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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 Load Centers** and related products.

Upon completion of **Basics of Load Centers** you should be able to:

- Explain the role of a load center in residential power distribution
- Distinguish between the terms panelboard and load center
- Explain the need for circuit protection
- Identify various components of a Siemens load center
- Distinguish between a main breaker and main lug only load center
- Identify various power supply systems used in residential applications
- Explain the use of load centers used as service-entrance equipment
- Describe the proper grounding techniques of service entrance and downstream panelboards
- Describe the proper use of GFCI and AFCI circuit breakers in a load center
- Describe the proper use of the circuit breaker surge arrester in a load center
- Identify various ratings of Siemens load centers

This knowledge will help you better understand customer applications. In addition, you will be able to describe products to customers and determine important differences between products. We recommend that you complete **Basics of Electricity** before attempting **Basics of Load Centers**.

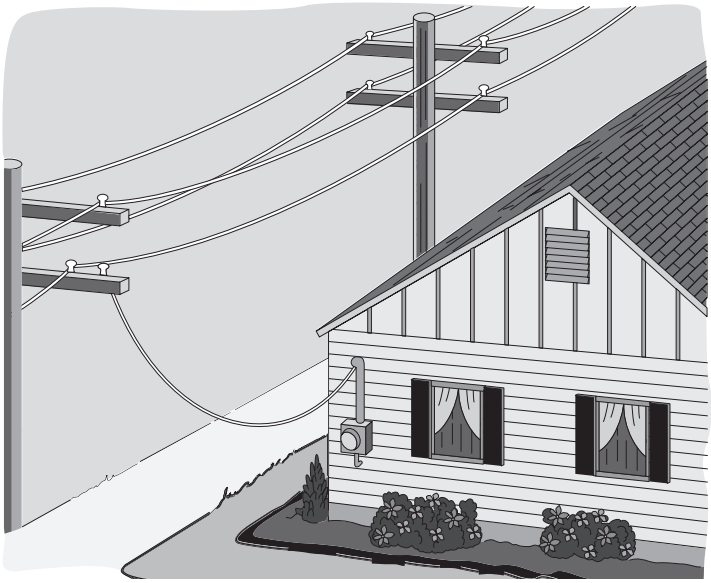
If you are an employee of a Siemens Energy & Automation authorized distributor, fill out the final exam tear-out card and mail in the card. We will mail you a certificate of completion if you score a passing grade. Good luck with your efforts.

Residential Power Distribution

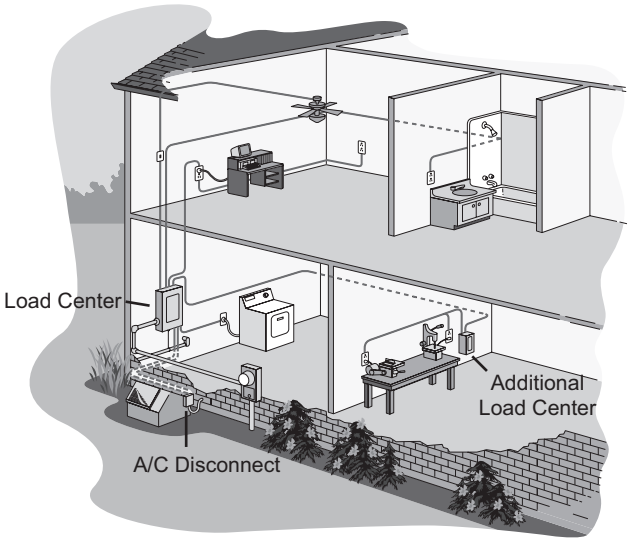
A **power distribution system** distributes electrical power throughout a building. Power distribution systems are used in every residential, commercial, and industrial building.

Residential 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 meter that records the electrical energy used.

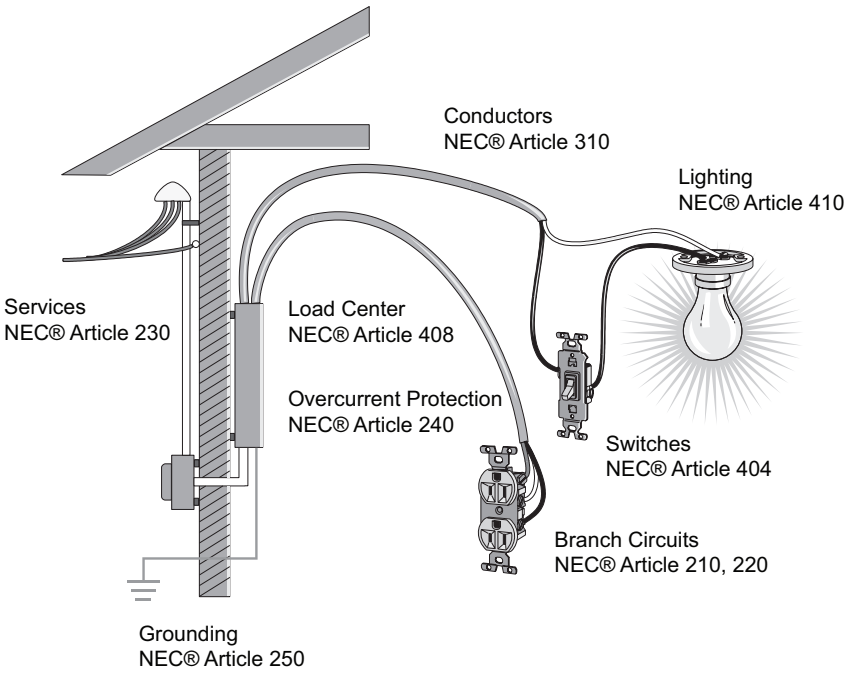


The incoming power then goes to a load center which provides circuit control and overcurrent protection. The power is distributed from the load center to various branch circuits for lighting, appliances, and electrical outlets. Careful planning is required so that the power distribution system safely and efficiently supplies adequate electric service for present and possible future needs.



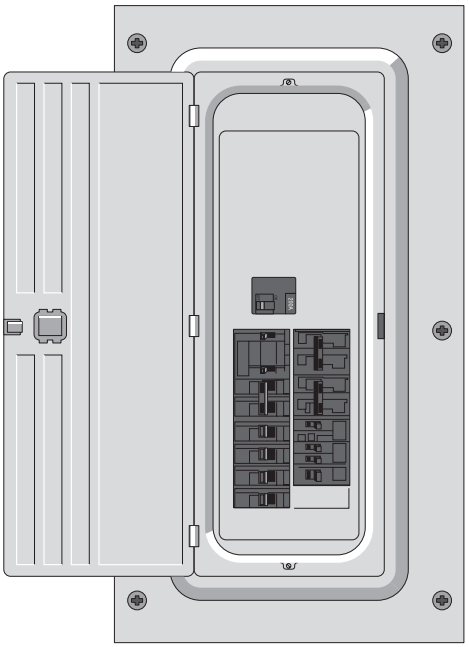
The National Electrical Code®

The **National Electrical Code® (NEC®)** is used extensively in the electrical industry. **Article 408** covers panelboards. Other articles shown in the following illustration cover related topics.



Load Centers

Load center is an industry term that applies to the types of **panelboards** used in residential or light commercial applications. The *National Electrical Code®* makes no distinction between a panelboard and a load center. Rules and definitions that apply to panelboards also apply to load centers.

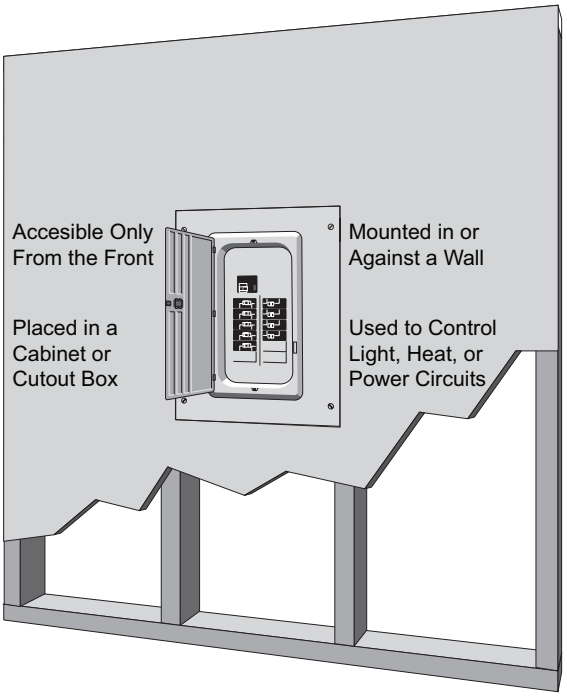


Definition

The *National Electrical Code®* 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).

According to this definition, panelboards, including load centers, 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



Review 1

1. A _____ system distributes electrical power throughout a building.

2. *NEC®* Article _____ covers panelboards which includes load centers.

3. Overcurrent protection is covered by *NEC®* Article ___.

4. The *National Electrical Code®* makes no distinction between a panelboard and a load center.

   a. true
   b. false

5. Which of the following statements does not meet the *NEC®* definition of a panelboard.

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

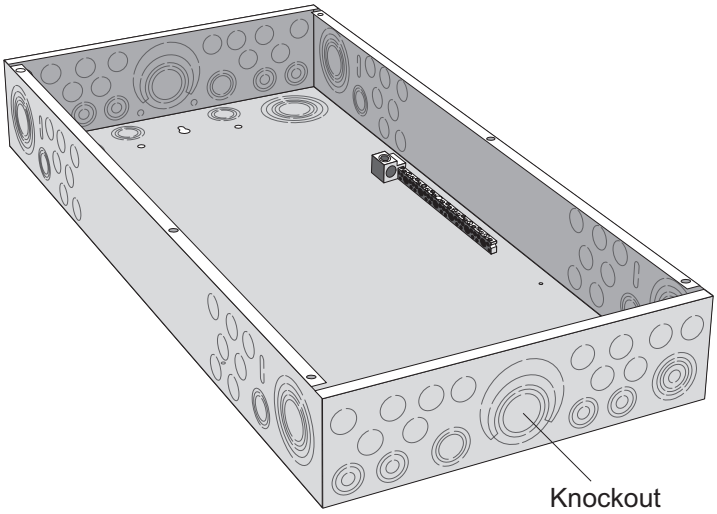
Load Center Construction

Load centers are constructed of the following three parts: **enclosure**, **interior**, and **trim**.

Enclosure

The **enclosure** is typically constructed of cold rolled steel (for indoor use) or galvanized steel (for outdoor use). Together with the trim, the enclosure is designed to provide component and personnel protection.

Knockouts are stamped into the enclosure to provide a convenient means of creating holes for use in routing electrical wiring. Approved cable clamps or conduit hubs are used in the holes to secure and protect the cable and conductors.

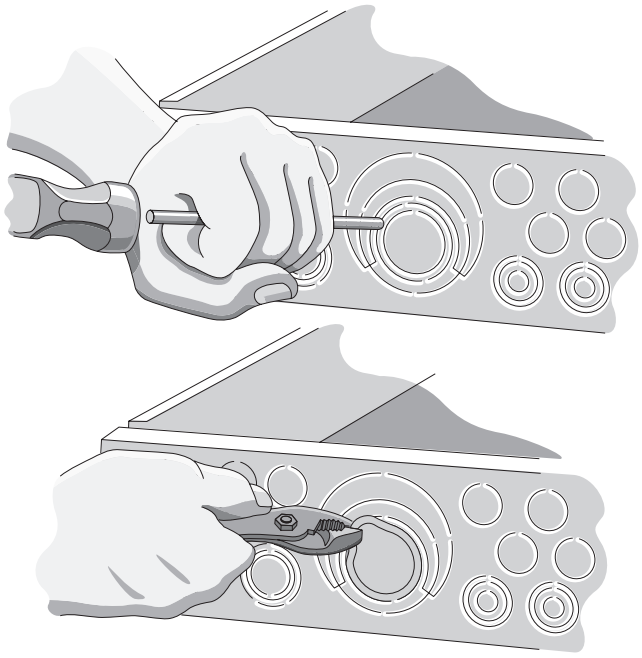


NEMA Enclosures

The **National Electrical Manufacturers Association (NEMA®)** has established standards for electrical equipment enclosures. NEMA type 1 enclosure are intended for indoor use. NEMA type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against rain, sleet and damage from external ice formation. Load center enclosures typically conform to one of these NEMA enclosure types.

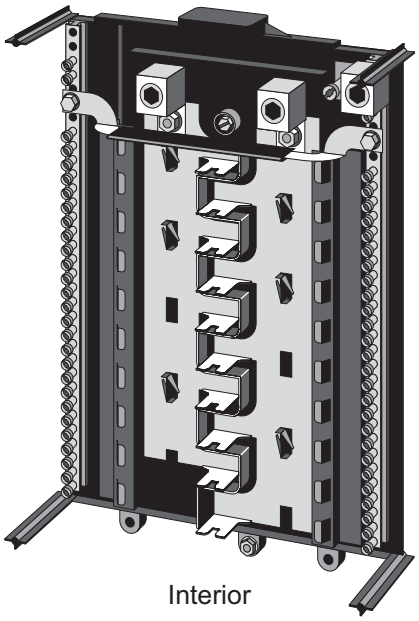
Removing Knockouts

Knockouts may be removed prior to mounting the enclosure. When there are multiple ring knockouts, remove the center section by striking at the point furthest from the tie. Then, bend the knockout back and forth to break the tie. If a larger opening is required, remove each additional ring one at a time by prying with a screwdriver and bending the ring back and forth with pliers as shown in the following figure.



Interior

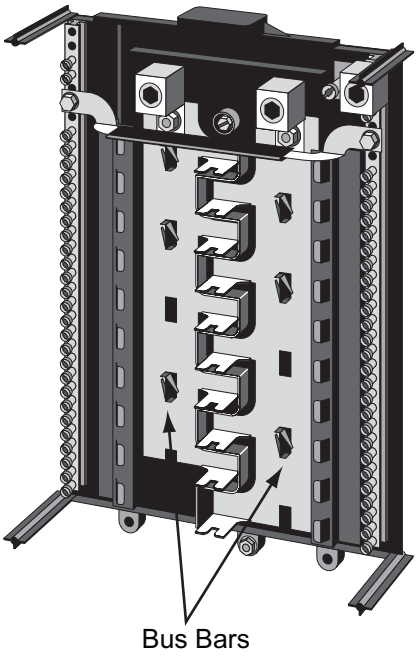
The load center **interior** mounts inside the enclosure and includes bus bars and related hardware.



Interior

Bus Bars

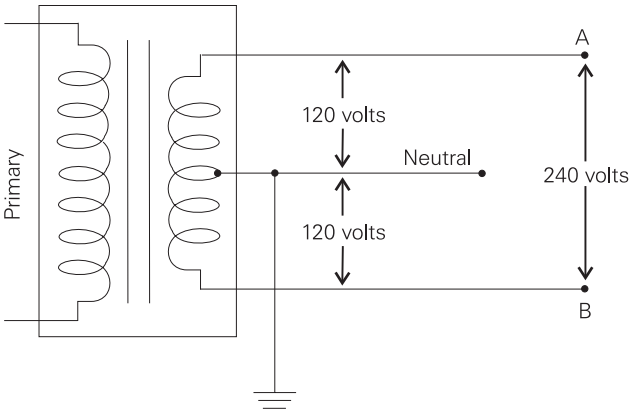
A bus bar serves as a common connection for two or more circuits. Siemens load center bus bars are made of copper or aluminum.



Power Source

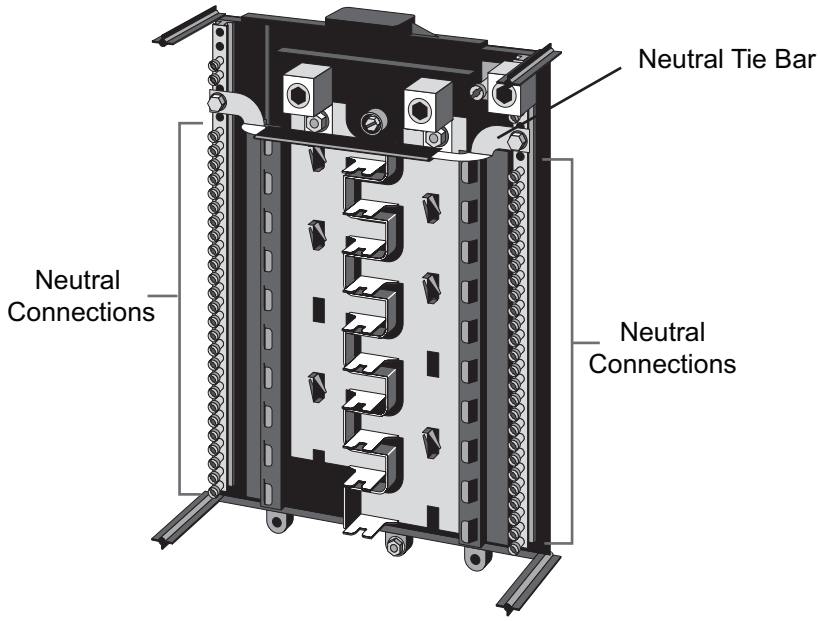
The most common method for powering a load center is to connect the load center's supply bus bars to the secondary winding of the utility transformer. Even though the secondary winding is providing single-phase power, one side of the secondary is called the A phase and the other side is called the B phase. The center tap connection to this transformer is grounded and becomes the neutral connection. The neutral is a current carrying conductor that connects to the load center's neutral bus.

