplying 1.732 times the phase-to-neutral voltage (277 V x 1.732 = 480 V).



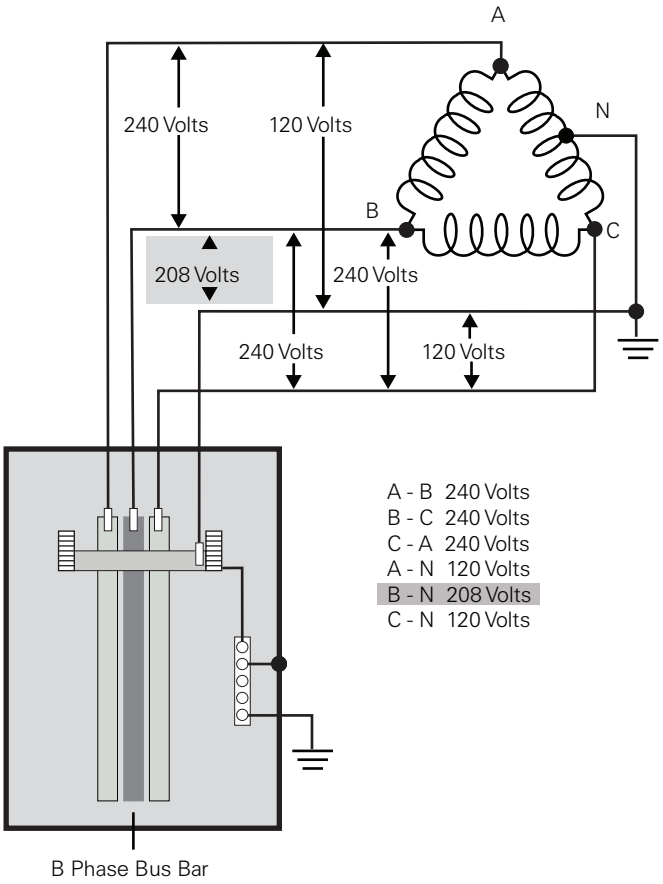
3Ø4W Delta-connected Transformer, BØ High Leg

A three-phase, four-wire (**3Ø4W**), delta-connected secondary works a little differently. The following illustration shows a delta-connected secondary with 240 V phase-to-phase. The midpoint of one phase winding is grounded to provide 120 V between phase A or C and the neutral connection. Between phase B and neutral, however, the voltage is 208 V. As previously discussed, this is referred to as the high leg.

Four-wire, delta-connected transformers are most often wired so that the B phase is the high leg. The high leg can be calculated by multiplying the phase A (or C) to neutral voltage times 1.732 (120 V x 1.732 = 208 V).

It is important to note that not all circuit breakers are suitable for use on the high leg. For example, breakers rated for 120/240 volts can be installed on legs rated for 120 volts, but cannot be installed on the high leg (208 volts).

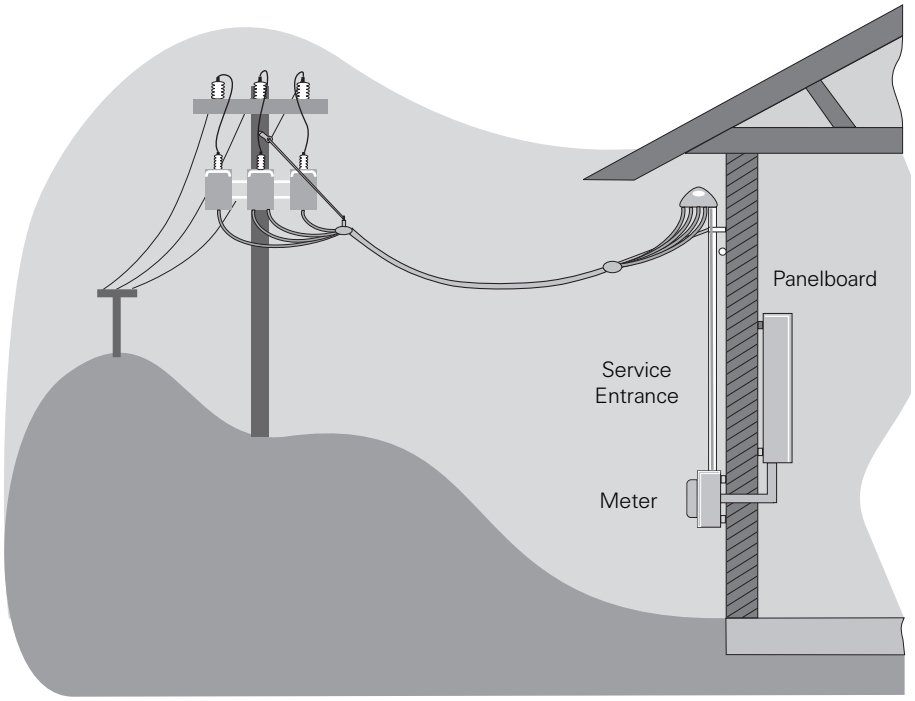
You may remember that *NEC*® Article 110.15 requires that the high leg bus bar or conductor be permanently marked with an orange finish "or by other effective means." This will help prevent someone from connecting a 120 V single-phase load to the 208 V high leg.



Service Entrance Panelboards

Sometimes panelboards are used as **service entrance equipment** for a building. This is the equipment located near where the power supply enters the building. The incoming power supply is connected to this equipment which provides a means to control and cut off the supply.

The *National Electrical Code*® discusses service entrance equipment in Article 230. Panelboards used as service entrance equipment must be approved and labeled as such. Siemens offers panelboards that have been factory labeled as **suitable for service entrance equipment** when *NEC*® requirements are met.



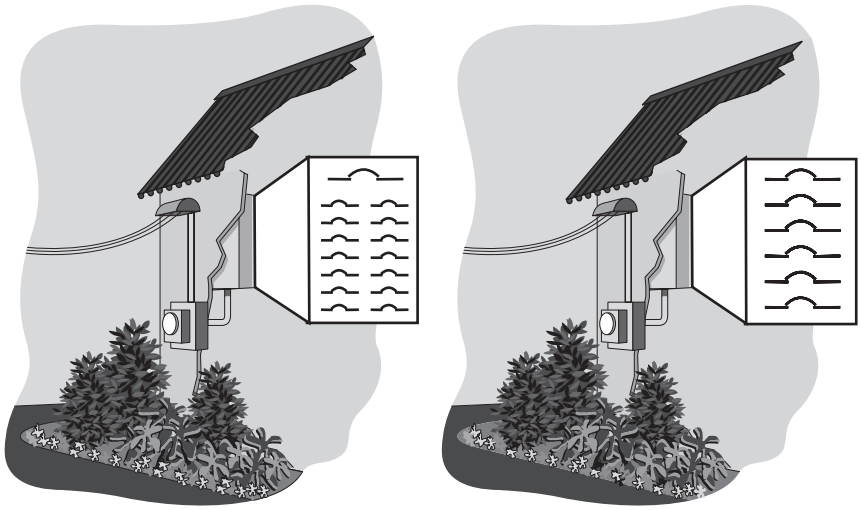
Maximum Number of Disconnects

Service entrance conductors must have a readily accessible means of being disconnected from the power supply. *NEC*® Article 230.71 (A) specifies that for each set of service entrance conductors no more than six switches or circuit breakers can be used to disconnect and isolate the service from all other equipment.

The following illustration shows two ways panelboards can be configured to meet this requirement. In the example on the left, a main breaker panelboard is used. In this example, a single main circuit breaker disconnects power to all equipment being supplied by the service.

In the example on the right, a main lug only panelboard is equipped with up to six circuit breakers to disconnect power to all equipment being supplied by the service.

Regardless of which of these examples is used, each circuit breaker must be clearly labeled to show the load it supplies.



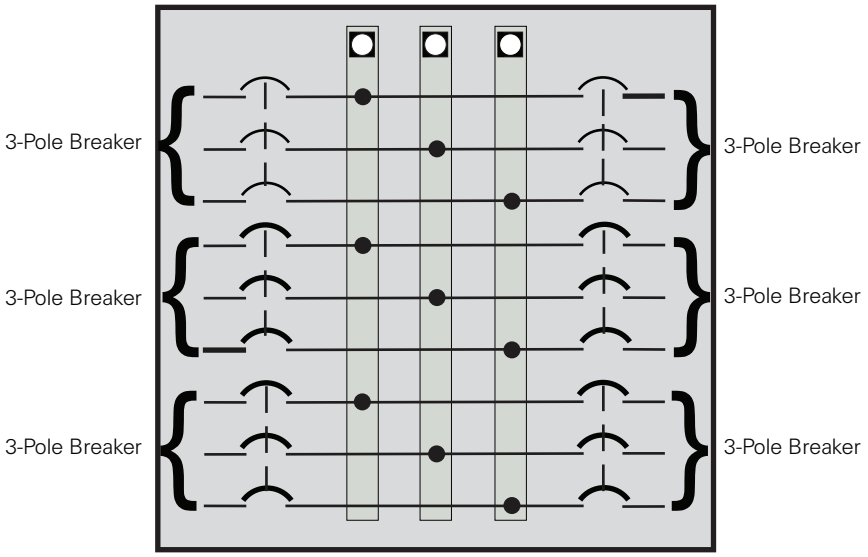
Main Breaker Panelboard with Branch Circuits