As the following illustration shows, with this configuration, the voltage applied to the load center's supply bus bars is 240 volts, but the voltage from the neutral connection to either supply bus bar is 120 volts.



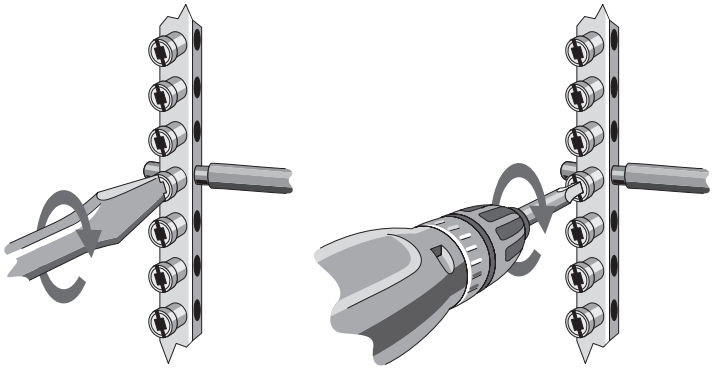
Split Neutral

Siemens Ultimate load centers and some Siemens EQ load centers have a **split neutral**, meaning that neutral connections are available on both sides of the load center interior. Split neutrals are connected together through a neutral tie bar.



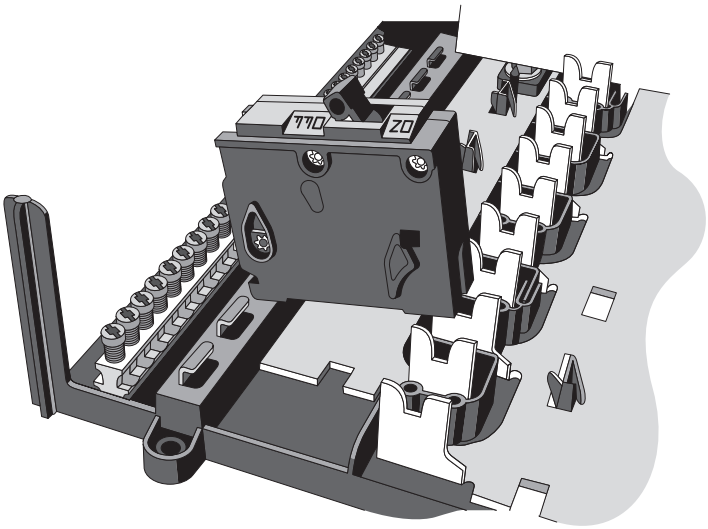
INSTA-WIRE

INSTA-WIRE is a feature found in Siemens Ultimate load centers. The INSTA-WIRE screw is a backed-out screw retained in place by a special feature on the screw thread. This feature prevents the screw from falling out during shipment. The INSTA-WIRE screw head will accept either a standard screwdriver or a square tool bit. The INSTA-WIRE feature saves an installer time by eliminating the need to back out every screw and by allowing the installer to use a power tool to tighten screws.



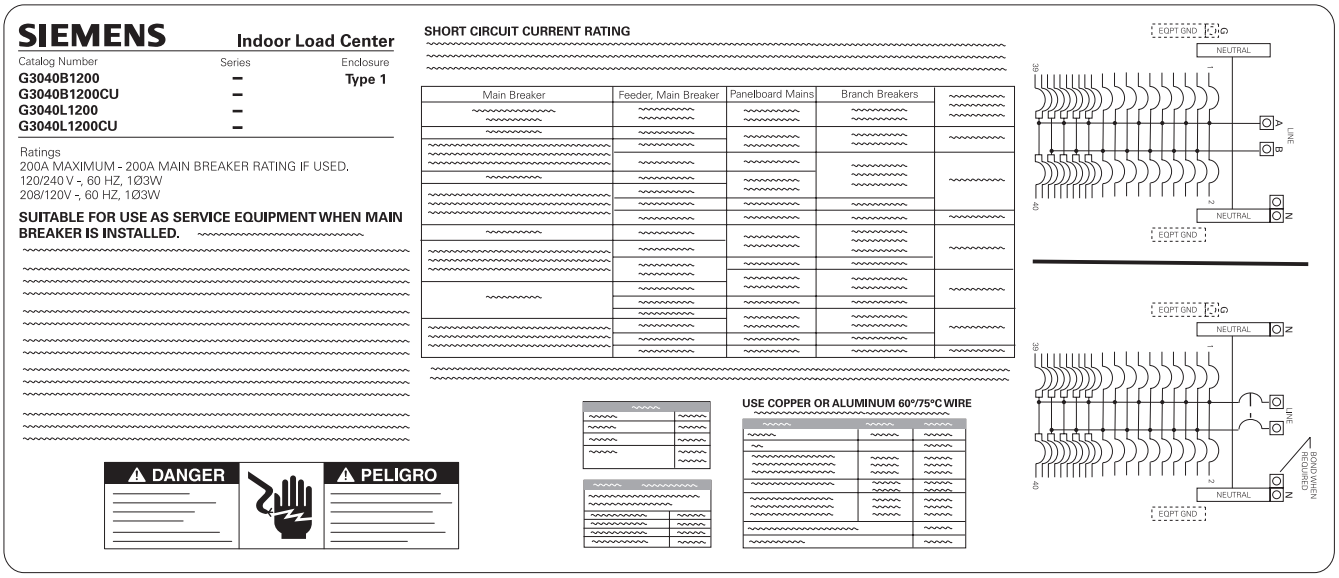
Branch Circuit Breakers

Branch circuit breakers plug directly onto the load center's supply bus bars as shown in the following illustration.



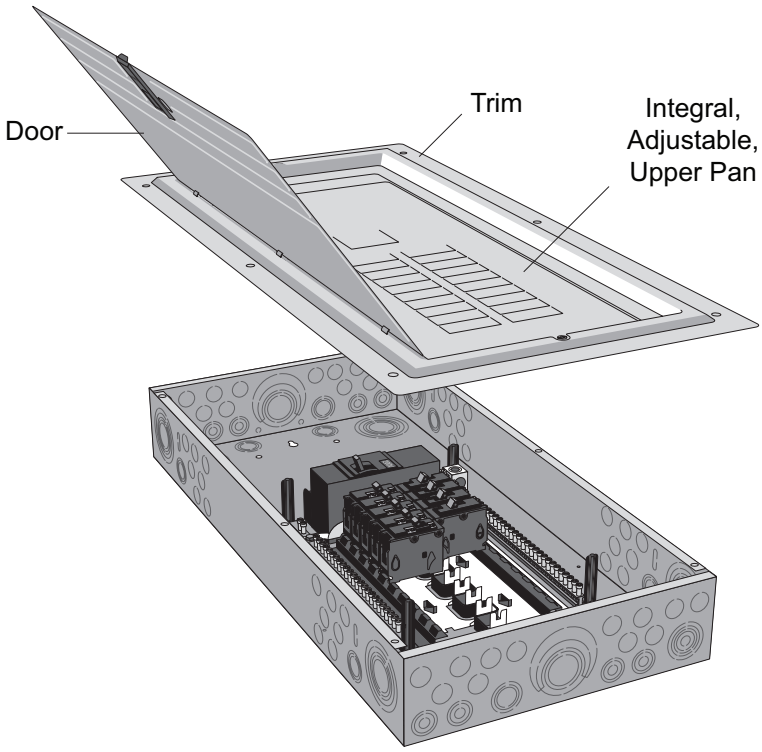
Label

The **label** identifies the load center's catalog number, enclosure type, voltage rating, and ampacity. Additional information on the label identifies circuit breaker types that can be used with the load center, short circuit ratings, and wiring diagrams.



Trim Assembly

The **trim assembly**, sometimes called a dead front, attaches to the front of the load center and covers the interior. The trim assembly includes an access door and an adjustable upper pan. The trim assembly provides access to the circuit breakers while sealing off live parts and internal wiring.

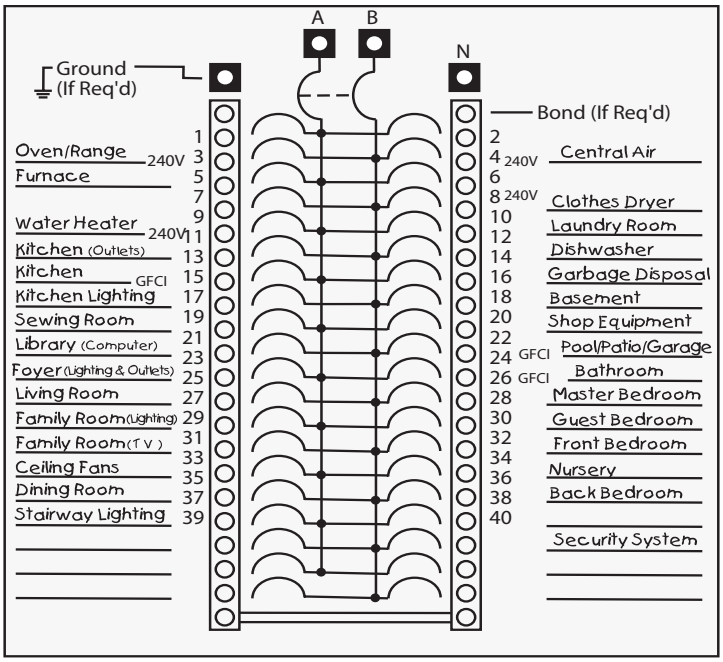


Twistouts

Part of the upper pan contains **twistouts**. These are used to cover any unused pole spaces not filled by a circuit breaker. Twistouts are removed by an up and down twisting motion with pliers. All unused openings in the upper pan must be filled with a filler plate.

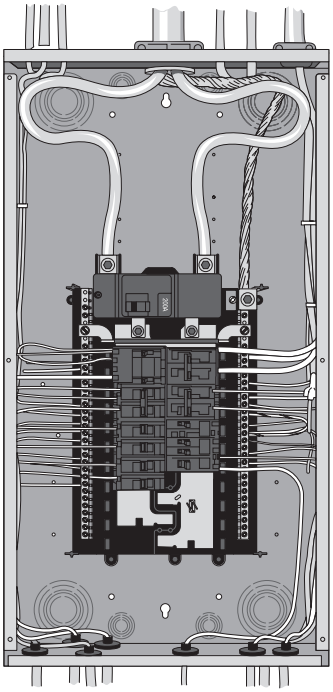
Circuit Directory

A **circuit directory** on the door, similar to one shown below, provides space for listing the services protected by each branch circuit breaker.

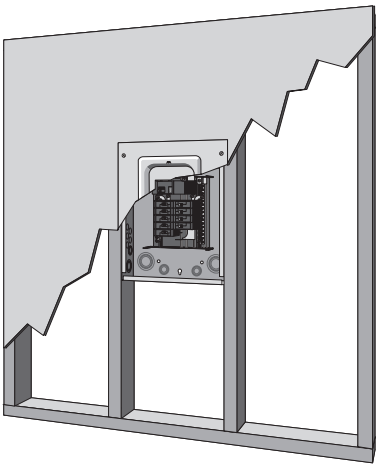


Load Center Installation

The enclosure, with the interior, is mounted to a wall. All incoming and outgoing conductors are connected to the load center.



Siemens load centers can be surface or flush mounted. For flush mounted devices, the load center is positioned so that the front edge of the enclosure is flush with the finished wall. The trim assembly is installed after the wall is finished.



NEC® Article 110.26

Load center 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. The intent of Article 110.26 is to provide enough working space for personnel to examine, adjust, service, and maintain energized equipment.

Review 2

1. The two types of NEMA enclosures available for Siemens load centers are NEMA type ____ and NEMA type ____ .

2. _____ circuit breakers plug directly onto the load center's supply bus bars.

3. A _____ provides neutral connections on both sides of the load center interior.

4. _____ is a time saving installation feature where screws are backed out and retained in place to prevent the screws from falling out.

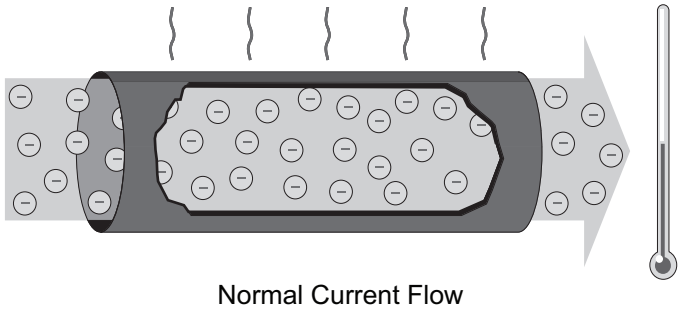
5. The _____ assembly provides access to the load center's circuit breakers while sealing off the bus bars and internal wiring from contact.

6. A _____ provides space for listing the services protected by each branch circuit breaker.

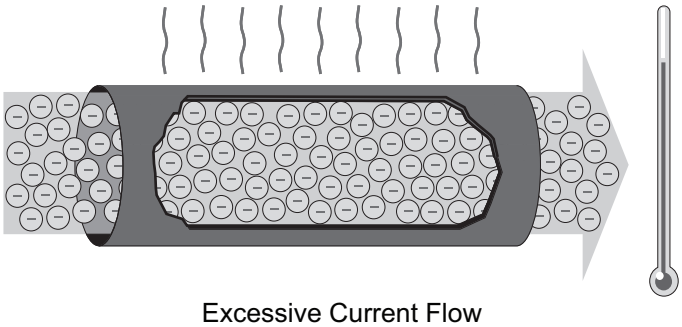
Load centers use circuit breakers to provide protection against **overcurrent**. The *National Electrical Code®* defines overcurrent as *any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault* (Article 100-Definitions).

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



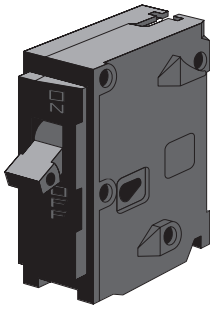
Excessive Current Flow

Circuit protection would be unnecessary if overloads and short circuits could be eliminated. Unfortunately, overloads and short circuits do occur. To protect a circuit against these currents, a protective device must determine when a fault condition develops and automatically disconnect the electrical equipment from the voltage source. Slight overcurrents can be allowed to continue for a short time, but as the current magnitude increases, the protection device must open faster. Short circuits must be interrupted instantly.

Circuit Breakers

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).

In other words, circuit breakers provide a manual means of energizing and de-energizing a circuit and automatic overcurrent protection for that circuit. Unlike fuses which must be replaced when they open, a circuit breaker can be reset once the overcurrent condition has been corrected. A simple push of the handle to the "Off" then "On" position restores the circuit. If a circuit reopens upon reset to the "On" position, a qualified electrician should be consulted to determine the problem.



Circuit Breaker

Circuit Breaker Ampere Rating

Every circuit breaker has ampere, voltage, and interrupting ratings. The **ampere rating** defines the maximum continuous current a circuit breaker can carry without tripping. Because the function of the circuit breaker is to protect circuit conductors, the appropriate ampere rating for a circuit breaker is dependent upon the ampacity of the conductors in a circuit.

Circuit Breaker Voltage Rating

Each circuit breaker also has a **voltage rating** which indicates the maximum voltage it can handle. In other words, the voltage rating of a circuit breaker must be at least equal to the circuit voltage. In residential applications, the most common power distribution system is the 1-phase, 3-wire system described later in this course. In these applications, a 1-pole branch circuit breaker protects a 120 volt branch circuit and a 2-pole branch circuit breaker protects a 240 volt branch circuit.

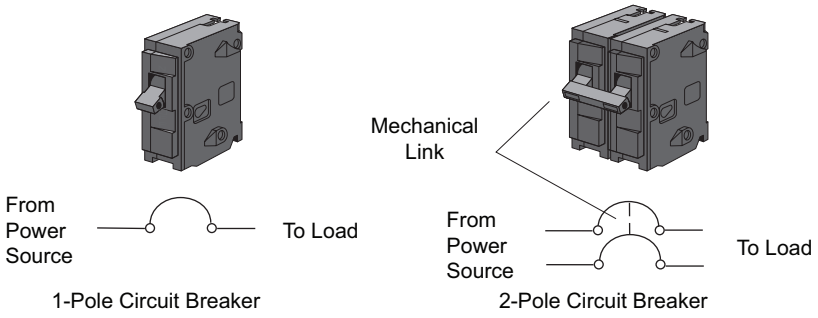
Circuit Breaker Interrupting Rating

A circuit breaker's **interrupting rating** is the maximum available fault current which the breaker is designed to interrupt. The most common interrupting rating for residential circuit breakers is 10,000 amps, often shown as 10 kA. However, circuit breakers with higher interrupting ratings are also available.

Circuit Breaker Poles

A circuit breaker's **pole** number indicates the number of circuits which supply current through the circuit breaker. For example, a 1-pole circuit breaker carries the current for one circuit and a 2-pole circuit breaker carries the current for two circuits simultaneously.

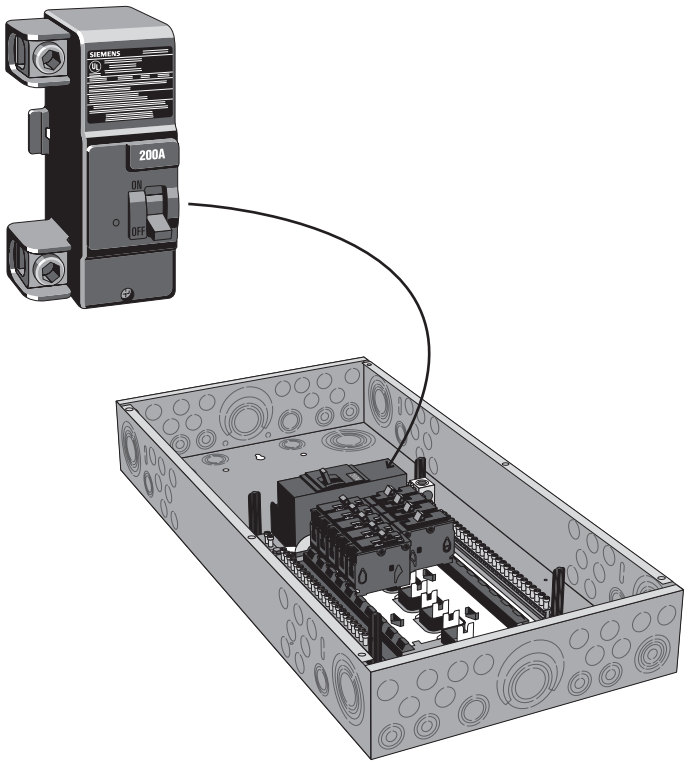
In a 2-pole circuit breaker, both circuits are controlled by the same trip unit so that both poles open at the same time when an overcurrent occurs. In addition, both circuits are mechanically interlocked so that they can be manually opened or closed at the same time.



Main Circuit Breaker

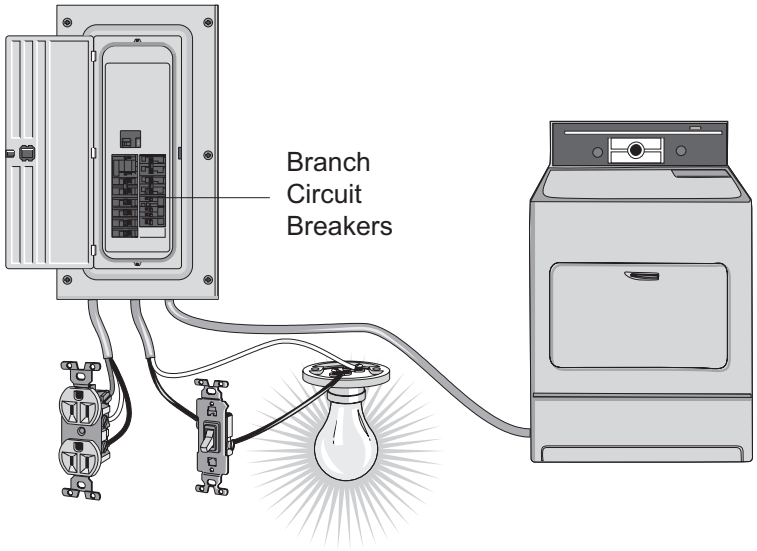
It is important to note the difference between a **main circuit breaker** and a branch circuit breaker. The main breaker of a load center shuts off power to the entire load center and all circuits supplied by that load center. The main circuit breaker ratings determine the overall ratings of the load center.

Siemens offers a wide selection of load centers equipped with a **main circuit breaker** as well as **main lug** load centers. Some of these load centers are convertible from main lug to main breaker or vice versa.

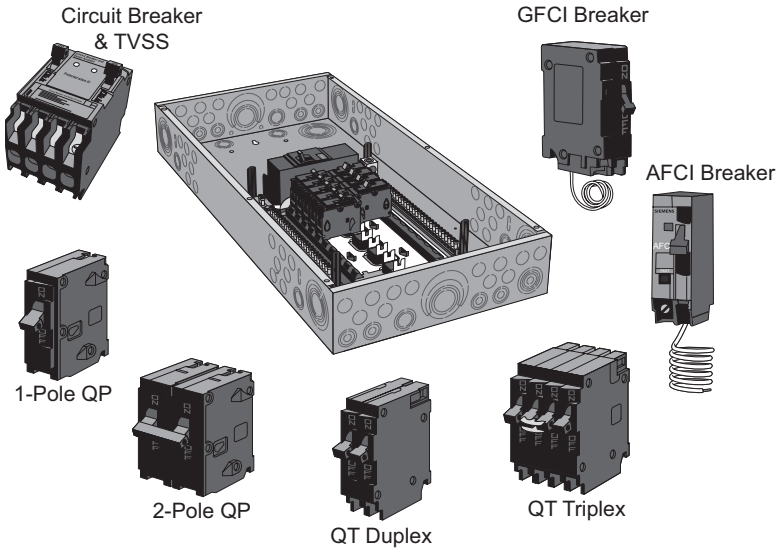


Branch Circuit Breakers

Residential circuit breakers are typically 1, 2 or 4-pole breakers with current ratings of 225 amps or less and voltage ratings of 120 volts, 120/240 volts, or 240 volts. Because residential circuit breakers are also used in commercial applications and many commercial applications require 3-pole breakers, some 3-pole breakers are also included in this category.



The most common branch circuit breakers used in Siemens load centers are full-sized 1-pole and 2-pole circuit breakers; however, Siemens also manufactures a variety of other circuit breaker types for use in load center branch circuits.



QP Circut Breakers

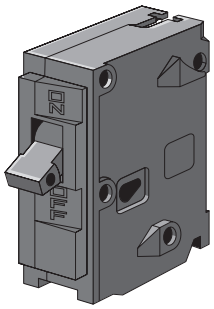
Type QP circuit breakers are full-size breakers available as 1-pole, 2-pole, or 3-pole breakers. Full size means that each circuit breaker has a width of 1 inch per pole.

1-pole QP breakers are rated for 120 VAC and have continuous current ratings from 10 to 70 amps.

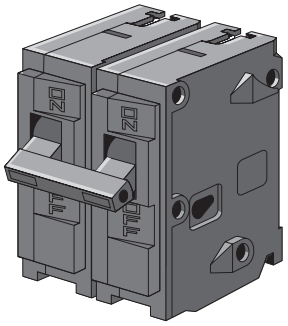
2-pole QP breakers are available with a 120/240 VAC rating or a 240 VAC rating. 2-pole 120/240 VAC QP breakers have continuous current ratings from 10 to 125 amps and 2-pole 240 VAC QP breakers have continuous current ratings from 15 to 100 amps.

3-pole QP breakers are rated for 240 VAC and have continuous current ratings from 10 to 100 amps.

All type QP circuit breakers have a 10 kA interrupting rating; however, Siemens also offers type QPH circuit breakers with a 22 kA interrupting rating and type HQP circuit breakers with a 65 kA interrupting rating.



1-Pole QP Circuit Breaker
Requires 1” (1 Space)



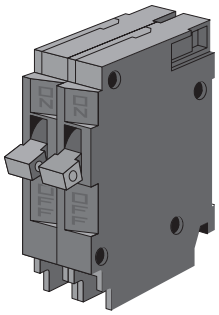
2-Pole QP Circuit Breaker
Requires 2” (2 Spaces)

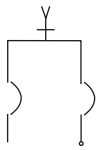
QT Circuit Breakers

Some Siemens load centers are designed to accept **type QT Duplex, Triplex, and Quadplex plug-in circuit breakers**. These breakers are space saving breakers that are half the width per pole of type QP circuit breakers. This reduced width allows more circuits to be serviced from a load center provided that the main circuit breaker has sufficient capacity. An important use for QT breakers is in cases where additional circuits are being added to an existing load center, but the number of spaces available in the load center is limited.

Type QT Duplex Circuit Breakers

Type QT Duplex circuit breakers combine two independent half-inch width breaker poles in a common unit. This unit plugs into one load center stab and requires one panel space.

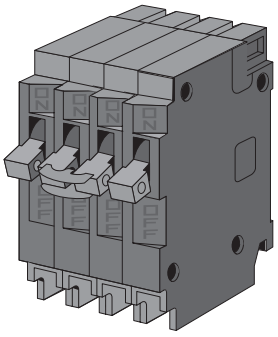




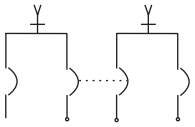
QT Duplex
Two Independent 1-Pole Breakers
Requires One Space

QT Triplex and Quadplex Circuit Breakers

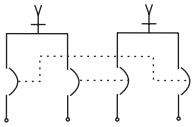
Type QT circuit breakers are also available in triplex and quadplex configurations. Triplex circuit breakers provide a 2-pole circuit breaker for 120/240 VAC circuits and two independent 1-pole circuit breakers for 120 VAC circuits. Quadplex circuit breakers incorporate two common trip 2-pole circuit breakers for 120/240 VAC circuits. Each Quadplex or Triplex circuit breaker requires two panel spaces.



QT Triplex
Two Independent 1-Pole Breakers
One Common Trip 2-Pole Breaker
Requires Two Spaces



QT Quadplex
Two Sets of Common Trip 2-Pole Breakers
Requires Two Spaces



Review 3

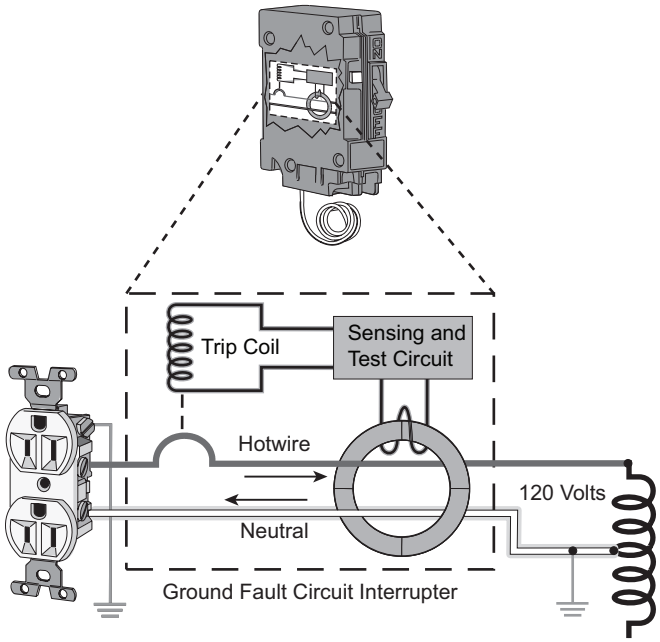
1. Current flow in a conductor always generates _____.
2. A circuit breaker's _____ number indicates the number of circuits which supply current through the circuit breaker.
3. A _____ circuit breaker shuts off power to the entire load center and all circuits supplied by that load center.
4. A QT _____ breaker is two breakers in a housing that has the same dimensions of a full-size, 1-pole breaker.
5. QT Triplex and Quadplex circuit breakers each require _____ panel spaces.

Ground Fault Protection

A ground fault occurs when a current-carrying conductor comes in contact with ground. A faulty appliance or the presence of water in contact with a conductor are examples of possible ways a ground fault can occur.

One way ground fault protection is accomplished is by the use of **ground fault circuit interrupter (GFCI)** receptacles. These are installed in place of a normal receptacle. Another way is with a GFCI circuit breaker such as a Siemens type QPF or QPHF GFCI circuit breaker. Both breaker types are available in 1-pole and 2-pole versions. Type QPF circuit breakers have a 10 kA interrupting rating and type QPHF circuit breakers have a 22 kA interrupting rating. Any receptacle connected to the same circuit as the QPF or QPHF GFCI circuit breaker is ground fault protected.

A ground fault circuit interrupter compares current on the hot wire with current returning on the neutral wire. Under normal circumstances the current is equal.



When a ground fault occurs, some of the current goes to the ground through an alternate path. For example, a ground fault can occur when an electrical appliance is placed on a wet surface that provides an alternate path to ground. Anyone coming in contact with the appliance or the wet surface is at risk from this ground fault. If the circuit providing power to the appliance is protected by a ground fault circuit interrupter; however, the GFCI will sense the ground fault, open the circuit, and remove power from the appliance.

GFCI circuit breakers, such as Siemens QPF and QPHF circuit breakers, are intended to provide "protection for personnel" and are designed to trip when a fault current to ground of 6 mA or more is sensed.

Ground Fault Protection for Personnel

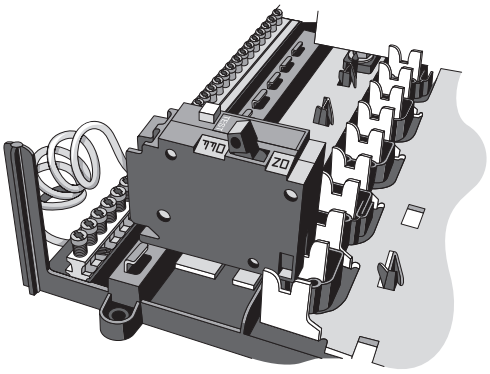
NEC® Article 210.8 describes the requirements for ground fault circuit interrupter protection for personnel in a variety of locations. Some of the more common locations requiring this protection for electrical receptacle circuits include: bathrooms; residential garages; unfinished basements; within six feet of a laundry, utility, or wet bar sink; crawl spaces; and outdoors.

Ground Fault Protection for Equipment

Ground fault circuit interrupter protection is also sometimes needed to protect equipment from damaging line-to-ground faults. Siemens type QE and QEH circuit breakers provide this protection by de-energizing the circuit when a ground fault of 30 mA or more is sensed. Type QE circuit breakers have a 10 kA interrupting rating and type QEH circuit breakers have a 22 KA interrupting rating. Both breaker types are available in 1-pole and 2-pole versions.

Installing GFCI Breakers

Siemens GFCI circuit breakers mount in a load center in the same way as a standard circuit breaker except that they have one additional wire, a white "pigtail" neutral lead which connects to the load center's neutral bus. These breakers are also equipped with a "Test" button to check the operation of the device after it has been installed.

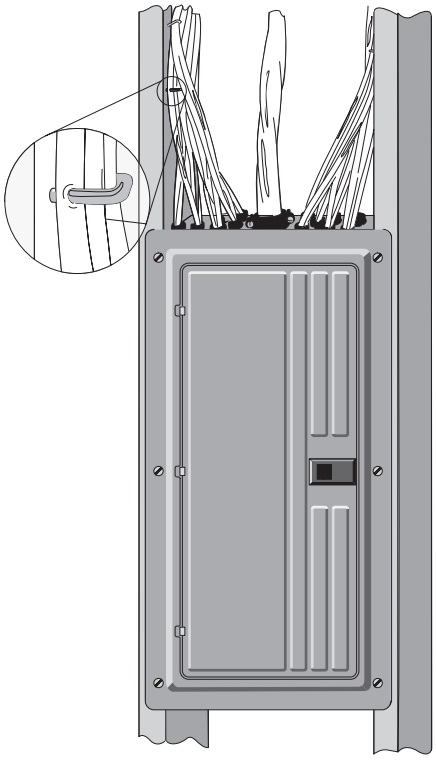


Arc Fault Protection

Arc Faults

Arc faults are undesired arcs in which current flows in unintended ways, but usually not in sufficient amounts to cause a standard overcurrent protection device to open.

Arc faults may occur for many reasons such as worn electrical insulation or damaged wire, misapplied or damaged appliance cords and equipment, or loose electrical connections. In the following example, a staple has been inadvertently driven through the insulation of a wire during installation. This could potentially cause arc faults to occur.



The arc fault problem is important because each year, in the U. S. alone, tens of thousands of fires are caused by electrical problems, and arc faults are one of the leading causes for these types of fires.