Main Lug Only Panelboard with Six Service DIsconnects

Disconnects Versus Poles

NEC® Article 230.71(B) states that *two or three single-pole switches or breakers, capable of individual operation, shall be permitted on multiwire circuits, one pole for each ungrounded conductor, as one multiple disconnect, provided they are equipped with identified handle ties or a master handle to disconnect all conductors of the service with no more than six operations of the hand.*

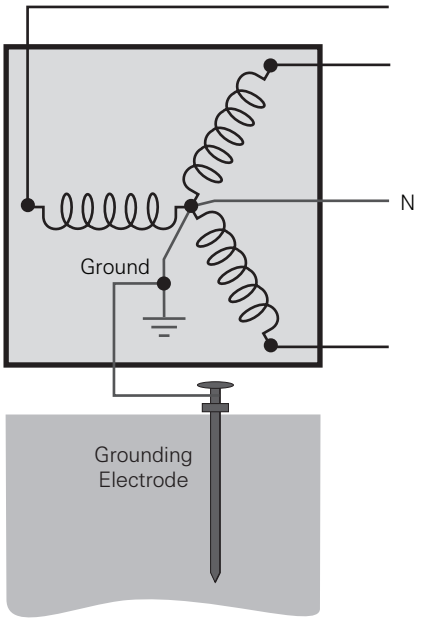
It is important to note that the "six disconnect rule" refers to the number of disconnects and not the number of poles. For example, the main lug only panelboard shown below has 18 poles but only six circuit breakers. Three poles are mechanically linked together to form one disconnect device. Therefore, the service can be disconnected with no more than six operations of the hand. This arrangement meets the "six disconnect rule."



Panelboard Grounding

Grounding is an important aspect of any electrical system and must be considered carefully. Any object that is electrically connected to the earth is grounded, but not all ground connections are intentional. A ground connection can occur accidentally as a result of faulty equipment or wiring. Proper intentional grounding, however, is essential to the safe operation of electrical equipment.

The following illustration, for example, shows the neutral (N) conductor of a wye-connected transformer connected to ground.



There are two objectives to the intentional grounding of electrical equipment:

- Keep potential voltage differentials between different parts of a system at a minimum to reduce the shock hazard.

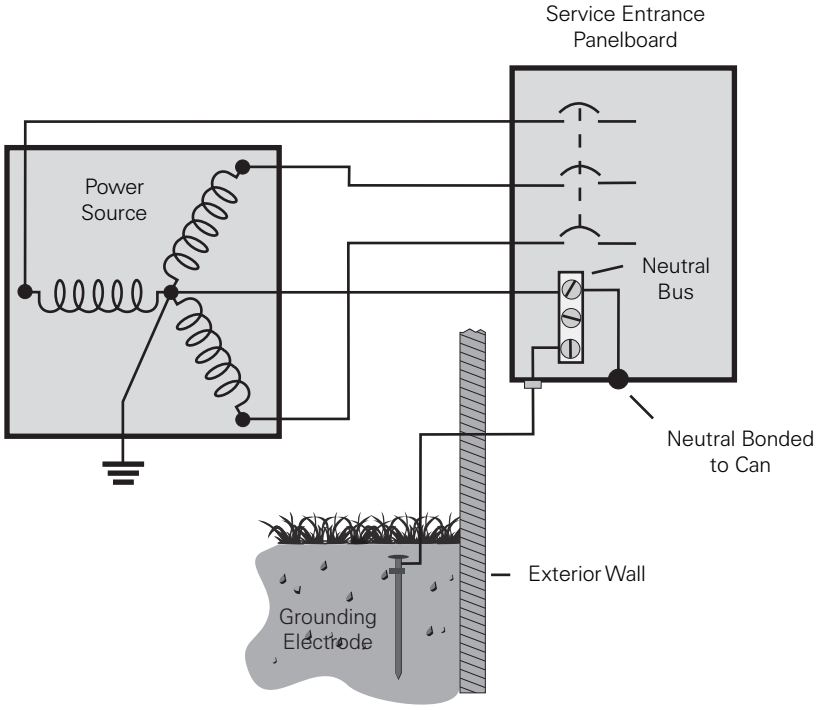
- Keep impedance of the ground path to a minimum. The lower the impedance, the greater the current is in the event of a fault. The greater the current, the faster an overcurrent device will open.

This section provides summary information on panelboard grounding. Refer to *NEC*® Article 250 for more detailed information on **grounding** and **bonding** practices.

Service Entrance Grounding

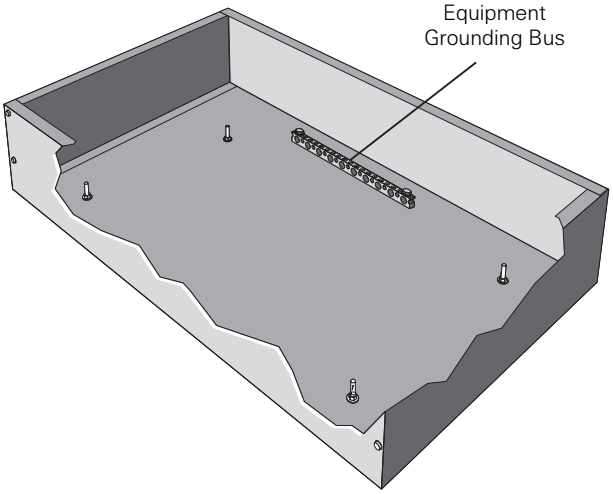
When grounding a panelboard, it is important to provide a direct connection to ground only at the service entrance, never at any downstream equipment. In the following illustration, the neutral is grounded at the service equipment by connecting the neutral conductor to a grounding electrode.

The neutral and the panelboard enclosure are bonded together at the service entrance so that the enclosure is also connected to ground through the grounding electrode connector. **Bonding** permanently joins metal parts to form a low-resistance path for electrical current.



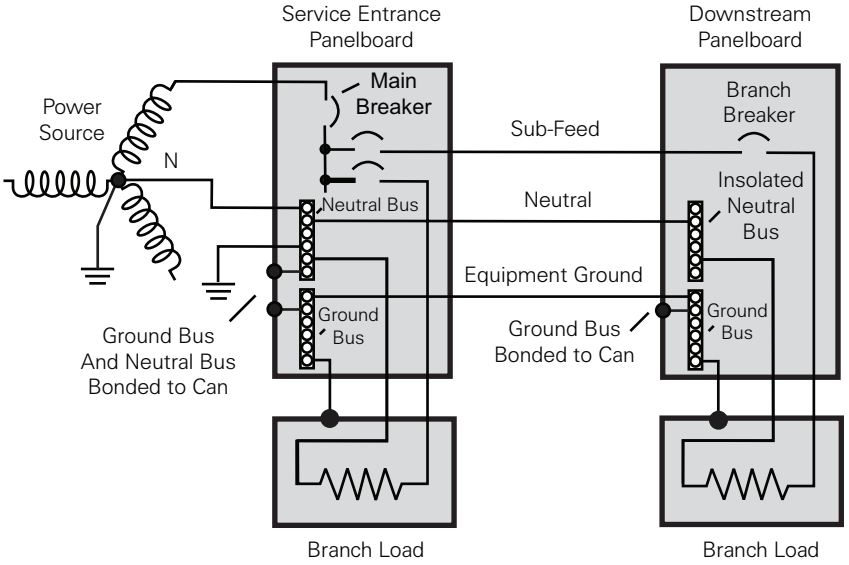
Equipment Grounding Bus

A panelboard may also require an **equipment grounding bus** which is non-insulated and mounted inside the panelboard directly to the can. All feeder and branch circuit equipment that are connected to the equipment grounding bus are at the same potential as the panelboard can. Siemens panelboards come with an equipment grounding bus.



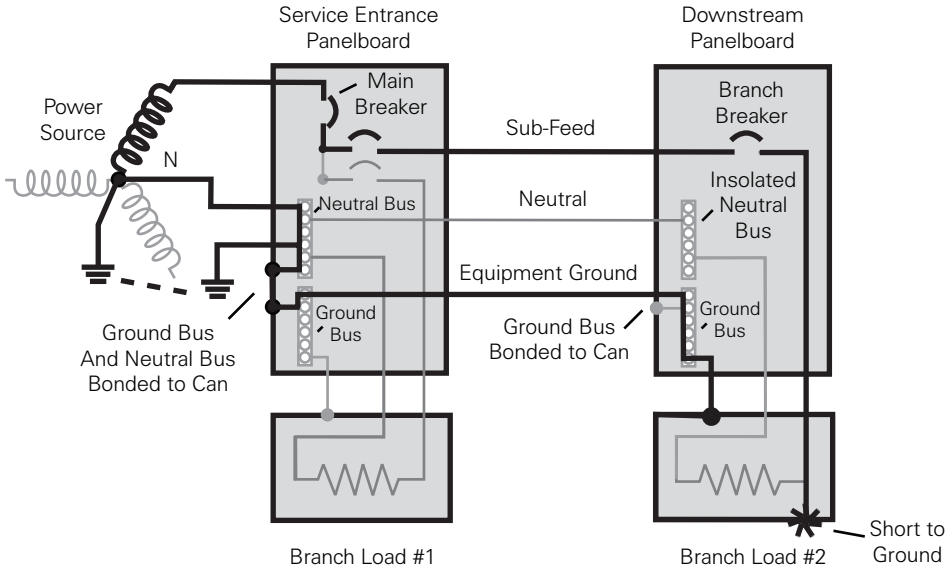
Grounding Panelboards Downstream

The neutral conductor is only connected to ground at the service entrance. As shown in the following illustration, when a downstream panel is used, the neutral is isolated from ground in that panel and connected to the neutral bus in the service entrance panel. In addition, the enclosure of the downstream panel is connected to ground through a grounding conductor which connects to the ground bus in the service entrance panel.



Fault Path

In the following illustration, load #2 has become shorted to its metal enclosure. Fault current is returned to the source through the path indicated. With a properly coordinated system, the branch circuit breaker in the downstream panelboard will open, removing the load from the power source.



Review 4

1. If the secondary of a four-wire, wye-connected transformer is 480 V phase-to-phase, the phase to neutral voltage is _____ V.

2. If the secondary of a four-wire, delta-connected, BØ high leg transformer is 240 volts phase-to-phase, determine the following phase to neutral voltages.

   _____ V from A-N
   _____ V from B-N
   _____ V from C-N

3. According to *NEC*® Article 230.71(A), the maximum number of disconnect devices that can be used to disconnect and isolate the service from all other equipment is ____ .

4. _____ permanently joins metal parts to form a low resistance path for electrical current.

5. The _____ conductor is grounded only at the service entrance equipment, never at any downstream equipment.

Ground Fault Protection

A **ground fault** is a condition in which electrical current unintentionally flows to ground. Because ground faults can cause damage to equipment and can endanger lives, **ground fault protection** is required in some situations.

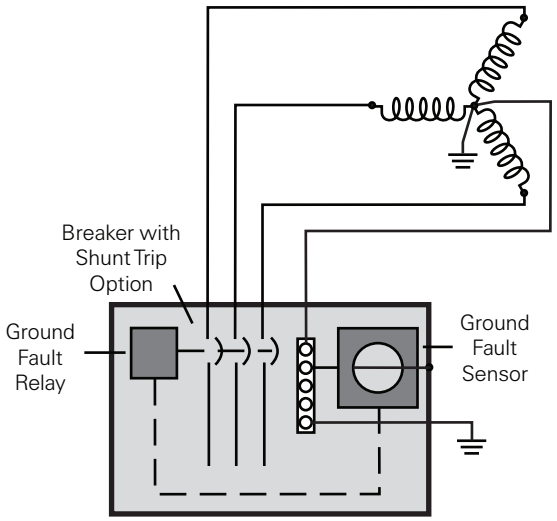
For example, *NEC*® Article 230.95 states that *ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground but not exceeding 600 volts phase-to-phase for each service disconnecting means rated 1000 amperes or more.*

Even when ground-fault protection is not required, it still may be desirable. Not all ground fault protection is the same, however. For example, **ground fault circuit interrupters** designed to provide **life protection** must open a circuit at 5 milliamps (± 1 milliamp), but **ground fault equipment protection** must open a circuit when ground fault current reaches 30 milliamps.

When ground fault protection is incorporated into a panelboard, it is generally through use of circuit breakers with ground fault protection.

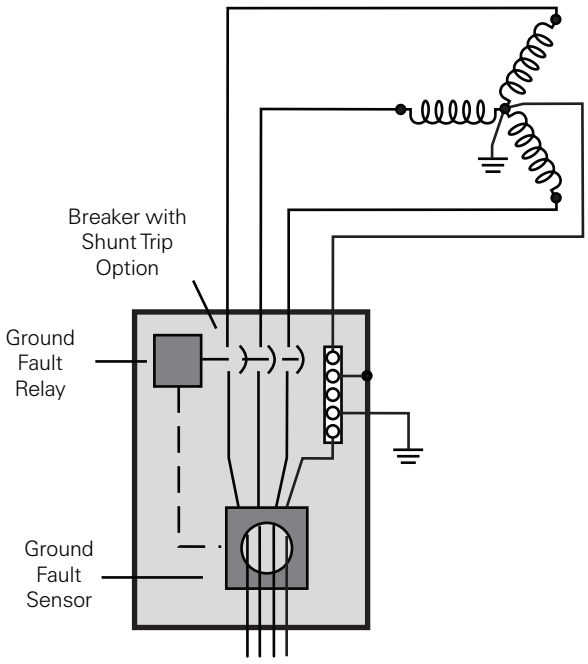
Ground Fault Sensor Around Bonding Jumper

One way a ground fault protector works is with a sensor around the insulated neutral bonding jumper. When an unbalanced current from a line-to-ground fault occurs, current will flow in the bonding jumper. When the current reaches a set level, the shunt trip opens the circuit breaker, removing the load from the line.



Ground Fault Sensor Around all Conductors

Another way a ground fault protector works is with a sensor around all the circuit conductors. When current is flowing normally, the sum of all the currents is zero. However, a ground fault causes an imbalance of the currents flowing in the individual conductors. When the imbalance reaches a set level, the shunt trip opens the circuit breaker, removing the load from the line.



Panelboard Ratings

When selecting panelboards and overcurrent protection devices, it is essential to know the available fault current for an application and the interrupting rating for the protective devices under consideration for use in the panelboard.

Interrupting Rating

The **interrupting rating** is the level of current that a protective device (fuse or circuit breaker) can safely interrupt without damage under specified conditions. The interrupting rating of the panelboard depends on the interrupting rating of the circuit protection devices and the rating method, full rating or series rating.

NEC® Article 110.9 states:

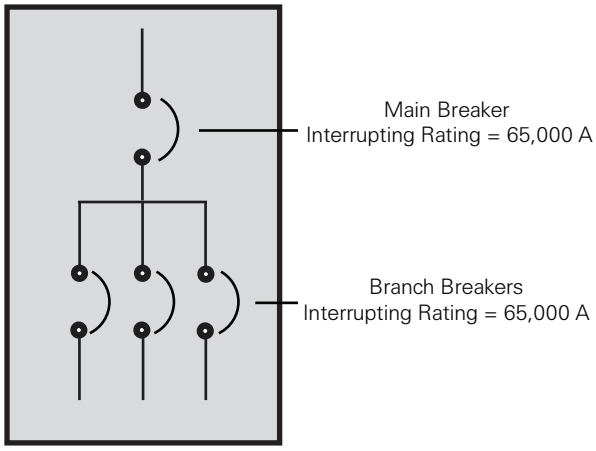
Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment.

Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

There are two ways to meet this requirement, the **full rating method** and the **series rating method**.

Full Rating Method

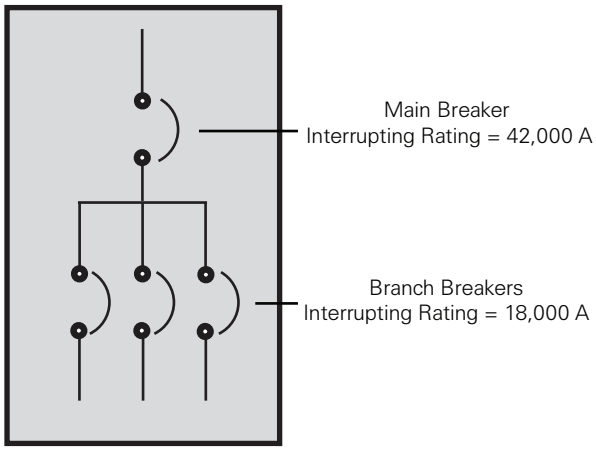
The full rating method requires selection of circuit protection devices with individual interrupting ratings equal to or greater than the available fault current. For example, in the case of a building with 65,000 amperes of fault current available at the service entrance, every circuit protection device must have an interrupting rating of 65,000 A. This example is shown in the following illustration. Note that the main circuit breaker and each branch breaker are rated for 65,000 A.



Series Rating Method

An alterative to the full rating method is the series rating method, which requires that the main upstream circuit protection device must have an interrupting rating equal to or greater than the available fault current of the system, but subsequent downstream circuit protection devices connected in series can be rated at lower values.

For example, a building with 42,000 A of available fault current might have a breaker at the service entrance with an interruption rating of 42,000 A and additional downstream breakers rated at a lower level, but "sufficient for the current that must be interrupted," 18,000 A in this example.



Series Connected Short Circuit Rating

The series rating method is used when the selected series combination of circuit protection devices has been tested and certified by UL. Each series combination of circuit protection devices has a **series connected short circuit rating.** For additional information, refer to the Series Connected Short Circuit Ratings tables in the SPEEDFAX catalog.

Review 5

1. A _____ is a condition in which current unintentionally flows to ground.

2. An _____ rating refers to the level of current that a protective device, such as a fuse or circuit breaker, can safely interrupt.

3. The _____ rating method requires selecting circuit protection devices with individual interrupting ratings equal to or greater than the available fault current.