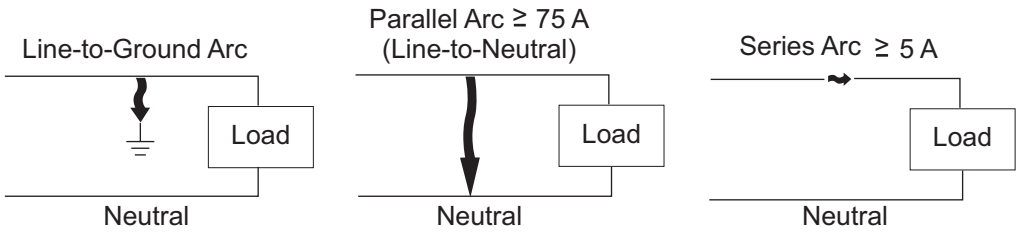
Because the causes of arc faults are many and often difficult to eliminate, detecting arc faults and shutting down affected circuits before property damage, personal injury, or loss of life occurs is even more critical.

AFCI Circuit Breakers

An **arc fault circuit interrupter (AFCI) circuit breaker**, in addition to providing overcurrent protection, is intended to provide protection from the effects of arc faults by recognizing the characteristics unique to arcing and de-energizing the circuit when an arc fault is detected.

There are two categories of AFCI circuit breakers on the market. The first AFCI circuit breakers developed were **branch/feeder AFCI circuit breakers** that, in addition to providing overcurrent protection, are intended to protect branch and feeder wiring from the damaging effects of line-to-ground arcs and high energy parallel arcs. High energy parallel arcs are line-to-neutral arcs greater than or equal to 75 A.

More recently, **combination AFCI circuit breakers** have been developed. Combination AFCI circuit breakers, in addition to providing overcurrent protection, are intended to protect downstream wiring from three categories of arc faults: line-to-ground arcs, high energy parallel arcs, and series arcs greater than or equal to 5 A. Series arcs are arcs on a single conductor.



NEC® Article 210.12

Requirements for arc fault circuit interrupter protection are covered in ***National Electrical Code*® Article 210.12.** Over the years, the wording of this article has evolved. The 1999 *NEC*® required arc fault interrupter protection in new construction for 125 V, single phase, 15 A and 20 A branch circuits supplying dwelling unit bedrooms. The 2005 *NEC*® allowed branch/feeder AFCIs to provide this protection until January 1, 2008. Thereafter, it requires use of combination AFCIs for this application in new construction. The 2008 *NEC*® further expands use of listed, combination AFCIs for the protection of 120 V, single phase, 15 A and 20 A branch circuits supplying outlets in many rooms in a dwelling unit. For a complete list of required locations, refer to 2008 *NEC*® Article 210.12.

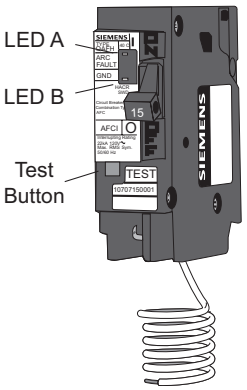
Because a number of governing authorities have not yet adopted the 2005 or 2008 *NEC*® or have allowed exceptions from the combination AFCI requirement, Siemens continues to offer both branch/feeder AFCI circuit breakers and combination type AFCI circuit breakers.

Siemens type QAF AFCI circuit breakers have a 10 kA interrupting rating and type QAFH AFCI circuit breakers have a 22 kA interrupting rating. Both breaker types are available in 1-pole and 2-pole versions.

Siemens AFCI circuit breakers have a white "pigtail" wire that attaches to the neutral bus and a "Test" button to check the device operation after it has been installed.

Siemens combination type AFCI circuit breakers are equipped with two LED trip indicators which help electricians and home owners identify the cause of a tripped breaker. The LED indications appear for five seconds each time the breaker is turned on and indicate whether the last trip was caused by overcurrent, an arc fault, or an arc fault to ground.

LED Indicator		Last Known Trip Condition
LED (A)	LED (B)	
OFF	OFF	Overcurrent
ON	OFF	Arc Fault
ON	ON	Arc Fault to Ground



Surge Protection

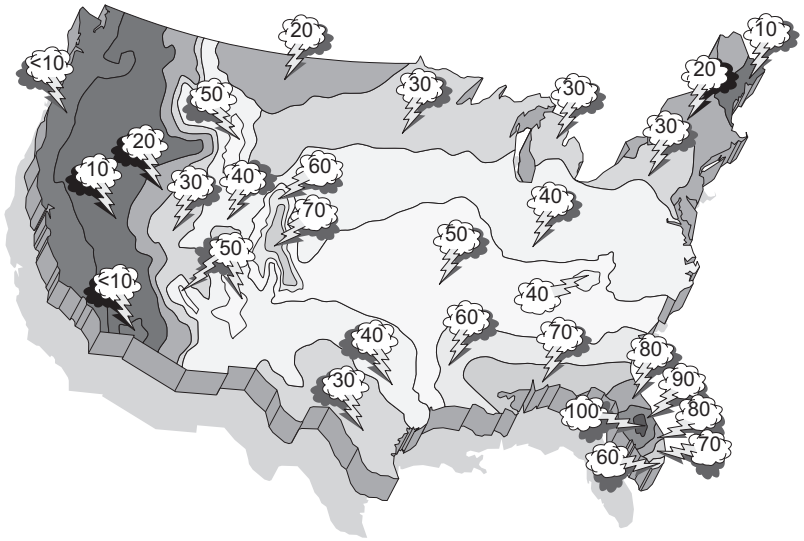
Today's homes have many electronic devices such as televisions, stereos, computers, microwave ovens, etc. These devices are highly susceptible to damage from electrical surges.

Electrical surges can be generated in the home by appliances such as vacuum cleaners and other motor driven devices; spark igniters on gas ranges, furnaces, and water heaters; and other equipment.

However, the most damaging surges are caused by lightning strikes. A lightning strike on a power line several miles away still has the potential to cause extensive electrical damage in a home. Lightning strikes on high voltage lines are generally dissipated by utility surge arresters. The average home, however, will experience eight to ten voltage surges of 1,000 to 10,000 volts annually. Damage to expensive electrical equipment can be instantaneous if the surge is significant, but even moderate surges over time can cause cumulative damage.

Thunderstorms

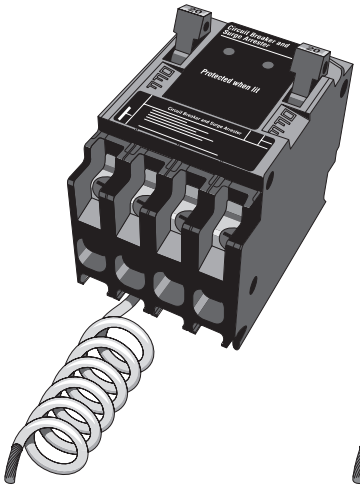
A typical lightning strike consists of 25,000 amps at 30 million volts. The following map shows the approximate mean annual number of days with thunderstorms in various regions of the United States.



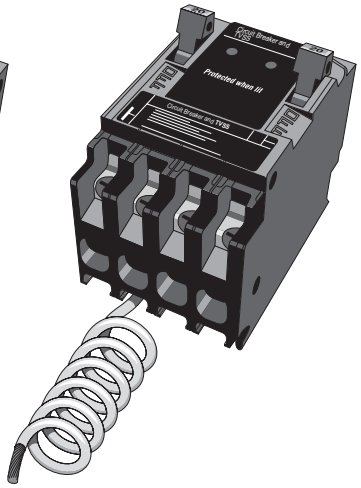
Point of Entry Surge Protection

Siemens offers a variety of devices intended to minimize damage from electrical surges. Two of these devices provide **point-of-entry surge protection** and also incorporate two 1-pole circuit breakers.

Siemens Circuit Breaker and Secondary Surge Arrester replaces two full-size, 1-pole circuit breakers and provides surge protection for all branch circuits. Siemens Circuit Breaker and Transient Voltage Surge Suppressor (TVSS) incorporates the features of our Circuit Breaker and Secondary Surge Arrester, but with a lower clamping voltage rating.

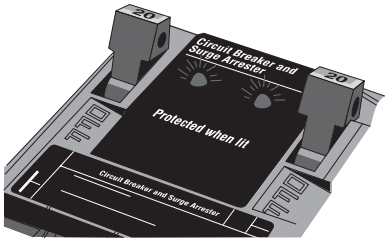


Circuit Breaker and Surge Arrester



Circuit Breaker and TVSS

Both types of devices incorporate two red LED indicator lights that illuminate to show that surge protection is provided for all circuits connected to the load center. These devices notify the owner of loss of surge protection by tripping one or both of the circuit breakers. The value of this feature is enhanced by using one of these breakers for circuit protection of frequently used household circuits so that the circuits controlled by the breaker indicate the status of the surge protection capability.

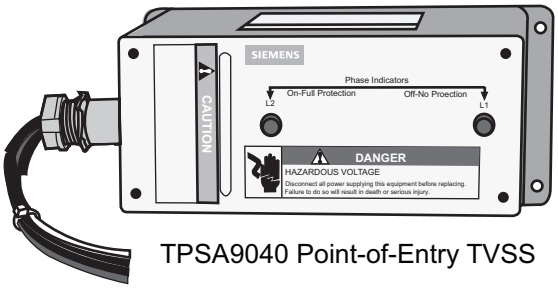


If one or both of the circuit breakers have tripped, turn both circuit breakers to the "OFF" then "ON" position. If either light is not illuminated, the device may still be used for circuit protection, but surge protection is no longer provided and the device should be replaced by a qualified electrician.

Installation is as simple as mounting a conventional circuit breaker in a Siemens load center. A lead wire is provided to connect the ground side of the module to the load center's neutral bus. It is recommended to position the device in the first position of the load center and connect the lead wire in the first neutral position.

TPSA9040 Point-of-Entry TVSS

The TPSA9040 TVSS is an alternative approach for providing point-of-entry surge protection. The TPSA9040 is a UL listed point-of-entry TVSS designed to shield motor-driven appliances against electrical power surges, including surges caused by lightning, from entering through the service entrance load center. The TPSA9040 TVSS is mounted external to the load center and can be used with Siemens or non-Siemens load centers.



TPSA9040 Point-of-Entry TVSS

Review 4

1. The *NEC*® does **not** require GFCI personnel protection for electrical receptacles in which of the following areas?

   a. bathroom
   b. living room
   c. outdoors
   d. near sinks

2. _____ are undesired arcs in which current flows in unintended ways, but usually not in sufficient amounts to cause a standard overcurrent protection device to trip.

3. Siemens combination type AFCI circuit breakers are intended to protect downstream wiring from which of the following categories of arc faults?

   a. line-to-ground arcs
   b. high energy parallel arcs equal to or greater than 75 A
   c. series arcs greater than or equal to 5 A
   d. all the above

4. Electrical surges can be generated in the home by appliances; however, the most damaging voltage spikes are caused by _____.

5. Two Siemens devices that provide point-of-entry surge protection and also incorporate two 1-pole circuit breakers are the Circuit Breaker and Secondary Surge Arrestor and the Circuit Breaker and _____.

Load Center Mains

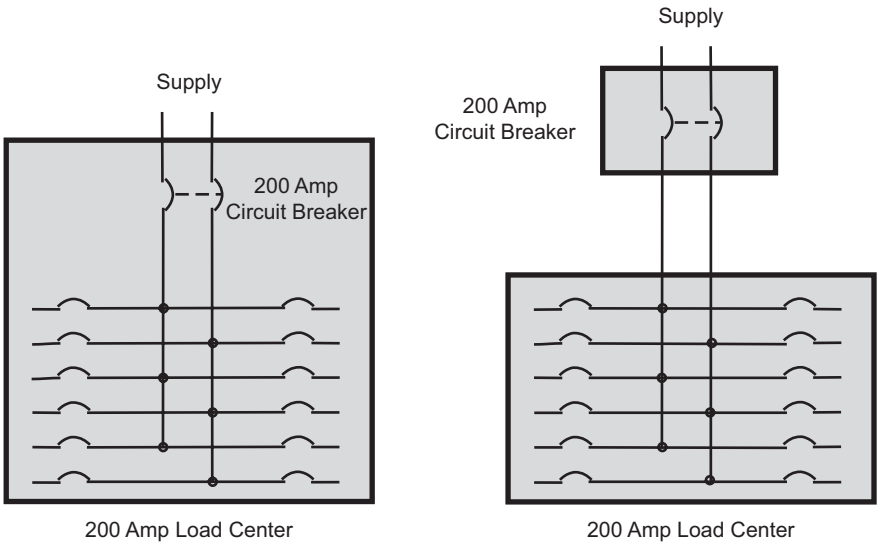
Main Breaker

There are two major categories of load centers, those with a **main breaker** and **main lug only** load centers. In addition, some load centers, such as Siemens Ultimate Load Centers, are convertible from main breaker to main lug only or vice versa.

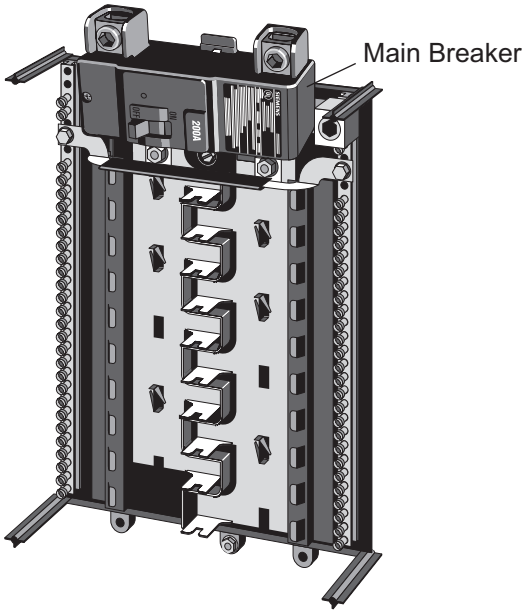
NEC® Article 408.36 requires that a panelboard have an overcurrent protective device with a rating that does not exceed the panelboard's rating. This overcurrent protective device can be located in the panelboard or on the supply side of the panelboard.

Individual Protection

The following illustration shows these two approaches for applying overcurrent protection. If a main circuit breaker is located as an integral part of the load center, it is a main breaker load center. If a main circuit breaker or main fusible switch is located remotely, then a main lug load center could be used. In this example the main breaker and load center are both rated for 200 amps.

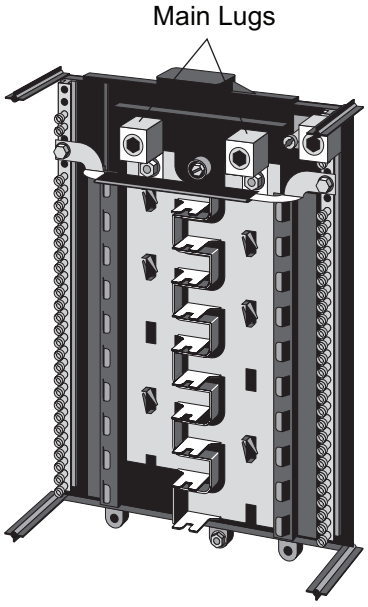


Main breaker load centers are suitable for use in service entrance applications where the incoming supply cables connect to lugs adjacent to the main breaker which, in turn, feeds power to the load center and its branch circuits. The main breaker provides a means of manually disconnecting power from the load center and automatic overcurrent protection.



Main Lug Only

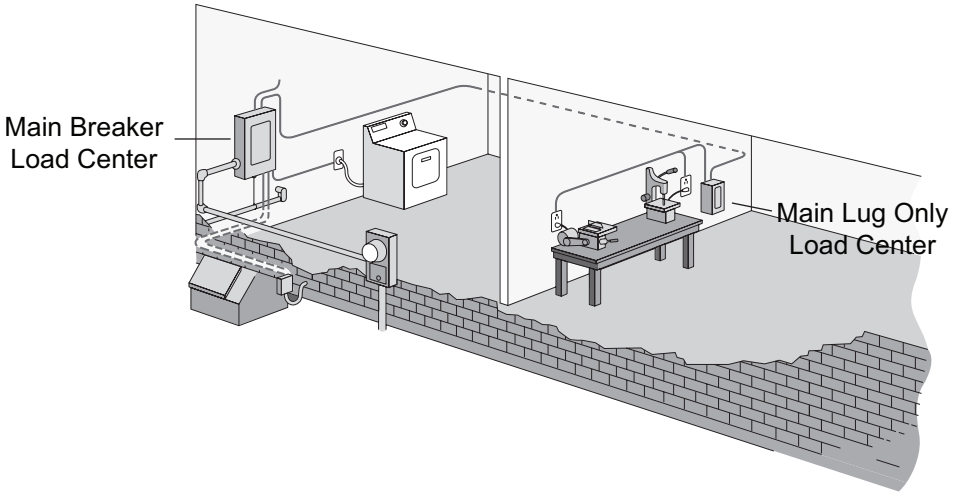
The following illustration shows the interior of a main lug only load center. As the name applies, main lug only type load centers do not have a main circuit breaker. The incoming supply cables are connected directly to the main lugs and bus bars.