4. Series connected circuit breaker combinations must be tested and certified by ____.

Siemens P Series Panelboards

Siemens P series of panelboards offers a stepped approach to power distribution. The **P1** fits the majority of lighting and appliance panel needs in a cost effective package. The P1 offers a flexible design that virtually eliminates the impact of common mistakes in feed direction or main lug versus main breaker selection. The next step in the series is the **P2** which offers maximum flexibility and options to fit demanding specifications. The **P3** is also a flexible and innovative panel. Sized more like a lighting and appliance panel for those tight areas, but with the power of a power distribution panel. The **P4** is a mid-sized power distribution panel that can include fusible switches as well as circuit breaker main and branch devices. Finally, the **P5** incorporates larger fusible and circuit breaker main and branch devices to provide maximum power to the distribution system.

Key Panelboard Features	P1	P2	P3	P4	P5
Lighting and Appliance Applications	●	●	●	●	●
Power Panelboard Applications	-	●	●	●	●
Convertible from Top Feed to Bottom Feed or Vice Versa	●	-	-	-	-
Change from Main Lug to Main Breaker or Add Subfeed Breaker Without Changing Enclosure Size	●	-	-	-	-
Space-saving, Horizontally Mounted Main Breaker	Up to 250 A	Up to 250 A	Up to 250 A	●	●
Short-circuit Rating Label Giving Performance Level	●	●	●	●	●
Standard Aluminum Ground Assembly	●	●	●	●	●
Blank End Walls Standard[1]	●	●	●	●	●
Bolted Current-carrying Parts	●	●	●	●	●
Split Neutral	●	●	●	●	●
Connection Accessible From Front	●	●	●	●	●
Screw-type Mechanical Lugs	●	●	●	●	●
Time-reducing Wing Nuts to Secure Interior Without Tools	●	●	●	●	●
Main And Branch Devices Connected With Case-hardened Hardware	●	●	●	●	●
Flush Lock, Concealed Door Hinges/Trim Screws	●	●	●	-	-
Symmetrical Interior Mounting Studs To Eliminate Upside-Down Mounting in Box	●	●	●	●	●
Interior Height Adjustment for Flush Applications	●	●	●	●	●
Mix and Match Fusible Switch Circuit Breaker Capability	-	-	-	●	●
Shallow Depth (Standard)	5.75"	5.75"	7.75"	10.00"	12.75"
Accepts A Wide Range of Fuse Types	-	-	-	●	●
Accepts Vacu-Break Fusible Switch	-	-	-	●	●
Accepts A Wide Range of Circuit Breakers	-	●	●	●	●
Optional Compression Lugs	●	●	●	●	●

● = Standard, - = Not Available

1. Knock-outs available on P1 and P2 5.75" deep x 20" wide boxes and P3 7.75" deep x 24" wide boxes.

General Specifications

P series panelboard interiors are designed to accommodate top or bottom feed. Regardless of which is specified for three-phase panels, the uppermost pole is always on "A" phase, the second pole down is always on "B" phase, and the third pole down is always on "C" phase.

As a standard configuration, branch breakers are mounted at the top of the panel with "spaces" at the bottom, regardless of the direction the panel is fed.

The panel design provides bracing up to 200,000 A. Keep in mind that this is not the interrupting rating of the panel which depends on the circuit breaker configuration.

Description	P1	P2	P3	P4	P5
Max. Voltage	480Y/277V AC Max.	600V AC Max.	600V AC Max.	600V AC Max.	600V AC Max.
	250V DC Max.	500V DC Max.	500V DC Max.	500V DC Max.	500V DC Max.
System	1-phase, 2-wire	1-phase, 2-wire	1-phase, 2-wire	1-phase, 3-wire	1-phase, 3-wire
	1-phase, 3-wire	1-phase, 3-wire	1-phase, 3-wire	3-phase, 3-wire	3-phase, 3-wire
	3-phase, 3-wire	3-phase, 3-wire	3-phase, 3-wire	3-phase, 4-wire	3-phase, 4-wire
	3-phase, 4-wire	3-phase, 4-wire	3-phase, 4-wire		
Main Lugs	125-400A	125-600A	250-800A	400-1200A	800-1600A
Main Breaker	100-400A	100-600A	225-600A	400-800A	800-1200A
Main Switch	Not Applicable	Not Applicable	Not Applicable	100-200A	400-1200A
Branch Ratings	15-100A	15-225A	15-600A	15-600A Breaker	15-1200A Breaker
				30-200A Fusible	30-1200A Fusible

Enclosure Options

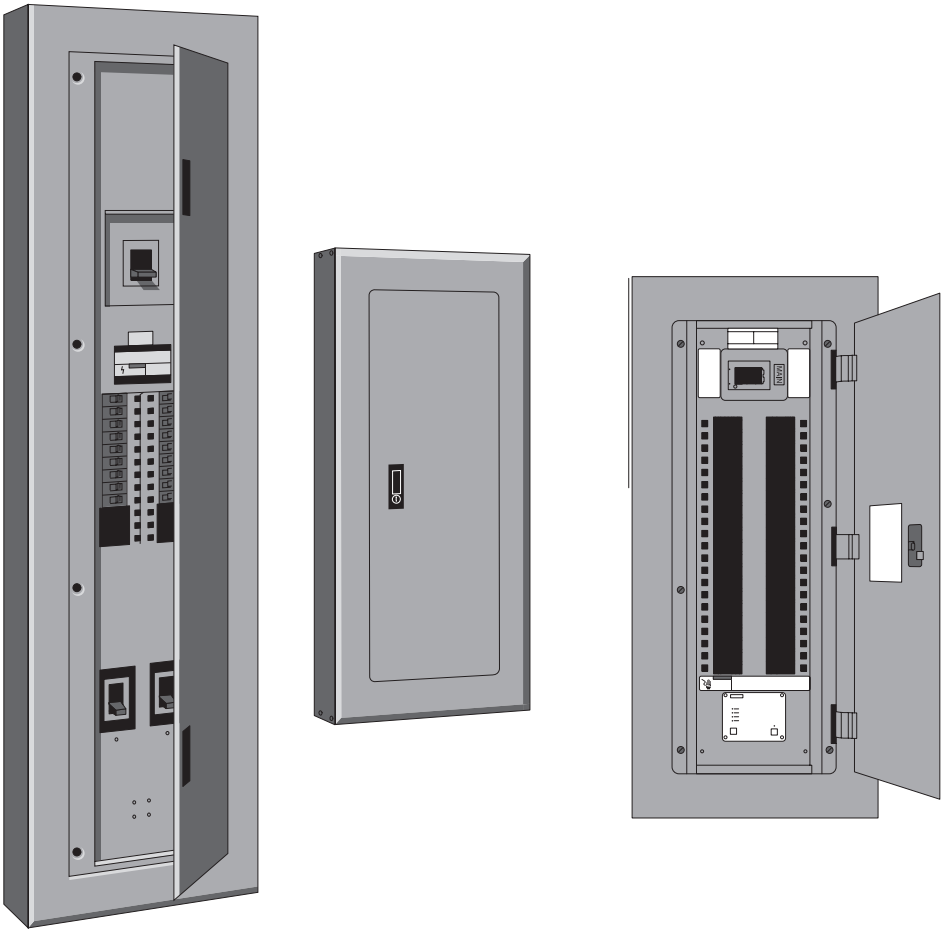
Description		P1	P2	P3	P4	P5
Box	Type 3R/12	●	●	●	●	●
	Type 4, 4X	●	●	●	●	●
	Drip Proof	●	●	●	●	●
	Drip Proof Hood Only	●	●	●	●	●
	Sealed Box	●	●	●	●	●
	Gasketed Trim	●	●	●	●	●
	Wider Box	●	●	●	●	●
	Deeper Box	-	●	●	●	●
Front	Hinged Door	●	●	●	●	●
	Door-in-Door Front	●	●	●	●	●
	Common Front	●	●	●	-	-
	Split Door	●	●	●	-	-
	Special Locks	●	●	●	●	●
	Nameplate	●	●	●	●	●

● = Option, - = Not Available

P1, P2, and P3 Panelboards

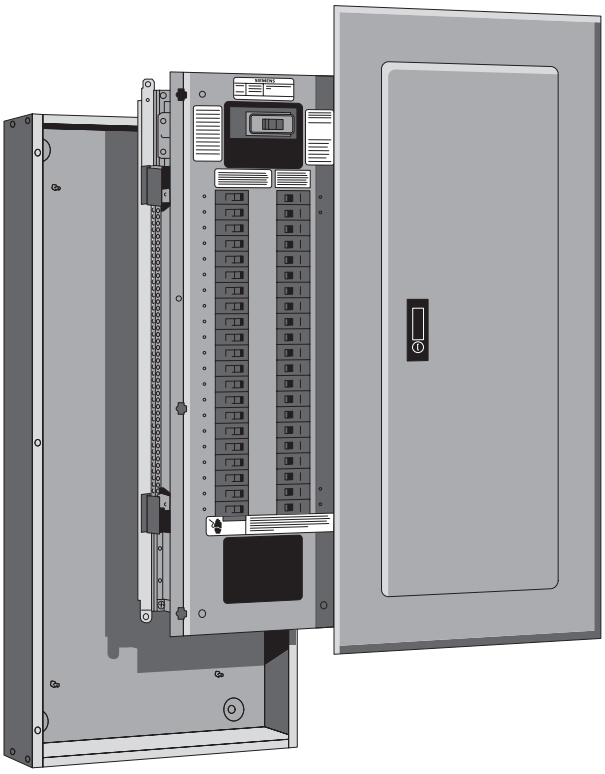
P1, P2, and P3 panelboards are grouped together in this section because they are similar in construction and function. Like all P series panelboards, these panels have symmetrical interior mounting studs to eliminate the problem of upside down mounting. P1, P2, and P3 panelboards feature concealed fasteners and hinges with a flush door lock. P1, P2, and P3 panelboards are designed to be wall mounted.

The standard bussing for P series panelboards is temperature rated aluminum with tin plating, but other bussing options are available.



P1 Panelboards

P1 panelboards are pre-engineered to accept the most common modifications without increasing box height. Refer to the P1 features list below for additional information.



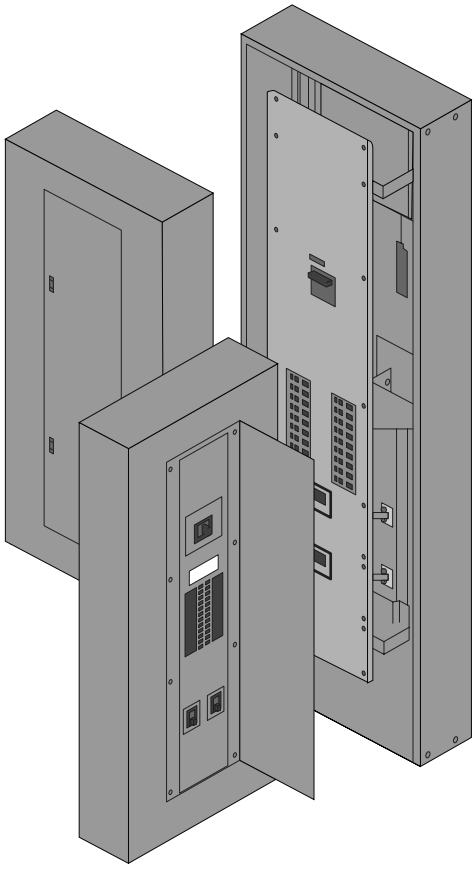
P1 Features

P1 panelboards have the following features:

- Symmetrical interiors - No top or bottom. To change from top to bottom or vice versa, simply invert the interior. The deadfront labeling is always right-side up.
- Field convertible from main lug to main breaker and vice versa with no increase in enclosure height.
- Field adaptability of feed-thru lugs or sub-feed circuit breaker without increasing enclosure height.
- Neutral system is field upgradeable to 200% capacity.
- Bonding provisions are shipped with each panel.
- Suitable for use as service entrance equipment (assuming NEC® compliance.)
- 250 V and 480 Y/277 V versions utilize identical boxes and fronts.

P2 Panelboards

P2 panelboards offer a wide variety of factory-assembled options to meet most lighting and appliance panelboard application requirements. The P2 design also offers the ability to mix breaker frames in unit space up to 250 A to meet many power distribution panel requirements in a much smaller package.



In addition to the standard bussing, P2 panelboard bussing options include temperature rated copper, 750 A/sq. in. aluminum, or 1000 A/sq. in. copper. Bussing is tin-plated, but silver-plated copper is available as an option. These bussing options also apply for P3, P4, and P5 panelboards.

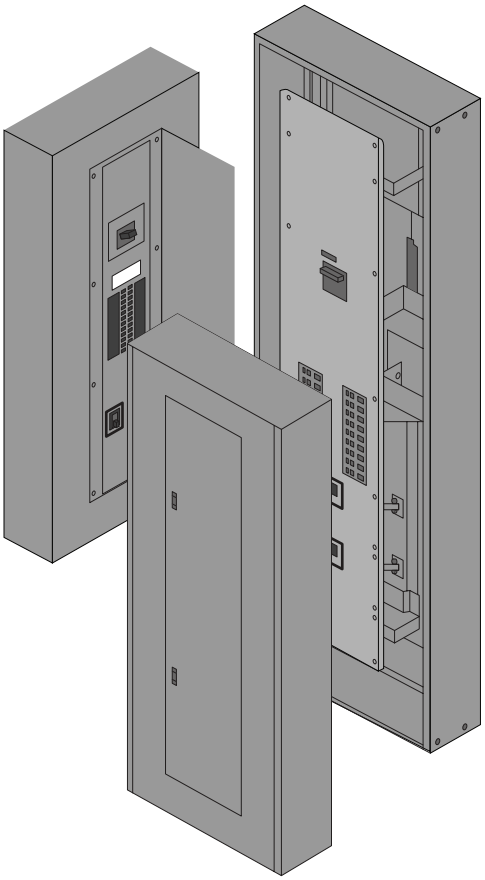
P2 panels are set up around 18, 30, 42, or 54 circuit configurations and allow the user to configure the panel to the smallest possible size. However, blank unit space can also be added, if needed, to allow for future expansions or modifications.

P3 Panelboards

P3 panelboards are small footprint power distribution panelboards designed for use in applications that require more or larger branch devices than a lighting and appliance panelboard can include.

P3 panelboards can include a wide variety of factory assembled options and have the ability to mix and match breaker frames in unit space up to 250 A.

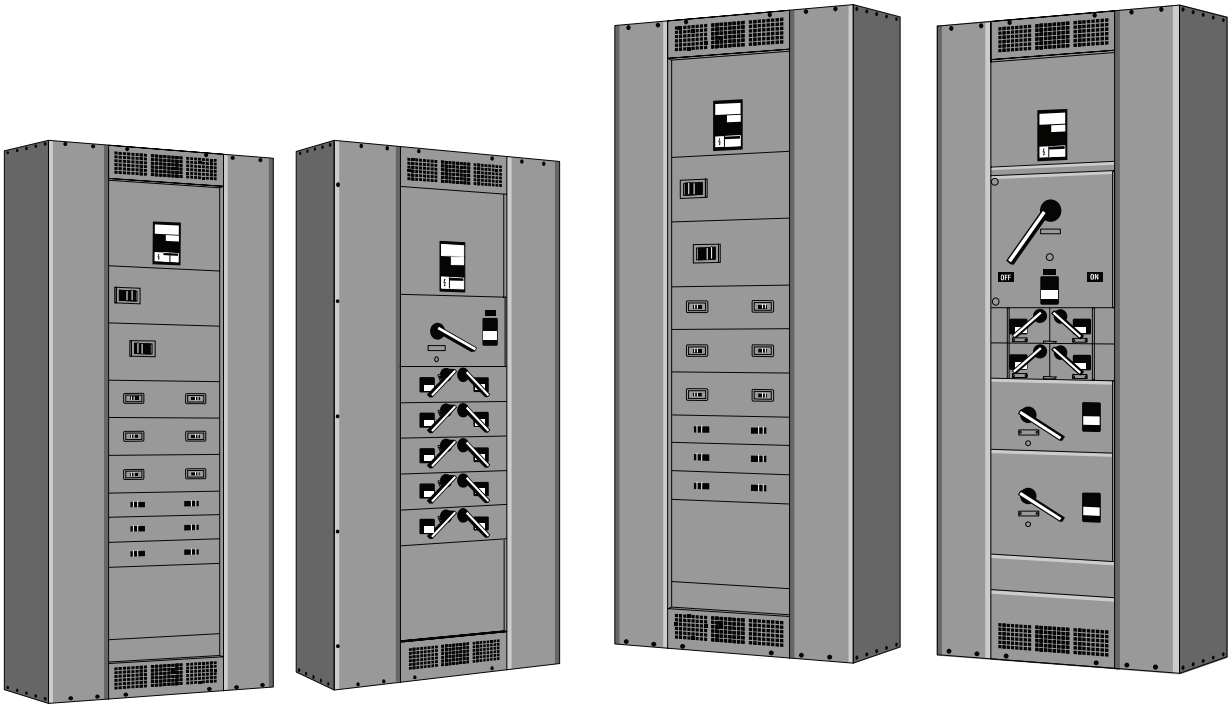
Like other power distribution panels, P3 panelboards can include blank spaces to allow for future expansions or modifications.



P4 and P5 Panelboards

P4 and P5 power panelboards are similar in design and features, but vary in the ratings available. P4 panelboards have a medium footprint to fit applications that require more or larger branch devices and higher current ratings than lighting and appliance panelboards can accommodate. P4 panelboards can incorporate circuit breaker frames in unit space up to 800 A and fusible switches up to 200 A.