Primary overload protection for a main lug load center is **not** provided as an integral part of the load center. Instead, a main lug load center is primarily used as a distribution panel where there is a main breaker upstream in the system.

One common application for a main lug only load center is as an add-on panel. For example, a main breaker load center might supply power to a main lug load center located in an area of the home used as a workshop. Keep in mind, however, that the main breaker would need to be sized appropriately to handle the additional load.

There are other reasons, however, when a main breaker may be located remote from the load center. For example, main lug load centers are often used in apartment installations where the main breakers and metering equipment are more centrally located.



There are two ways to supply power to a main lug only load center from the main breaker load center. One way is to connect power from a branch circuit breaker in the main breaker load center. The other way is to install a lug kit in the main breaker load center and route power from the installed lugs to the downstream load center.

Load Center Interrupting Ratings

When selecting load centers and overcurrent protection devices, it is essential to know both the maximum continuous amperes and available fault current. **NEC® Article 110.9** states:

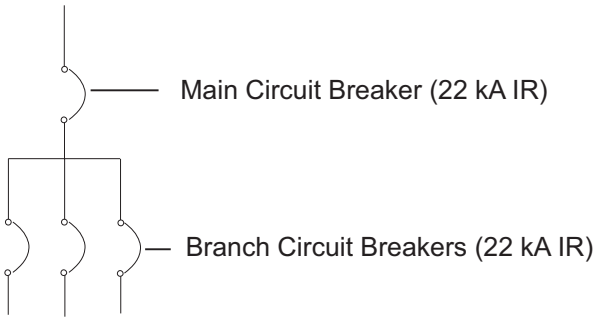
Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

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.

Full Rating

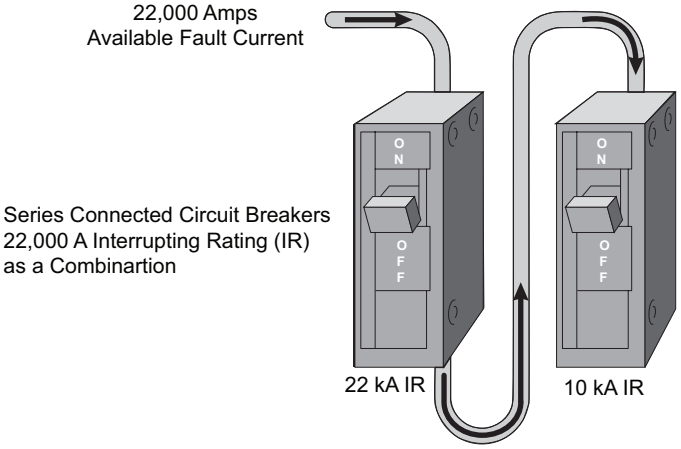
There are two ways to meet this requirement. The **full rating method** requires selection of circuit protection devices with individual ratings equal to or greater than the available fault current. In single family homes, the available fault current normally does not exceed 10,000 amperes. This makes it inexpensive to use the full rating method,

In some instances the available fault current may exceed 10,000 amperes. For example, in the case of a building with 22,000 amperes of fault current available at the service entrance, every circuit breaker must have an interrupting rating of at least 22,000 amperes as shown in the following example.

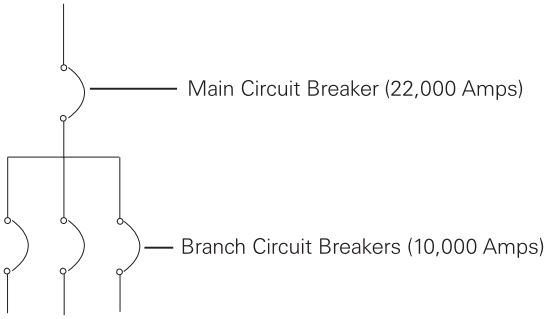


Series Rated

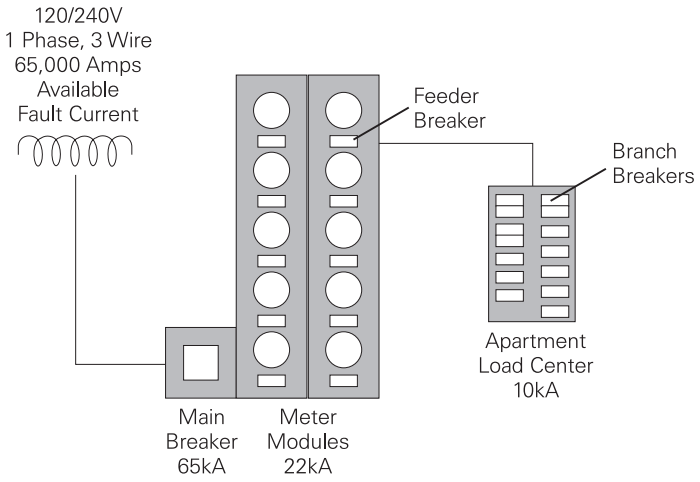
The **series rated method** also requires that the main upstream circuit protection device must have an interrupting rating equal to or greater than the available fault current of the system, but subsequent downstream circuit protection devices connected in series can be rated at lower values. For example, a building with 22,000 amperes of available fault current might have the breaker at the service entrance rated at 22k A IR and additional downstream branch breakers rated at a lower value. In this example, the downstream branch circuit breaker is rated at 10 kA IR.



The series rating method is less expensive to the customer because it allows use of branch circuit breakers with a lower interrupting rating.



In larger installations, such as apartments, condominiums and commercial facilities, the available fault current will normally be greater than 10,000 amperes. In these situations it is not uncommon to see three breaker series combinations. The main power of an apartment complex, for example, might have 65,000 amperes available fault current. The main disconnect must be capable of interrupting this fault current. The feeder disconnects, however, may only have to be rated for 22,000 amperes of fault current, and individual apartments rated for 10,000 amperes of fault current.

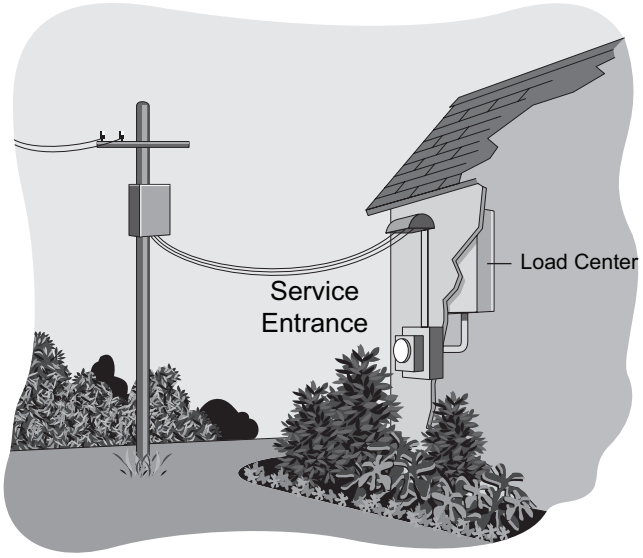


Series-rated circuit breaker combinations must be tested in series in order to be UL recognized. In addition, **NEC® Article 110.22** requires the series ratings to be marked on the enclosure.

Service Entrance Equipment Load Centers

Load centers are frequently 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.

Load centers used as service equipment must be listed and labeled as suitable for use as **service entrance equipment (SUSE)**.



Maximum Number of Disconnects for Service Entrance Equipment

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

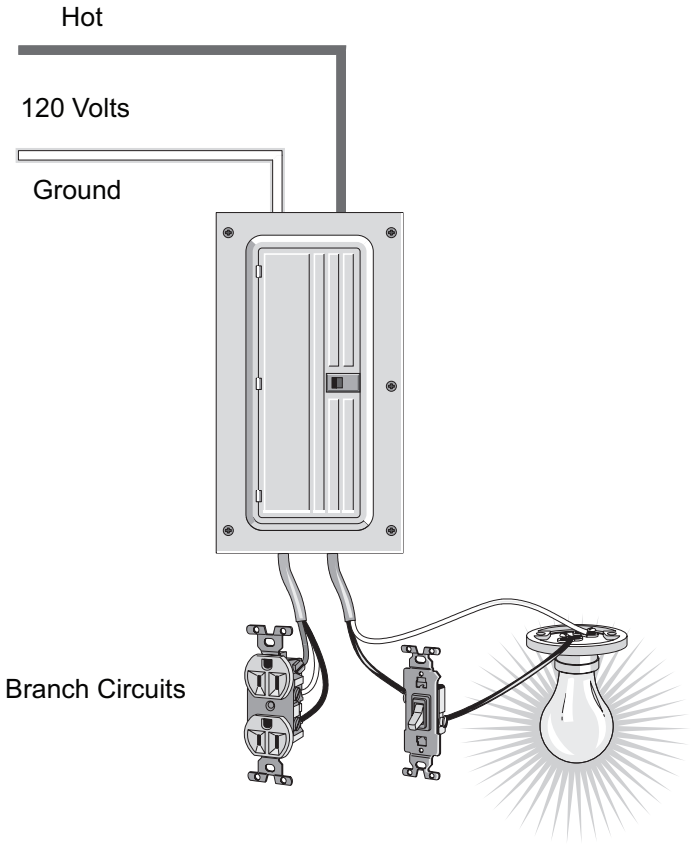
Normally a main breaker load center is used as a service entrance panel and the main breaker provides the means of disconnecting and isolating the service.

Main lug only load centers are not normally used as service entrance equipment because to do so would limit the service entrance load center to no more that six circuit breakers.

Power Supply Systems

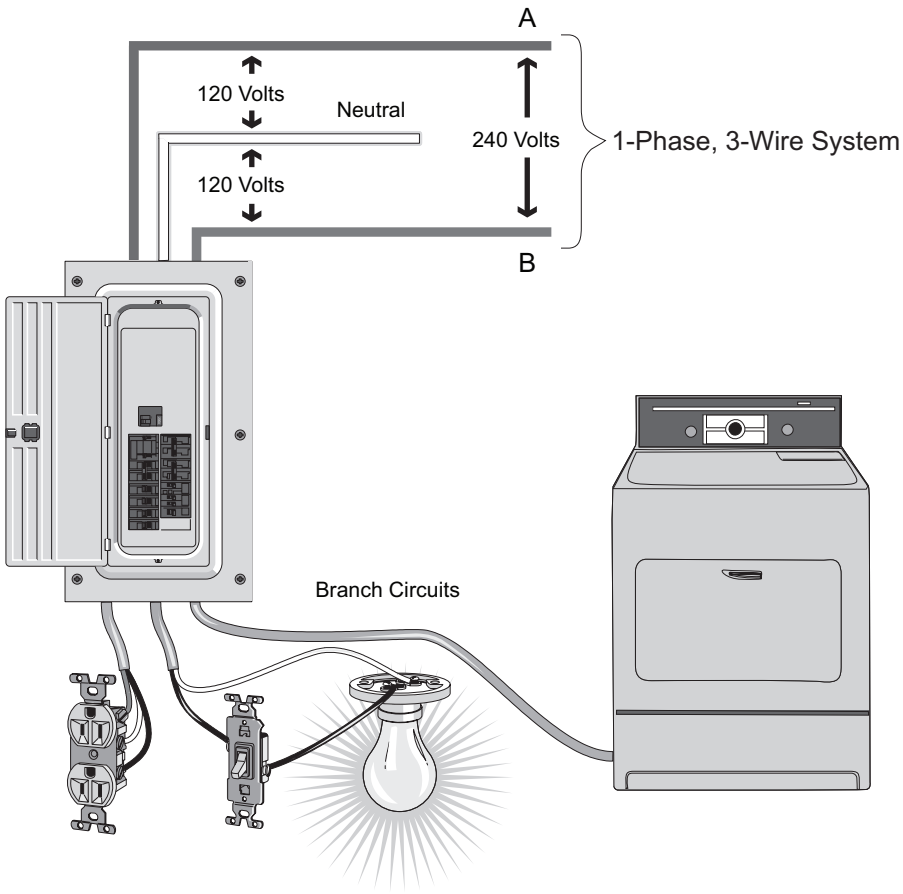
1-Phase, 2-Wire System

Homes built prior to 1936, especially in rural areas, used a **two-wire supply system**. This system provided 120 volts between a hot conductor and a grounded conductor. A 2-wire system is usually inadequate for today's residential electrical demands and is not allowed for new construction.

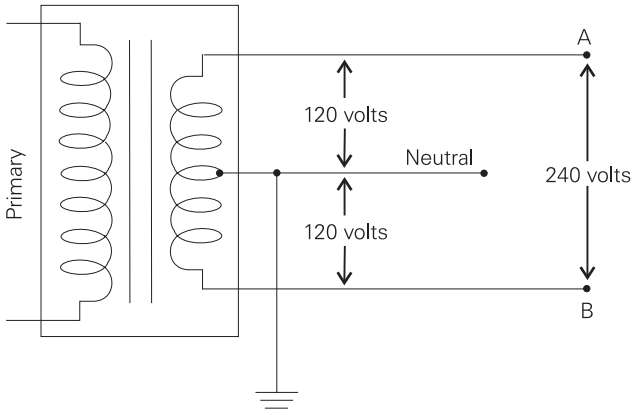


1-Phase, 3-Wire System

The most common supply system used in residential applications today is a **1-phase, 3-wire supply system**. This system provides 240 volts from the A phase connection to the B phase connection and 120 volts between either the A or B phase connection and neutral.



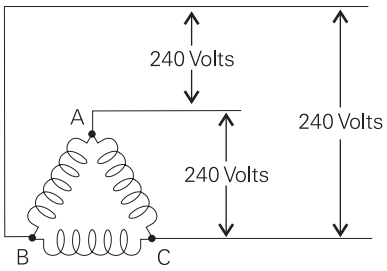
The following illustration shows how the **A and B phase connections** and the **neutral** connect to the secondary winding of the utility transformer.



Load centers can also be used in commercial applications that may require **3-phase power**. Two of the more common approaches for providing 3-phase power in these applications are shown below.

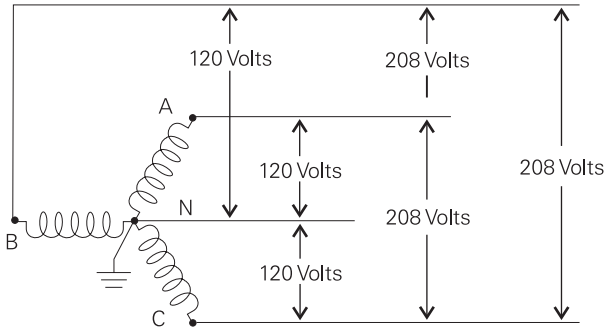
3-Phase, 3-Wire, 240 Volt

The following illustration shows the utility transformer secondary windings for a **3-phase, 3-wire**, 240 volt system. This system uses a delta transformer configuration with each phase providing 240 volts.



3-Phase, 4-Wire, 208Y/120V

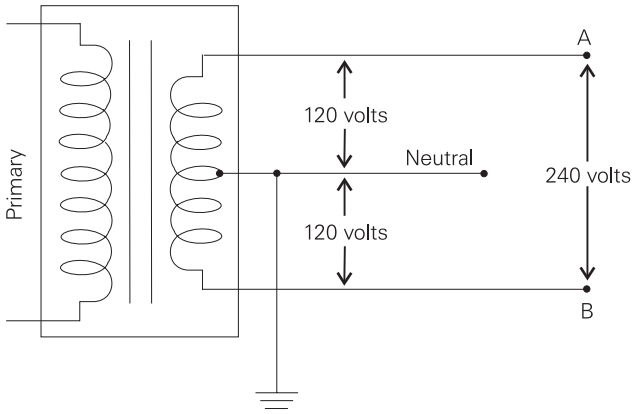
There are multiple approaches for **3-phase, 4-wire** services. The following illustration shows the utility transformer secondary windings for one of the more common approaches, a 3-phase, 4-wire, 120/208 volt system. This system uses a wye transformer configuration with a grounded neutral (N). This system provides 120 volts between any phase connection and neutral and 208 volts between any two phases.



Load Center 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 secondary connected to ground.