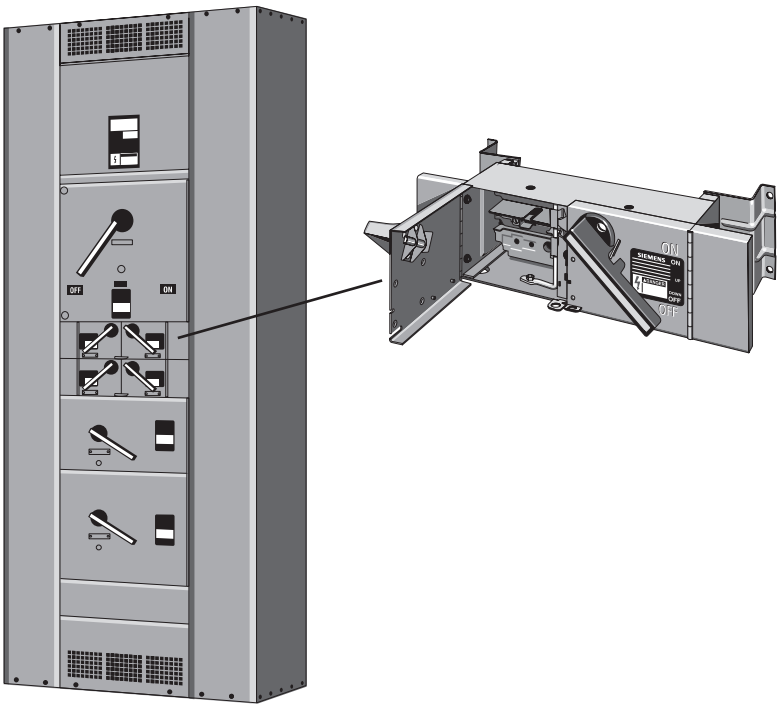
P5 panelboards have the largest footprint of any P series panel, allowing even higher rated main and branch devices, including circuit breaker frames in unit space up to 1200 A and fusible switches up to 1200 A.



Fusible Switch

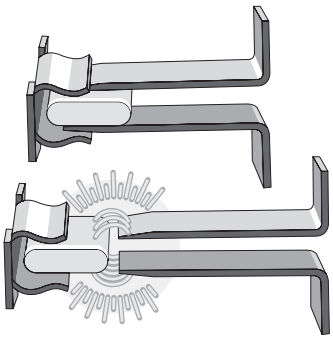
As previously mentioned, P4 and P5 panelboards can incorporate fusible switches or circuit breakers. For additional information on Siemens circuit breakers, refer to **Basics of Circuit Breakers**.

P4 panelboards can accommodate a main fusible switch with ratings from 100 A to 200 A and branch fusible switches with ratings from 30 to 200 A. P5 panelboards can accommodate a main fusible switch with ratings from 400 to 1200 A and branch fusible switches with ratings from 30 to 1200 A.



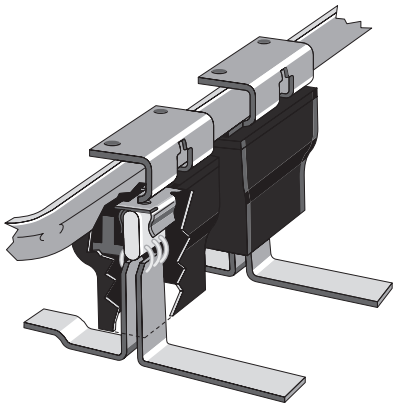
Clampmatic Action

Siemens Vacu-Break fusible switches, through 600 A, feature a **Clampmatic action**. This action holds the current carrying contact surfaces in a vise-like grip. Heat build-up due to current is minimized. When the switch is moved to the "OFF" position, the movable contact snaps from between the jaws providing a quick, clean break. Twin arcs are produced which are smaller and extinguish quicker than a single arc produced by other designs.



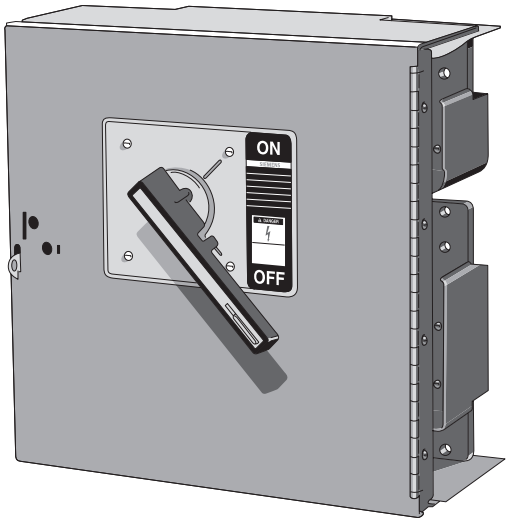
Enclosed Arc Chamber

The contacts are surrounded by an **enclosed arc chamber** which absorbs much of the heat from the arching. The enclosed chamber limits oxygen to more rapidly cool and extinguish arcs.



High Contact Pressure Fusible Switch

Siemens **high contact pressure (HCP) fusible switches** have continuous current ratings from 400 A to 1200 A.



P Series Panelboard Catalog Numbers

The following P series panelboard catalog number description provides summary information. For more detail including information on circuit breaker selection, refer to the SPEEDFAX catalog.

The catalog number provides a description of the panelboard. There are eight parts to the standard P series panelboard catalog number as the example below shows.

1	2	3	4	5	6	7	8
P1	C	42	FX	250	A	T	S

Part 1

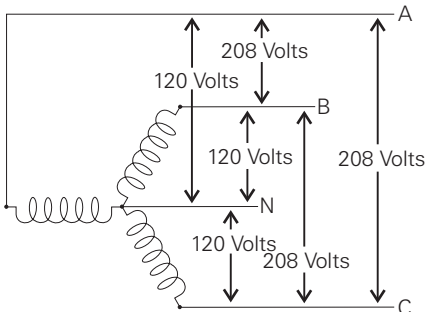
Part 1 identifies the type of panel, P1, P2, P3, P4, or P5. The sample panelboard catalog number shown is a P1 panelboard.

Part 2

Part 2 identifies the voltage and system. The following table shows voltage and system configurations available.

C	208Y/120 3Ø4W Wye AC - All	R	415/240 3Ø4W Wye AC - All
E	480Y/277 3Ø4W Wye AC - All	S	440/250 3Ø4W Wye AC - All
D	240 3Ø3W Delta AC - All	L	600/347 3Ø4W Wye AC - All
F	480 3Ø3W Delta AC - P2, P3, P4, P5	T	230 3Ø3W Delta AC - All
G	600 3Ø3W Delta AC - P2, P3, P4, P5	Z	380 3Ø3W Delta AC - P2, P3, P4, P5
I	347 3Ø3W Delta AC - P2, P3, P4, P5	1	24V DC 1 Pole Branches Only (3) - All
B	240/120 3Ø4W Delta BØ High Leg AC - All	2	24V DC 2 Pole Branches Only (3) - All
Q	240/120 3Ø4W Delta CØ High Leg AC - P2, P3, P4, P5	3	48 V DC 1 Pole Branches Only (3) - All
X	120/240 2Ø5W Single Neutral AC - P2, P3, P4, P5	4	48 V DC 2 Pole Branches Only (3) - All
A	120/240 1Ø3W Grounded Neutral AC (2) - All	5	125 V DC 1 Pole Branches Only (3) - All
H	120 1Ø2W Grounded Neutral AC (2) - All	N	125 V DC 2 Pole Branches Only - All
J	240 1Ø2W No Neutral AC (3) - All	O	125/250V DC 2 Pole Branches Only - All
Y	125 1Ø2W Grounded Neutal AC (2) - P2, P3, P4, P5	P	125/250V DC 2 & 3 Pole Branches - All
Z	500 2W DC - P2, P3, P4, P5	U	120V AC 3Ø3W - All
K	220/127 3Ø4W Wye AC - All	V	240V 3Ø3W Grounded BØ - All
M	380/220 3Ø4W Wye AC - All		

The panelboard identified in the example is configured for a 208Y/120V, 3Ø4W power system. This indicates it is rated for a 208 volt wye-connected secondary. There are 208 volts phase-to-phase and 120 volts phase-to-neutral. It is a 3-phase (3Ø) 4-wire (4W) system.



Part 3

Part 3 indicates the number of circuits in a P1 or P2 type panelboard. If the panelboard is a P3, P4, or P5 type, this number represents the enclosure height in inches. In this example, the panelboard is a P1 with 42 circuits.

Part 4

Part 4 indicates whether the panelboard is a main breaker (2-digit code varies for each different circuit breaker), main lug (ML) or main switch (MS). In this example, FX indicates that the panelboard has an FXD6 main breaker.

Part 5

Part 5 indicates the panelboard current rating. In this example, the panelboard is rated for 250 amps.

Part 6

Part 6 indicates the bus material. The following table shows bus materials available. In this example, A indicates that the panelboard has standard temperature rated aluminum bus bars with tin plating.

Bus Code	Bus Material	Bus Plating	P1	P2	P3	P4	P5
A	Temp. Rated Aluminum	Tin Plated	●	●	●	●	●
B	750 A/sq. in. Aluminum	Tin Plated	N/A	●	●	●	●
C	Temp. Rated Copper	Tin Plated	●	●	●	N/A	N/A
E	Temp. Rated Copper	Silver Plated	N/A	Optional	Optional	●	●
F	Temp. Rated Copper	Tin Plated	N/A	●	●	●	●
G	1000 A/sq. in. Copper	Tin Plated	N/A	●	●	Optional	Optional
H	1000 A/sq. in. Copper	Tin Plated	N/A	Optional	Optional	●	●

● = Default for this bus type, N/A = Not Available

Part 7

Part 7 indicates whether feed location is from the top (T) or bottom (B). In this example, the panelboard is top fed.