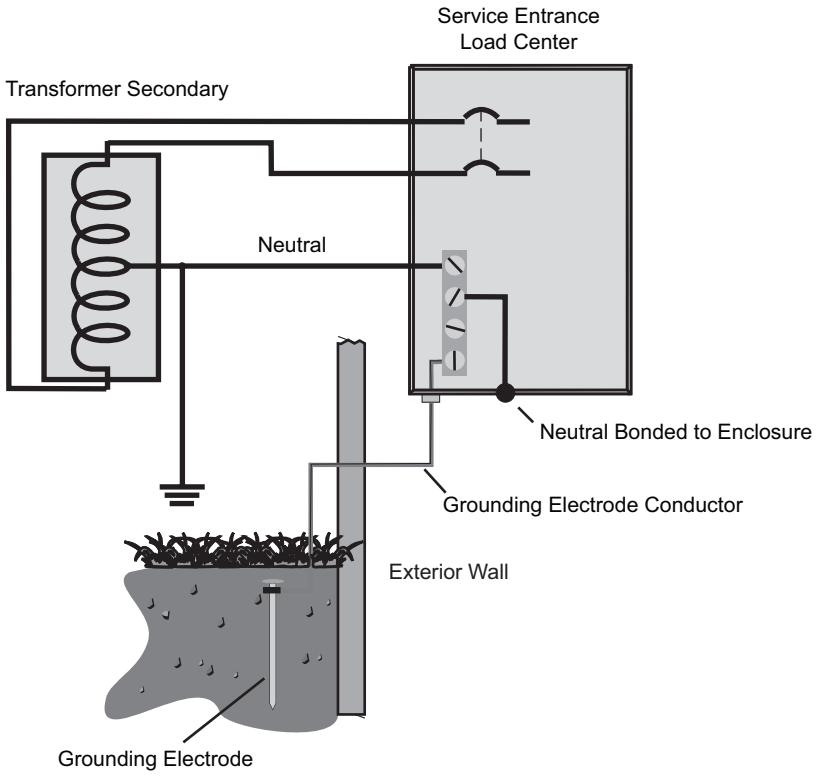
There are two objectives to the intentional grounding of electrical equipment:

- 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.

Service Entrance Grounding

When installing a load center, it is important to ground the neutral bus only at the service entrance as shown in the following illustration. This is accomplished by connecting a grounding electrode to the neutral bus. The neutral bus is bonded to the enclosure at the service equipment so that the enclosure is also connected to ground. In addition, the grounded neutral connection from the power source is also connected to the load center neutral bus.

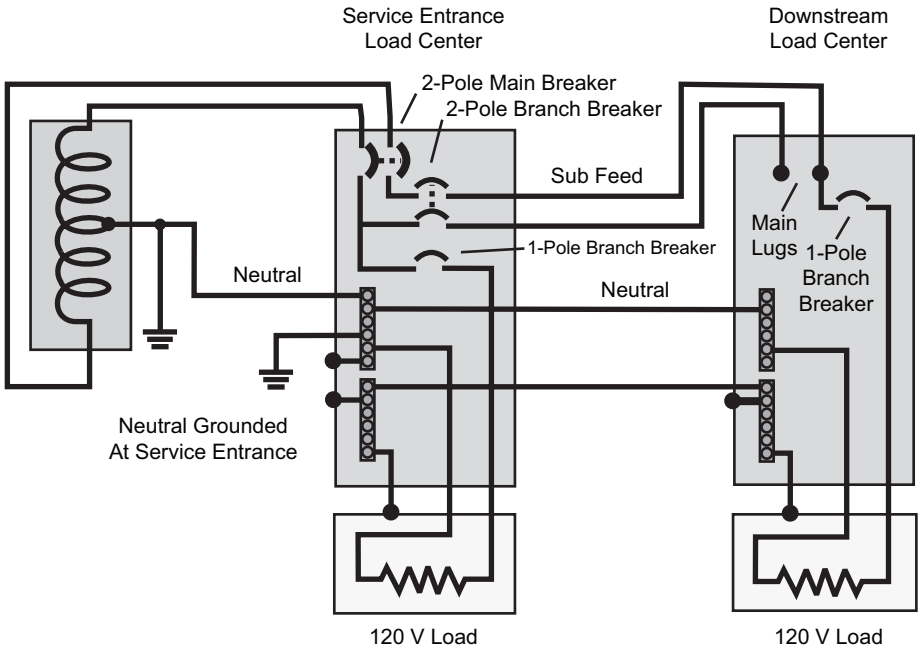


Bonding

Bonding in this context is the joining of metallic parts to form an low resistance electrical connection. This is often accomplished through use of a **bonding screw** that connects a bus to a metal enclosure. Depending on the equipment design, a metal bonding strap may also be required. Siemens Ultimate load centers incorporate a **pre-positioned** bond screw that eliminates bond strap/screw assemblies, and reduces the risk of losing components in the field.

Grounding Downstream Load Centers

The neutral conductor is only directly connected to ground at the service entrance. When a downstream panel is used, the neutral is insulated and isolated in that panel. The downstream panel must have a ground connection bonded to the enclosure. The equipment ground conductor connects the downstream panel to the ground at the service entrance panel.



Review 5

1. There are two major categories of load centers, those with a _____ and _____ load centers.

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

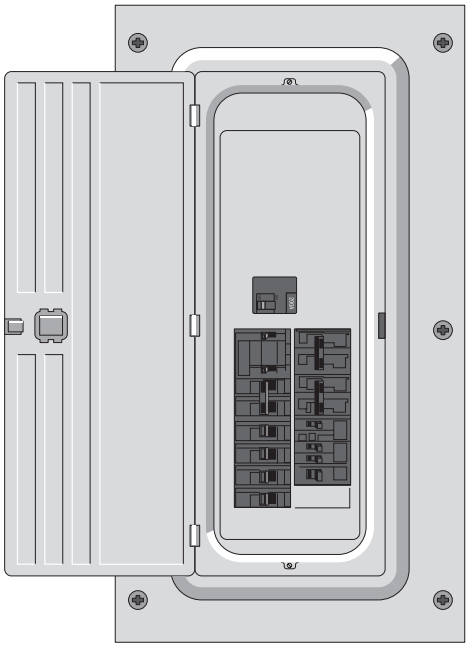
3. *NEC*® specifies that a maximum of _____ switches or circuit breakers shall be used to disconnect and isolate the service from other equipment.

4. When installing a load center, it is important to ground the neutral bus only at the _____.

Siemens Ultimate Load Centers

Siemens Ultimate load centers are 1-phase, 3-wire, split neutral load centers designed to meet the needs of most single family homes. They are available as main breaker/convertible or main lug/convertible load centers with indoor (NEMA 1) or outdoor (NEMA 3R) enclosures.

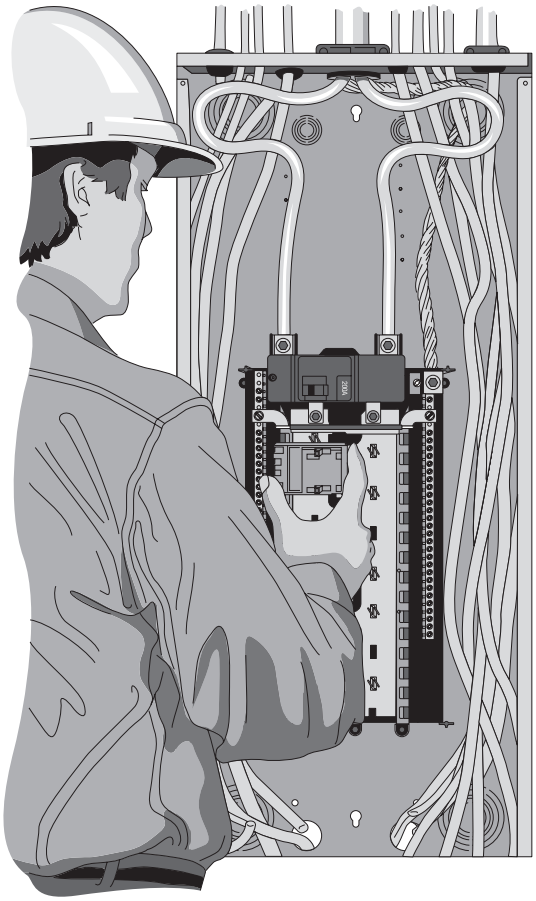
Ultimate main breaker/convertible load center sizes range from 12 to 42 circuits, 100 to 225 A. Ultimate main lug/convertible load center sizes range from 12 to 42 circuits, 125 to 225 A.



Ultimate load centers incorporate a number of innovative features that ease installation or increase flexibility. For example:

- Load centers are convertible from main breaker to main lug or vice versa
- Main breakers are straight-in wired (no back feeding)
- Horizontal main breaker handle allows for inverting for bottom-fed applications
- Visible neutrals ease insertion of neutral conductors
- Neutral connections are provided for 140% of the maximum branches ensuring availability of connections

- INSTA-WIRE screws are backed out and ready for wire insertion
- Screws have a combination slotted/square-drive head that allows for a choice of installation tools
- Factory-installed, INSTA-WIRE, visible ground bars in main lug load centers
- Pre-positioned bonding screw saves time and eliminates the possibility of a lost bonding screw
- Tabs hold the trim in place during installation freeing both hands to drive trim screws
- Tangential knockouts eliminate the need for conduit offsets



Siemens EQ Load Centers

Siemens manufactures a variety of **EQ load centers** ranging from circuit breaker enclosures and small circuit load centers to 3-phase and 300-400 A 1-phase load centers.

EQ Circuit Breaker Enclosures

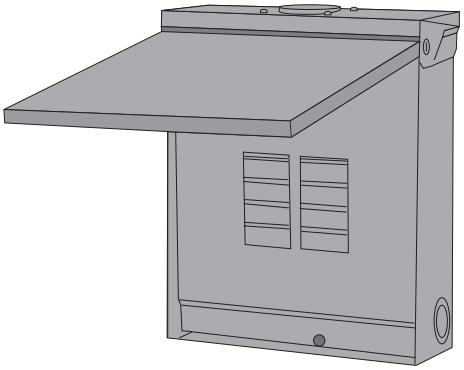
EQ circuit breaker enclosures are designed for use with QP, QT, QPH, HQP, BQ, BQH, HBQ, QPP, QPPH, HQPP, QJ2, QJH2, and QJ2-H circuit breakers. Both indoor (NEMA 1) and outdoor (NEMA 3R) enclosures are available.

EQ circuit breaker enclosures for 1-phase, 3-wire, 120/240 V applications are available with ampere ratings from 60 to 225 A. EQ circuit breaker enclosures for 3-phase applications are also available.

Circuit breaker enclosures are useful for providing a means to disconnect power within sight of equipment located some distance from a load center. For example, a 50 amp circuit breaker in a load center could supply another circuit breaker in an enclosure suitable for outdoor use located next to an air conditioner.

EQ Small Circuit Load Centers

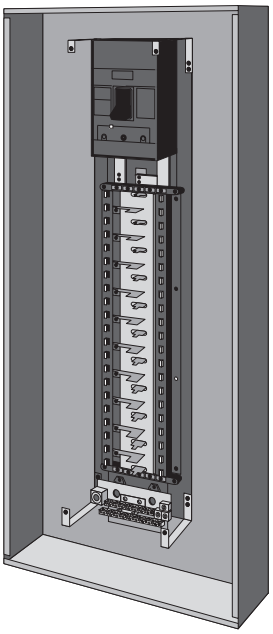
EQ small circuit load centers are 1-phase, 3-wire, 120/240 V load centers available with main lugs or main breaker and copper bus or main lugs and aluminum bus. Both indoor (NEMA 1) and outdoor (NEMA 3R) enclosures are available. EQ small circuit load center sizes range from 4 to 16 circuits, 100 to 200 A.



EQ 3-Phase and 300-400 A, 1-phase Load Centers

EQ main breaker load centers are available for 3-phase, 3-wire 240 V, 3-phase, 4-wire, 240 V, or 3-phase, 4-wire 120/208 V applications. Both indoor (NEMA 1) and outdoor (NEMA 3R) enclosures are available. EQ 3-Phase load center sizes range from 12 to 42 circuits, 100 to 400 A.

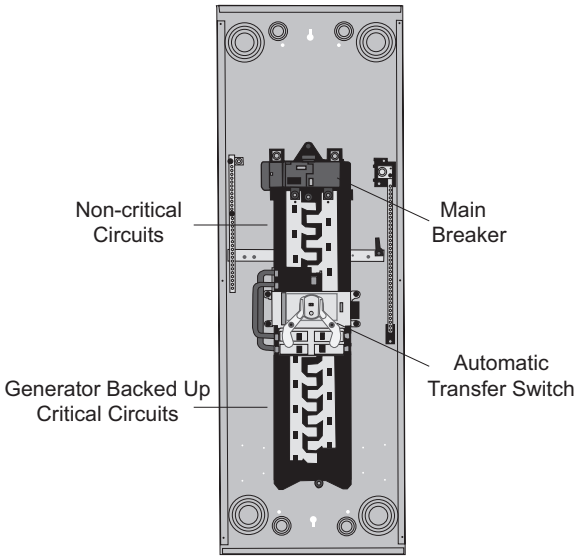
EQ 1-phase, 3-wire, 300-400 A, 120/240 V load centers are available with a main breaker or main lugs and with an indoor (NEMA 1) or outdoor (NEMA 3R) enclosure.



Special Application Load Centers

Generator Ready Load Centers

Siemens **Generator Ready Load Center** is a UL listed 200 A, 30 circuit, 42 space indoor load center that provides an effective solution for implementing generator backup of critical circuits. Both main lug only and main breaker versions are available.



Main Breaker
Load Center

These load centers are equipped with two interiors. Up to 30 critical circuits are wired to the lower interior. Non-critical circuits are wired to the upper interior. Both interiors are powered by the electrical utility during normal operation. When utility power is not available, the critical circuits connected to the lower interior can be switched to generator power.

In order to accomplish this, a field addable automatic transfer switch or a manual transfer switch must be installed. The switch, along with any branch circuit breakers required for the application, must be ordered separately. However, installing the load center without the transfer switch is a cost effective approach for new construction when a generator will not be initially installed. This approach allows the wiring needed for standby generator operation to be completed during initial construction. At a later time, the homeowner can a install standby generator without the cost of re-wiring.

Renovation Panels

Renovation panels are designed for renovation projects in older homes in which the distance between studs is narrower than current construction practices provide. Use of this narrower panel eliminates the need to notch out existing studs.

Trailer Panels

Trailer Panels are feed-through panels UL listed as service entrance equipment. These panels are intended for serving mobile homes located on private lots. The panels either have factory or field added main breakers with subfeed lugs. Additional breaker positions allow for connection of external circuits.

Spa Panels

Spa panels are designed for outdoor applications requiring the use of a ground fault circuit interrupter (GFCI). These panels incorporate a 2-pole GFCI breaker and provide two extra circuits.

Load Center Catalog Numbers

Each type of load center is identified by a catalog number. The following figure shows a typical catalog number.

1	2	3	4	5	6	7	8	9
G	12	24	MB	1	100	S	CU	22

Part 1

Part 1 identifies the type of enclosure or the component.

E = Indoor type 1, 2-10 and 30-42 circuits 300-400 Amp
G = Indoor type 1, 12-42 circuits
W = Outdoor type 3R
T = Trim
I = Interior

Part 2

Part 2 identifies the number of spaces or poles. The number of spaces is the maximum number of 1-inch, 1-pole circuit breakers that can be installed.

Part 3

Part 3 identifies the maximum number of circuits.

Part 4

Part 4 identifies the type of load center.

ML or L = Main Lug Only
MB or B = Main Breaker
MC = Convertible

Part 5

Part 5 identifies the voltage and system.

1 = 1-Phase, 3-Wire
3 = 3-Phase, 3-Wire or 3-Phase, 4-Wire

Part 6

Part 6 identifies the main ampere rating. For example, 100 = 100 amps.

Part 7

Part 7 identifies the type of trim and other characteristics.

Blank = Combination
S = Surface
F = Flush
T = Feed Through Lugs
G or GB = Ground Bar Factory Installed

Part 8

Part 8 identifies the type of bus bar.

Blank = Aluminum
C or CU = Copper

Part 9

Part 9 identifies the main breaker interrupting rating.

Blank = 22,000 AIR
22 = 22,000 AIR (3-phase load centers)
42 = 42,000 AIR (3-phase load centers)

Review 6

1. Which of the following descriptions do **not** apply to Siemens Ultimate load centers?

   a. They are convertible from main breaker to main lug and vice versa.
   b. They incorporate a number of innovative features to save installation time.
   c. They are only available with an indoor enclosure.