Part 8

Part 8 indicates whether the panelboard is surface mounted (S) or flush mounted (F). In this example, the panelboard is surface mounted.

Review 6

1. ___ panelboards can be converted from main lug to main breaker panels or vice versa in the field.

2. Standard bussing for P series panelboards is temperature rated _____ with _____ plating.

3. P2 panelboards are set up around 18, 30, ___, and ___ circuit configurations.

4. ___ and ___ panelboards can accept fusible switches as main and branch devices.

5. Fusible switches used in P series panels are either _____ or HCP switches depending on the required ratings.

6. A P series panelboard part number ending in TF indicates that the panelboard is _____ fed and _____ mounted.

Transient Protection System (TPS)

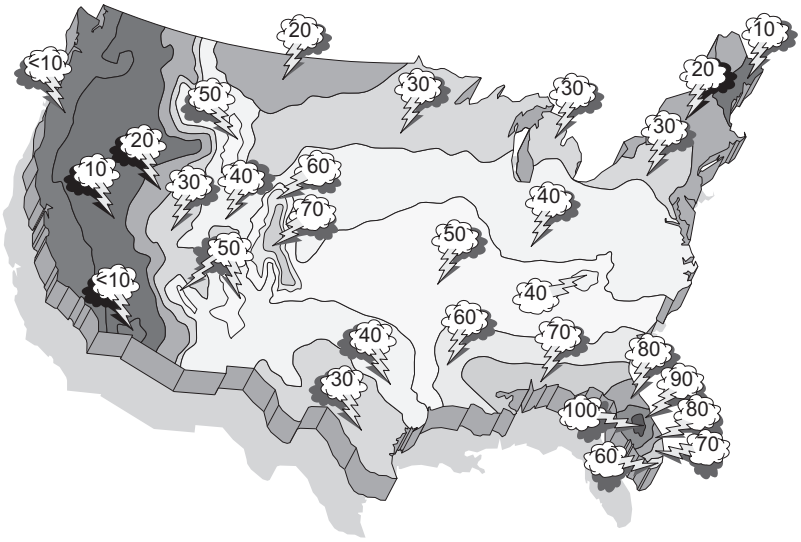
The Need for Protection

Transient voltage spikes appear on an electrical system as a result of lightning and switching transients. These transients are capable of destroying sensitive electronic equipment in commercial and industrial applications.

The most damaging voltage spikes are caused by lightning strikes. Although lightning strikes on high voltage lines are generally dissipated by utility transmission and arresters, a lightning strike on a power line several miles away still has the potential to cause extensive electrical damage. Damage to expensive electrical equipment can be either instantaneous or cumulative.

Number of Thunderstorms

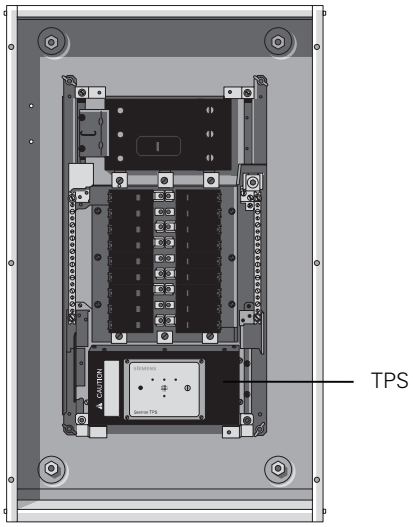
A typical lightning strike consists of 25,000 amps at 30 million volts. The following map shows the approximate mean annual number of days with thunderstorms in the United States.



TPS

Computers and other office equipment are susceptible to the high energy levels from electrical surges caused by lightning or other electrical equipment. Any component between the source of the surge and ground can be damaged. **Siemens TPS transient protection system** channels these damaging voltage spikes to ground to reduce the potential for damage to expensive and sensitive equipment.

Various TPS units are available. For example, a TPS 1 unit can be bolted directly to the bus bars in a P1 panelboard. Once installed, LEDs indicate that the device is working and provide voltage and diagnostic monitoring. There is an audible alarm and test button. Options include a surge counter and a remote monitoring device.



P1 Panel with TPS

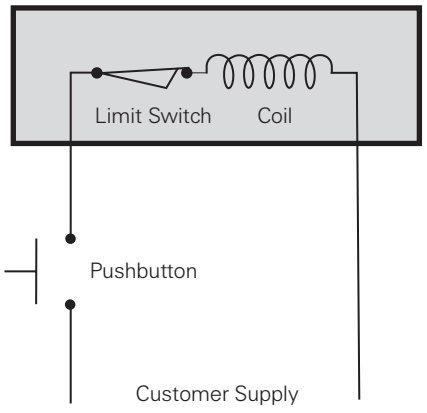
Accessories

Accessories add to the performance of a panelboard or adapt the panelboard for specific application requirements. Various accessories are available for Siemens panelboards. The shunt trip accessory described on this page is just one example of a circuit breaker accessory. Refer to the SPEEDFAX catalog for a complete listing.

Shunt Trip

Some accessories modify the circuit breaker. For example, it is sometimes necessary to trip a breaker from a remote location. This capability might be required for a variety of reasons, such when it is necessary to have a "panic button" that de-energizes machinery for safety reasons. One way to accomplish this is to provide power to the machinery through a circuit breaker equipped with a **shunt trip accessory**.

The shunt trip may be part of the main breaker, which will shut off the entire panelboard, or part of a branch breaker. The shunt trip device consists of a coil in series with a limit switch. When the circuit breaker contacts are closed, the limit switch is closed. Depressing a customer-supplied pushbutton energizes the shunt trip coil, causing the breaker's mechanical latch to disengage the trip mechanism and opening the circuit breaker's contacts. When the circuit breaker's contacts open, the limit switch also opens, removing power from the shunt trip coil. As with any trip, the breaker must be reset manually.

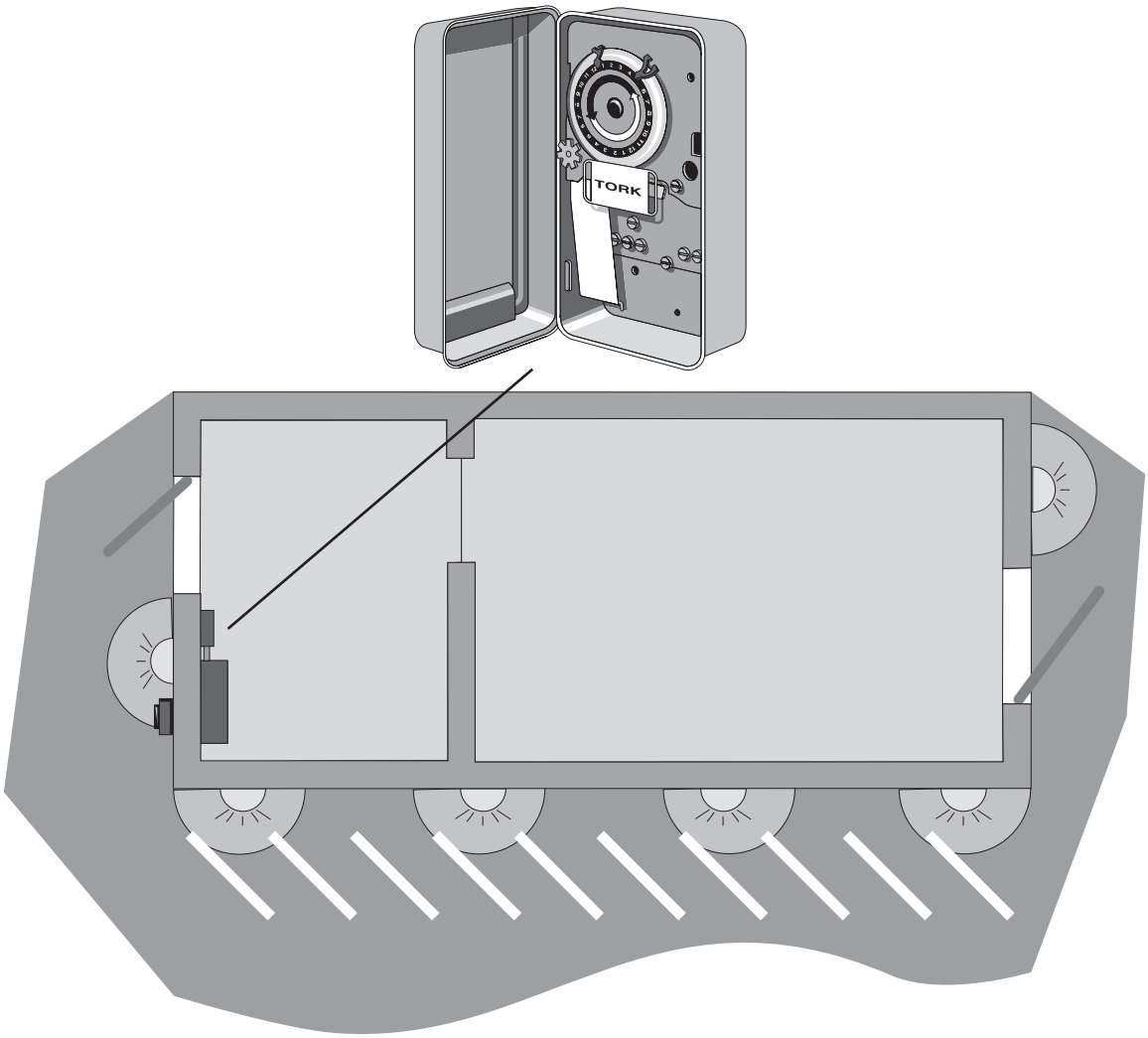


Time Clocks

Tork, Sangamo or Paragon time clocks are available as an external accessory for P1 panelboards and can be mounted internally in P2, P3, P4, or P5 panelboards. Time clocks are available in 1 or 2-pole, single or double throw devices, or 3-pole, single throw. They are rated for a maximum of 277 volts.