2. Siemens Ultimate load centers are available for 12 to _____ circuits and 100 to _____ A.

3. Which of the following types of load centers are included in the Siemens EQ load center line? List all that apply.

   a. circuit breaker enclosures
   b. small circuit load centers
   c. 3-phase load centers
   d. 300-400 A 1-phase load centers

4. Which of the following special application load centers includes a GFCI circuit breaker as a standard feature?

   a. generator ready load center
   b. renovation panel
   c. trailer panel
   d. spa panel

5. A _____ in the first position of a Siemens load center part number indicates that it has a NEMA 3R enclosure.

Sizing The Load Center

Planning is an important first step for all electrical projects. Careful engineering is required so that the distribution system safely and efficiently supplies adequate electric service to both present and possible future loads. As part of this planning, procedures in the *National Electrical Code*® should be used to correctly size the load center based upon the following characteristics:

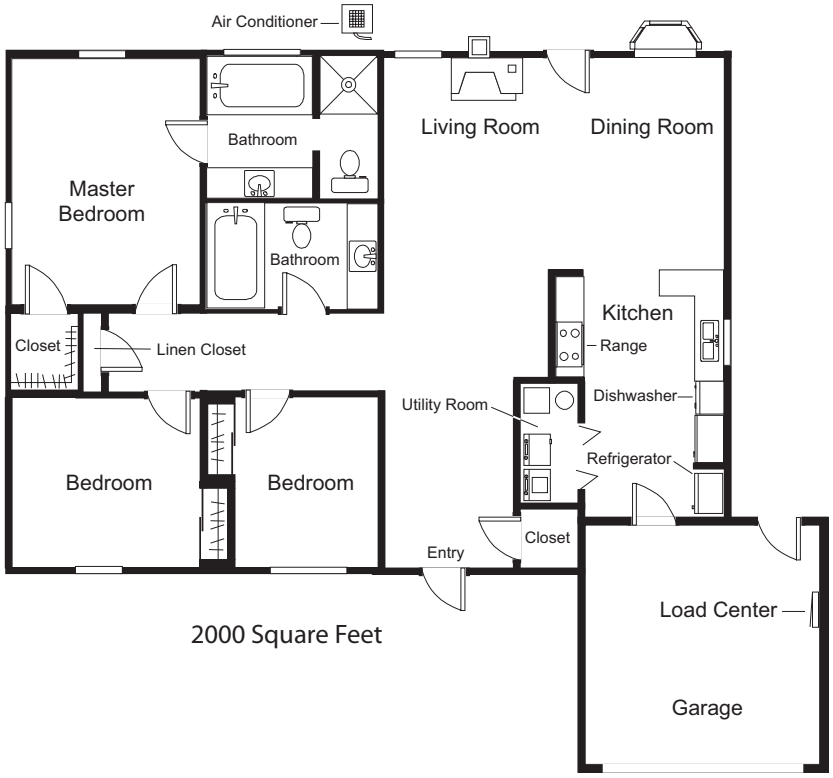
- General lighting based on square footage of living space
- Small appliance load
- Laundry circuit
- Large appliance load
- Miscellaneous appliance load

Power Calculations

When a force causes motion, work is accomplished. In an electrical circuit, voltage applied to a circuit causes electrons to flow. Voltage is the force and electron flow, measured in amps, is the motion.

The rate at which work is done is called power. The unit of measure for power depends on the type of power. For example, apparent power is the product of voltage (in volts) times current (in amps). Therefore, apparent power is expressed in volt-amps (VA). True power, on the other hand, is the product of apparent power times the power factor. True power is expressed in watts. For a more complete explanation of true power and apparent power refer to the STEP course titled **Basics of Electricity**.

Manufacturers of electrical equipment often rate their products in watts based on power measurements taken with rated voltage and current applied. For many applications, such as the single-family home described on the following pages, power is expressed in VA when rated current and voltage are known, but power factor is not known. The following example uses apparent power values, expressed in VA, to simplify the description and arrive at an approximate solution. More exact calculations are often needed to design circuits for real applications.



This sample floor plan is for a 2000 square foot home that has a 9600 VA (240 volts x 40 amps) air conditioner, a 9600 VA (240 volts x 40 amps) electric range, 12,000 VA (240 volts x 50 amps) of electric heating, a 5000 VA (240 volts x 20.8 amps) clothes dryer, a 1500 VA (120 volts x 12.5 amps) dishwasher, and a 1176 VA (120 volts x 9.8 amps) garbage disposal. Three small appliance circuits will be used in the kitchen area.

Note: A thorough knowledge of the *National Electrical Code®* is required to properly size load centers and conductors. If you will be performing these task, you are encouraged to become familiar with this code.

General Lighting Load

According to *NEC ®* Table 220.12, the minimum general lighting load for a dwelling is calculated at 3 VA per square foot of living space. This includes non-appliance receptacles for items such as table lights and television sets. The example has 2,000 square feet of living space. The calculated living space does not include carports, garages or unfinished spaces, such as basements, that are not adaptable for future use. The required general lighting load for this example is 6000 VA.

3 VA x 2000 square feet = 6000 VA

Small Appliance Loads

According to *NEC* ® Article 210.11(C)(1) at least two 120 volt, 20 amp small appliance circuits shall be provided. These are located in the kitchen area for small appliances such as toasters and coffee makers. *NEC*® Article 220.52(A) also states that these circuits shall be rated at 1500 VA. In this example house, there will be three small appliance circuits for a total rating of 4500 VA.

3 x 1500 VA = 4500 VA

Laundry Circuit

NEC® Article 210.11(C)(2) requires at least one 120 volt, 20 amp circuit for the laundry area. Article 220.52(B) states that this circuit shall not be less than 1500 VA.

1500 VA

Total General Lighting and Small Appliance Load

From the previous calculations the total general lighting and small appliance load is:

General lighting	*6000 VA*
Small appliance load	*4500 VA*
Laundry circuit	*1500 VA*
Total	**12,000 VA**

Demand Factors

All residential electrical outlets are never used at one time. Knowing this, the *NEC*® allows for a demand factor in sizing electric services. Demand factors for general lighting are given in *NEC*® Table 220.42. The first 3000 VA is rated at 100%. The remaining 9000 VA (12,000 VA minus 3000 VA) may be rated at a demand factor of 35%.

First 3000 VA at 100%	*3000 VA*
Remaining 9000 VA at 35%	*3150 VA*
Net general lighting and small appliance load	**6150 VA**

Large Appliance Loads

Large appliance loads must be considered individually. The following large appliances are used in the example:

Air conditioner	*9600 VA*
Electric clothes dryer	*5000 VA*
Electric heat	*12,000 VA*
Electric range	*9600 VA*

Air conditioner and electric heat will not be used at the same time. Only the larger of the heater load or air conditioner load is used (*NEC*® Article 220.82(C)). In this case, the heater load (12,000 VA) is greater than the air conditioner load (9600 VA).

All other large appliance loads must be calculated at 100% except for the electric range. *NEC*® Table 220.55 allows a demand factor for electric ranges. Not all burners will normally be on high at the same time. According to Table 220.55, an electric range with a rating not greater than 12,000 watts can have a demand factor of 8000 watts. For the purpose of this calculation, assume that the power factor is 0.9, this results in an apparent power rating for the electric range of 8889 VA (8000 watts divided by 0.9).

Electric heat	*12,000 VA*
Electric clothes dryer	*5000 VA*
Electric range	*8889 VA*
Net large appliance load	**25,889 VA**

Miscellaneous Loads

Miscellaneous appliance loads must also be taken into consideration. The example has the following miscellaneous appliance loads:

Dishwasher	*1500 VA*
Garbage disposal	*1176 VA*
Total miscellaneous appliance load	**2676 VA**

Required Service

The required service size is found by adding the calculated values together.

General lighting, laundry and small appliance load	*6150 VA*
Net large appliance load	*25,889 VA*
Miscellaneous appliance load	*2676 VA*
Total load	**34,715 VA**

The average power supply for residential use is 120/240 volts. To determine the required load center rating divide the total load by 240 volts (the highest voltage used).

34,715 VA ÷ 240 volts = 144.6 amps

A Siemens load center rated for 150 amps could be selected. Before a load center is selected, however, it is important to plan for electrical service expansion by providing space for at least two future branch circuits. Since the load for these future circuits is undetermined, add ten amperes per space. The amperage requirement is now 160.9 amps.

144.6 amps + 20 amps (expansion) = 164.6 amps

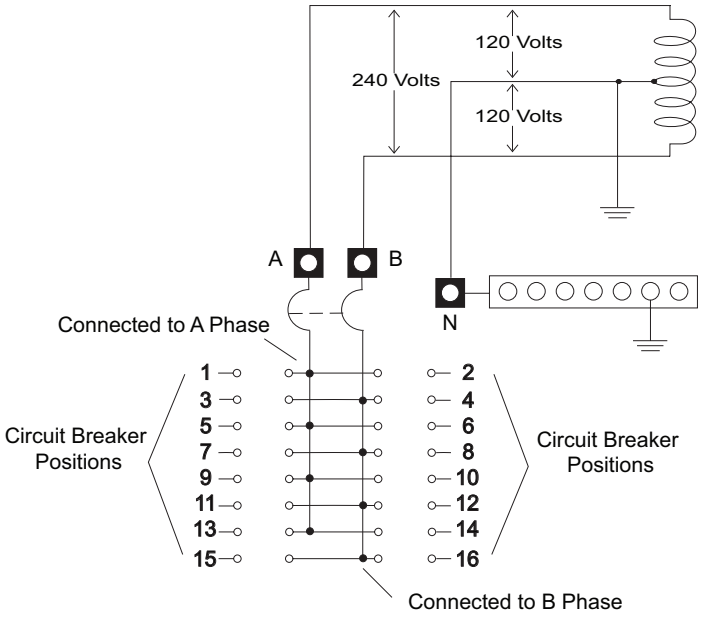
Safety Factor

Circuit breakers are affected by the temperature of the air surrounding them. For this reason an additional safety factor of 20% is added to the load center requirements.

164.6 amps + (.20 x 164.6) = 197.5 amps. Therefore, a **200 amp load center** is a good choice.

Determining the Number of Circuits

Calculating the number of circuits required in a load center involves an understanding of how circuits are configured. In the following example, a 120/240 volt power supply is connected to a 16-space/circuit load center.

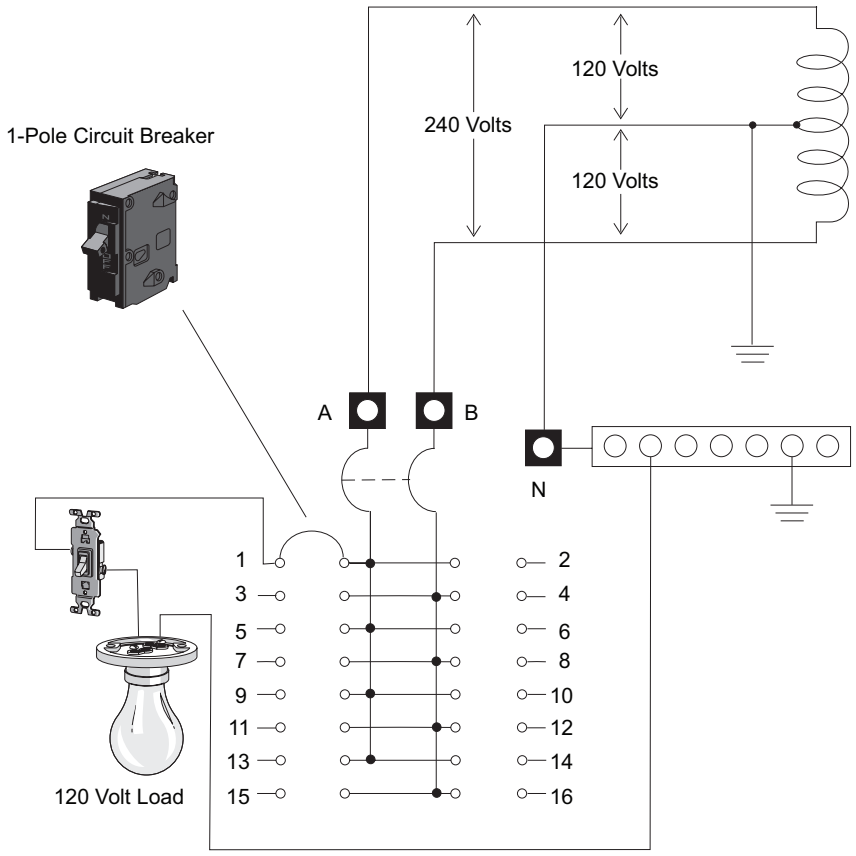


The term A phase refers to the part of a single-phase system between one hot wire and neutral. The term B phase refers to the part of a single-phase system between the other hot wire and neutral. Half of the circuits are connected to A phase and half to B phase.

For example, circuits 1 and 2 are connected to A phase; circuits 15 and 16 are connected to B phase. The number of usable circuits in this load center depends on how many 120 volt and 240 volt circuits need to be connected to it. Each 120 volt circuit will use one of the circuit breaker positions. Each 240 volt circuit will use two of the circuit breaker positions.

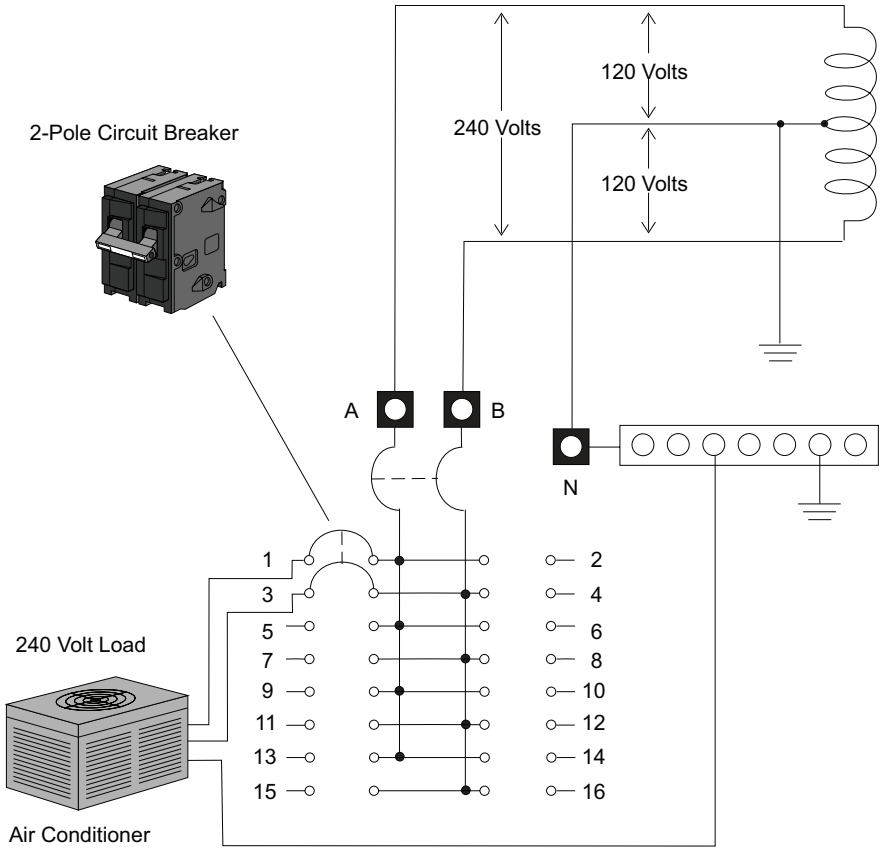
120 Volt Circuit

A circuit requiring 120 volts, such as general lighting and electrical receptacles, is connected through a 1-pole circuit breaker. In the following example a 1-pole circuit breaker has been installed in position 1. A lighting circuit receives 120 volts from A phase, through the circuit breaker and returning to the neutral connection. Power to the light can be interrupted by the light switch. There are 15 circuit breaker positions left for additional circuits.



240 Volt Circuit

A circuit requiring 240 volts, such as an air conditioner or water heater, is connected through a 2-pole circuit breaker. In the following example a 2-pole circuit breaker has been installed in positions 1 and 3. An air conditioner receives 240 volts from phase A, through the circuit breaker pole connected to position 1, and phase B, the pole of the circuit breaker connected to position 3. This leaves 14 circuit breaker positions left for additional circuits.



Determining the Number of Circuits

In the following example, the number of circuits (spaces) required for a load center will be calculated using the same example to determine the load center current rating.

General Lighting Circuits

The minimum number of lighting circuits required for general lighting is calculated first. In the sample home, the general lighting load was 6000 VA. To determine the amount of current used by a 6000 VA load, divide by the maximum voltage. The maximum voltage for general lighting is 120 volts.

6000 VA ÷ 120 V = 50 A

Either 15 amp or 20 amp circuit breakers (with appropriately sized wiring) can be used. Typically, 15 amp circuit breakers are used for general lighting. The minimum number of circuits is calculated by dividing current by breaker size. If 15 amp circuit breakers are used, four circuits are required. Depending on the layout of lighting and receptacles, an electrician may specify more than the minimum number of circuits.

50 A ÷ 15 A = 4 circuits (3.33 rounded up to 4)

Small Appliance Circuits

There are three 120 volt, 20 amp small appliance loads. Three 20 amp circuit breakers are required.

Laundry Circuit

There is one 120 volt, 20 amp laundry circuit. One 20 amp circuit breaker is required.

Air Conditioner Circuit

Large appliances are considered individually. The air conditioner, heater, clothes dryer and range are all rated for 240 volts. Each 240 volt circuit will require a 2-pole circuit breaker which occupies two positions in the load center. The amperage is calculated by dividing VA rating by 240 volts. The air conditioner, for example, is 9600 VA.