A time clock can be used to turn a branch circuit or an entire panelboard on and off at predetermined times. In the following illustration, for example, a time clock connected to a panelboard is used to turn outside lights for a small commercial building on and off.

Tork Time Clock



Additional Modifications

A variety of additional options and modifications are available for Siemens panelboard, but the accessories available and how they are mounted vary depending on the panel model.

For example, when a P1 panelboard application requires remote control of loads, an **ASCO 911 or 920 mechanically-held remote control switch** or **Siemens LEN electrically-held lighting contactor** can be mounted in a separate 23″ relay cabinet as a main disconnect. These devices are also listed as available modifications for P2 and P3 panelboard and can be mounted internally with appropriate space allowance.

For a complete listing of available panelboard options and modifications, refer to the SPEEDFAX catalog.

Information Needed to Order Panelboards

You can minimize the potential for error by making sure that you have the correct answers to the following questions.

1. What is the power system (voltage, phases, number of wires)?

2. What is the interrupting rating required for the panel?

3. Which NEMA type enclosure is required?

4. How many circuits are required for a P1 or P2 panel or what will the enclosure height be for a P3, P4, or P5 panel?

5. Does the panelboard need to be suitable for service entrance? Suitable for use on service entrance Labels (SUSE) are available provided *NEC*® requirements are met. A main lug only panelboard, for example, can only have a maximum of 6 breakers or it violates the 6 disconnect rule.

6. What type of main will the panelboard require: main lug only, main breaker, or main switch?

7. If the panelboard will be a main breaker or main switch type, which main breaker or switch will be use?

8. What amperage rating is required for the panel?

9. What type of bussing will be required?

10. Will the panelboard be top or bottom fed?

11. Will the panelboard be surface mounted or flush mounted?

12. Which branch device types are needed and how many devices of each type will be used.

13. What accessories are needed?

14. What special modifications are needed?

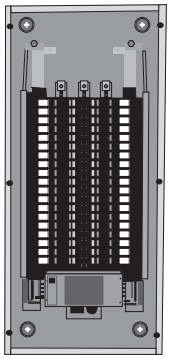
15. When will the equipment be needed?

Additional Types of Panels and Cabinets

In addition to the P series panelboards described in this course, Siemens also offers C1 and C2 column type panelboards, lighting control panels and systems, and telephone and equipment cabinets.

Siemens C1 and C2 panelboards have a narrow width suitable for column mounting. C1 panelboards are designed for a 250 VAC maximum supply and C2 panelboards are designed for a 480Y/277 VAC maximum supply. Both panels are designed for 250 A mains and can be main breaker or main lug only.

Siemens P1 Series Lighting Panel with i-3 Control Technology provides a compact solution for controlling branch lighting circuits via a time schedule or external signal. The panel incorporates i-3 components and can be sized for 18, 30, or 42 circuits. i-3 technology can function independently or can be networked to a building automation system.



Siemens telephone and equipment cabinets are 5.75" deep, 20 or 24" wide, and vary in height from 23" to 59". These cabinets feature Siemens FAS latch fronts with concealed hinges and fastening screws.

For additional information about these additional panels and cabinets or other products described in this course, refer to the SPEEDFAX catalog.

Review 7

1. A _____ is a circuit breaker accessory designed to trip a breaker from a remote location.

2. _____ are available as an external accessory for P1 panelboards or mounted internally in P2, P3, P4, or P5 panelboards when an application requires a panelboard to be turned on and off at predetermined times.

3. A _____ can be mounted in a separate cabinet to function as a main disconnect for a panelboard.

4. Siemens _____ clamps damaging voltage spikes to reduce the potential for damage to expensive and sensitive equipment.

Review Answers

Review 1	1) power distribution; 2) b; 3) 408; 4) Only 18 devices (poles) and more than 10% of these poles are rated at 30 amps or less.
Review 2	1) bus; 2) current; 3) overload, short circuit, ground fault; 4) 50,000 amps; 5) R; 6) current; 7) deadfront and trim; 8) 1.
Review 3	1) breaker, lug; 2) horizontally or vertically; 3) lug; 4) Feed-thru; 5) Sub-feed; 6) sub-feed.
Review 4	1) 277; 2) 120 A-N, 208 B-N, 120 C-N; 3) 6; 4) Bonding; 5) neutral.
Review 5	1) ground fault; 2) interrupting; 3) full; 4) UL.
Review 6	1) P1; 2) aluminum, tin; 3) 42, 54; 4) P4, P5; 5) Vacu-Break; 6) top, flush.
Review 7	1) shunt trip; 2) Time clocks; 3) remote control switch; 4) transient protection system.

Final Exam

The final exam is intended to be a learning tool. The book may be used during the exam. A tear-out answer sheet is provided. After grading the test, mail the answer sheet in for grading. A grade of 70% or better is passing. Upon successful completion of the test a certificate will be issued. Those receiving a score of less than 70% will be provided a second test.

1. Which of he following statements does not agree with the *NEC*® definition of a panelboard?

   a. Used to control, light, heat, or power circuits.
   b. Placed in a cabinet or cutout box.
   c. Mounted in or against a wall.
   d. Accessible from the front or rear.

2. Panelboards are covered by *NEC*® article _____.

   a. 376 b. 402
   c. 408 d. 424

3. The interrupting rating of a Class R fuse is _____ amps.

   a. 10,000 b. 50,000
   c. 100,000 d. 200,000

4. A _____ is used in a Siemens panelboard to cover any pole spaces not filled by a circuit breaker.

   a. dead front b. QF3 filler plate
   c. trim d. label

5. A NEMA _____ enclosure is intended for outdoor use and provides a degree of protection against rain, sleet and damage from external ice formation.

   a. Type 1 b. Type 3R
   c. Type 4X d. Type 12

6. Panelboard working space dimension requirements are provided in *NEC®* Article _____.

   a. 110.26 b. 230.71
   c. 240 d. 408.16

7. Which of the following is not a common type of panelboard main configuration?.

   a. main breaker b. main switch
   c. main contactor d. main lug only

8. On a three-phase, four-wire, wye-connected transformer with a secondary voltage of 480 volts phase-to-phase, the phase-to-neutral voltage is _____ volts.

   a. 277 b. 240
   c. 208 d. 480

9. On a three-phase, four-wire, delta-connected transformer with a B phase high leg and a phase-to-phase voltage of 240 volts, the high leg voltage is _____ volts.

   a. 120 b. 208
   c. 240 d. 277

10. According the NEC ®, the maximum number of switches or circuit breakers required to disconnect and isolate the service from all other equipment on service-entrance equipment is ___ .

    a. 1 b. 2
    c. 4 d. 6

11. The neutral conductor is _____ grounded at the service-entrance panelboard.

    a. always b. never
    c. rarely d. often

12. The neutral conductor is _____ grounded at panelboards downstream from the service-entrance panelboard.

    a. always b. never
    c. rarely d. often

13. Article 230.95 of the NEC® requires ground-fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground and not exceeding 600 volts phase-to-phase for each service disconnecting means rated _____ amperes or more.

    a. 100 b. 250
    c. 1000 d. 2500

14. The _____ rating method requires selection of circuit protection devices with individual interrupting ratings equal to or greater than the available fault current.

    a. individual b. group
    c. series d. full

15. _____ panelboards are designed to be field convertible from main lug only to main breaker and vice versa.

    a. All P series b. P1, P2, and P3
    c. P1 d. P2

16. _____ panelboards are designed to accommodate fusible switches.

    a. All P series b. P1, P2, and P3
    c. P5 only d. P4 and P5

17. Position 3 in the part number of a P2 panelboard indicates the _____.

    a. number of circuits b. height in inches
    c. width in inches d. current rating

18. Which of the following is not a bussing option for P series panelboards.

    a. silver plated aluminum b. silver plated copper
    c. 750 A/sq. in. aluminum d. 1000 A/sq. in. copper

19. A _____ is an accessory used to trip a circuit breaker remotely.

    a. remote control switch b. shunt trip
    c. time clock d. contactor

20. Siemens _____ system is used to reduce the potential for damage to sensitive equipment resulting from voltage surges.

a. LCP
b. C1
c. TPS
d. LEN

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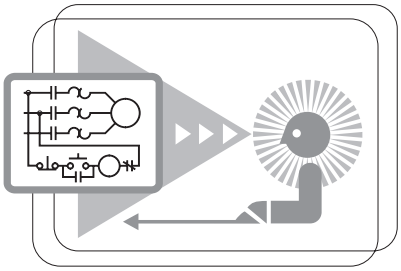

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