9600 VA ÷ 240 V = 40 A

Generally the ampere rating of a circuit breaker is selected at 125% of the continuous load current. This usually corresponds to the conductor ampacity, which is also selected at 125% of load current. The air conditioner is a 40 amp load. 50 amp wiring and a 50 amp circuit breaker would be selected.

40 A x 1.25 (125%) = 50 A

Electric Heater Circuit

The electric heater is a 240 volt, 50 amp (12,000 VA ÷ 240 V) device.

50 A x 1.25 (125%) = 62.5 A

Because the circuit breaker rating must not exceed the ampacity of the conductor, wiring capable of handling 70 amps should be used along with a 70 amp breaker, the next standard size above 60 amps.

Clothes Dryer Circuit

The clothes dryer is a 240 volt, 21 amp (5000 VA ÷ 240 volts) device.

21 A x 1.25 = 26.25 A

30 amp wiring and a 30 amp circuit breaker should be used.

Electric Range Circuit

The electric range is a 240 volt, 40 amp (9600 VA ÷ 240 volts) device.

40 A x 1.25 = 50 A

50 amp wiring and a 50 amp circuit breaker would be selected.

Dishwasher Circuit

The dishwasher and garbage disposal are 120 volt loads. The dishwasher is a 120 volt, 12.5 amp (1500 VA ÷ 120 volts) device.

12.5 A x 1.25 = 15.6 A

20 amp wiring and a 20 amp circuit breaker should be used.

Garbage Disposal Circuit

The garbage disposal is a 120 volt, 9.8 amp (1176 VA ÷ 120 volts) device.

9.8 A x 1.25 = 12.3 A

15 amp wiring and a 15 amp circuit breaker should be used.

Total Number of Spaces

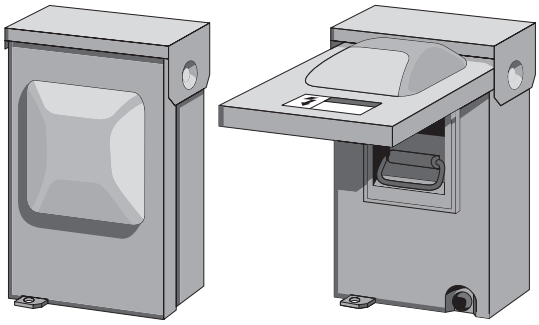
The total number of load center spaces (circuits) can now be calculated. A load center with a minimum of 18 spaces are needed. Because load centers are typically selected with spare circuit breaker spaces, a **24-space load center** would be a good choice.

Circuit	Qty	Circuit Breaker	Voltage	Spaces Required
General Lighting	4	15 A	120 V	4
Small Appliance	3	20 A	120 V	3
Laundry	1	20 A	120 V	1
Air Conditioner	1	50 A	240 V	2
Electric Heater	1	70 A	240 V	2
Clothes Dryer	1	30 A	240 V	2
Electric Range	1	50 A	240 V	2
Dishwasher	1	20 A	120 V	1
Garbage Disposal	1	15 A	120 V	1
			Total Spaces Required	**18**

AC Disconnects

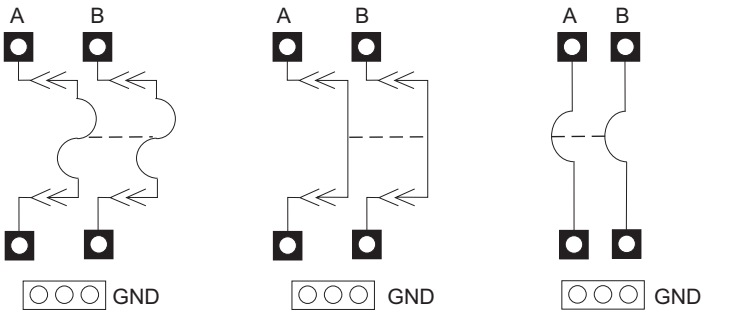
Fused, Non-Fused, and Molded Case Switch Disconnects

Siemens manufactures fused, non-fused and molded case switch air conditioning (AC) disconnects. These are supplied in a NEMA type 3R enclosure. Both steel and plastic enclosures are available.



Disconnect Enclosure Fused Disconnect

The fused pullouts are 240 volt, 2-pole, 30 or 60 amps. The non-fused pullouts are 240 volt, 2-pole, 60 amps. The molded case switch disconnects are 240 volt, 2-pole, 50 or 60 amps. Molded case switch disconnects are supplied with nonautomatic (QP molded case switch) circuit breakers.



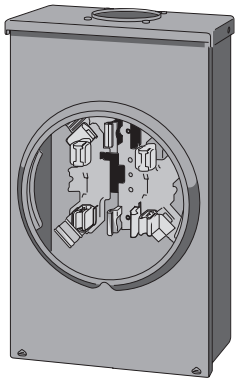
Fused Disconnect | Non-Fused Disconnect | Molded Case Switch Disconnect

Residential Metering

For many years, power companies have used the familiar watt-hour meter to determine how much electricity has been consumed for billing purposes. Siemens manufactures a variety of metering enclosures to meet virtually every residential metering need. Siemens also manufacturers metering enclosures for commercial and industrial applications, but the following paragraphs only lists the most common residential metering enclosure types.

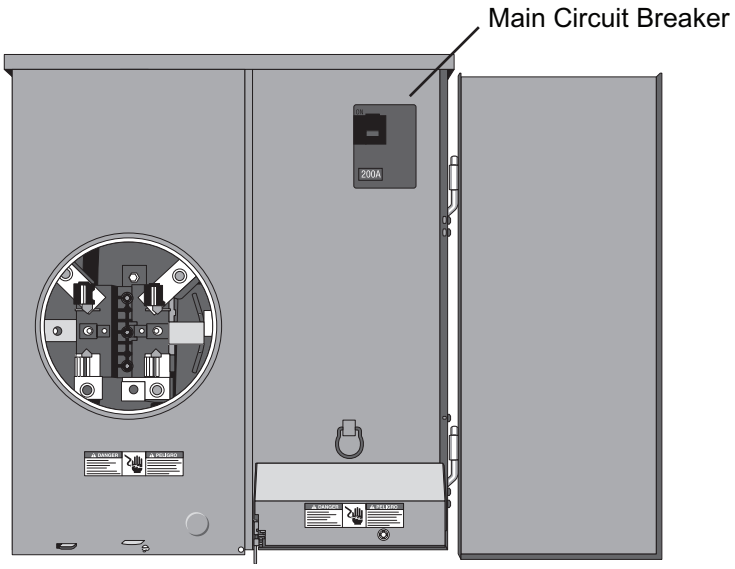
Residential Meter Sockets

Siemens features one of the most complete and comprehensive meter socket lines available from any manufacturer. Siemens residential meter sockets utilize the **Landis & Gyr design** known for quality throughout the utility industry for more than 50 years. All enclosures are NEMA type 3R and made of 16-gauge galvanized steel with a polyester powder coat finish.



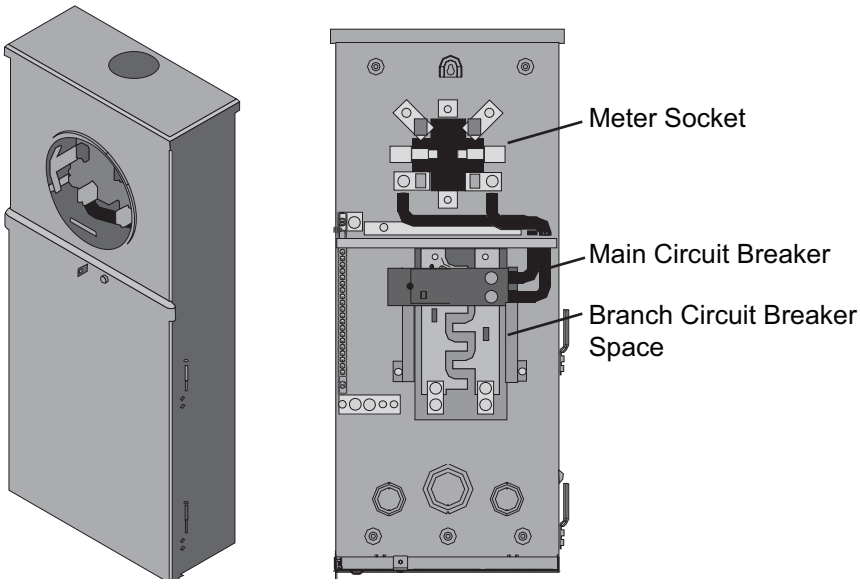
Surface Mount Meter Mains

Siemens 1-phase, 3-wire 120/240 V **surface mount meter mains** incorporate a meter socket enclosure and a main circuit breaker or provisions for field installed main breakers. Factory installed main breaker sizes range from 125 to 200 A. Ampere ratings for field installed main breakers range from 100 to 400 A.



Surface Mount Meter Load Centers and Trailer Service Panels

Siemens 1-Phase, 3-wire 120/240 V **surface mount meter load centers** incorporate a meter socket enclosure and a load center. Ampere ratings for meter load center combinations range from 125 to 400 A. Load center locations are either beside or below the meter socket. Included in this line of products are trailer service panels.



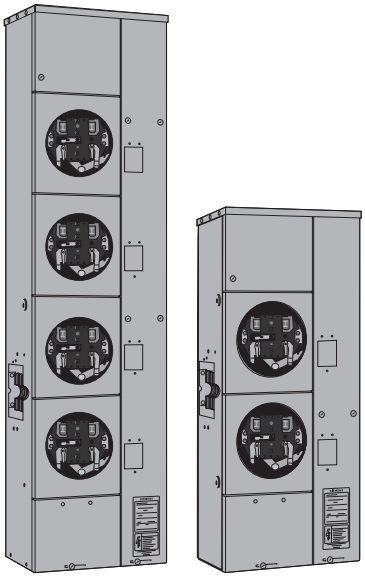
EUSERC-Approved Meter Mains and Meter Load Centers

In addition to non-EUSERC meter mains and meter load centers, Siemens also offers a variety of meter mains and meter load centers approved by the **Electric Utility Service Requirements Committee (EUSERC)**. These types of load centers are primarily found on the West Coast; however, EUSERC currently works with utilities in 12 states.

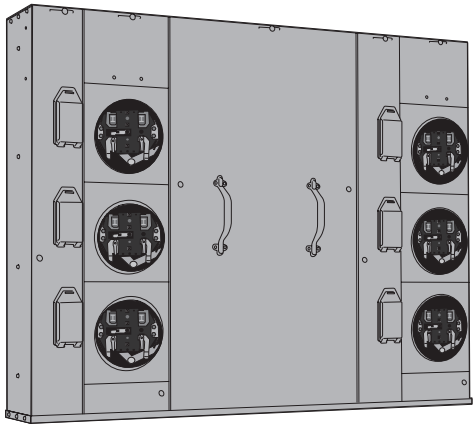
Modular Meter Centers and Metering Systems

Modular meter centers are used for multi-family dwellings such as duplexes or apartment buildings, but can be adapted for a broad range of residential and commercial applications. Meter centers are configured by combining the following basic module types which include circuit breaker, fusible switch, and tap box service entrance modules and two-socket, three-socket, four-socket, five socket, and six socket meter modules.

Metering systems are another option for multi-family dwellings. These are self-contained systems with two to six meter compartments. Individual branch circuit breakers for each tenant are located in a separate compartment adjacent to each meter socket.



Modular Meter Centers



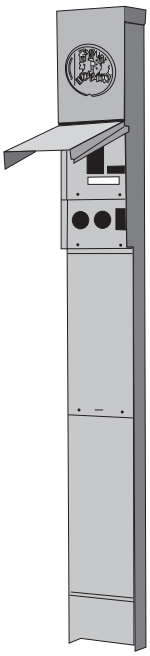
Metering System

Temporary Power Outlet Panels

The need for easily accessible receptacles to provide electrical power for various types of portable equipment continues to rise as Americans build more homes and travel in recreational vehicles (RVs). In order to satisfy the electrical power needs of temporary service and meet the requirements of the National Electrical Code, a safe and reliable power outlet is required.

Siemens **All-Sites temporary outlet panels** provide a variety of options for UL listed power outlets suitable for use as temporary service equipment during construction or as recreational vehicle (RV) power supply panels.

All-Sites temporary outlet panels are available for surface mounting or on earth mounted or pad mounted pedestals in single panel or back-to-back configurations. Unmetered and ring type and ringless metered versions are available in all configurations.



Enclosures
- Rainproof NEMA 3R Construction
- Quality Finish
- Removable Deadfront
- Theft Resistant
- Meters Top or Bottom
- Removable Door
- Overhead or Underground Feed
- Optional Lighting

Interiors
- Plated copper bus bars
- Internal components pre-wired
- Lifetime warranted Siemens Breakers
- Impact-resistant, Thermoplastic Receptacles
- GFCI Protection for Receptacles

Review 7

1. According to the *NEC®*, when calculating the general lighting load, use ___ VA per square foot of living space.

2. The *NEC®* requires a demand factor of _____ % for the first 3000 VA of general lighting and small appliance load.

3. Each 240 volt circuit breaker requires _____ position(s) in a load center.

4. Siemens manufactures fused, non-fused, and _____ air conditioning disconnects.

5. Siemens residential meter sockets use the _____ design and have a NEMA type _____ enclosure.

Review Answers

Review 1	1) power distribution; 2) 408; 3) 240; 4) a; 5) c.
Review 2	1) 1, 3R; 2) Branch; 3) split neutral; 4) INSTA-WIRE; 5) trim; 6) circuit directory.
Review 3	1) heat; 2) pole; 3) main; 4) duplex; 5) 2.
Review 4	1) b; 2) Arc faults; 3) d; 4) lightning; 5) TVSS.
Review 5	1) main breaker, main lug only; 2) full; 3) 6; 4) service entrance.
Review 6	1) c; 2) 42, 225; 3) a, b, c, d; 4) d; 5) W.
Review 7	1) 3; 2) 100; 3) 2; 4) molded case switch; 5) Landis & Gyr, 3R

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 completing 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. The basic requirements for panelboards, including load centers, are described in *NEC®* Article _____.

   a. 230 b. 408
   c. 310 d. 410

2. Which of the following does **not** meet the *NEC®* definition for 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 either the front or rear

3. _____ is a component used in a load center that serves as a common connection between two or more circuits.

   a. The trim b. A knockout
   c. A bus bar d. A hub

4. *NEC®* Article _____ covers spaces about electrical equipment.

   a. 110.26 b. 250
   c. 210 d. 310.1

5. Two major categories of load centers are _____.

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

6. The most common power distribution system used in residential applications is _____.

   a. 1-phase, 2-wire, 120 V
   b. 1-phase, 3-wire, 120/240 V
   c. 3-phase, 3-wire, 480 V
   d. 3-phase, 4-wire, 208Y/120 V

7. *NEC*® Article 230.71 specifies that for each set of service entrance conductors, no greater than _____ switches or circuit breakers can be used to disconnect and isolate the service from all other equipment.

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

8. The neutral conductor is _____ grounded at the service-entrance load center.

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

9. The neutral conductor is _____ grounded at a load center downstream from the service-entrance load center.

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

10. The _____ method requires the main circuit breaker to be equal to or greater than the available fault current, but allows downstream circuit breakers rated at lower values.

    a. series rating b. parallel rating
    c. full rating d. compound rating

11. According to *NEC*® Article 210.8, receptacles in which of the dwelling unit locations shown below must have GFCI protection for personnel?

    a. bedrooms
    b. bathrooms
    c. living rooms
    d. dining rooms

12. How many critical circuits can be wired to the lower interior of a Siemens Generator Ready Load Center for backup by a standby generator?

    a. 12 b. 18
    c. 30 d. 42

13. How many 1-pole circuit breakers are incorporated in Siemens Circuit Breaker and Secondary Surge Arrester?

    a. 0 b. 1
    c. 2 d. 4

14. A 240 volt circuit breaker requires _____ spaces in a load center with a 3-wire, 120/240 volt supply.

    a. 4 b. 3
    c. 2 d. 1

15. A _____ circuit breaker incorporates two, independent 1-pole circuit breakers, but fits in a 1" width space.

    a. QP b. QT Quadplex
    c. QT Triplex d. QT Duplex

16. Which of these statements is true regarding Siemens air conditioning (AC) disconnects?

    a. All enclosures are NEMA type 3R.
    b. All enclosures are made of steel.
    c. All enclosures are made of plastic.
    d. All disconnects are fused.

17. Siemens Ultimate load centers have _____.

    a. a split neutral b. INSTA-WIRE screws
    c. a pre-positioned bonding screw d. all the above

18. Siemens Ultimate load centers are available with a maximum continuous current rating of _____ amps.

    a. 100 b. 200
    c. 225 d. 250

19. Siemens EQ circuit breaker enclosures and small circuit load centers are available in a NEMA type _____ enclosure.

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

20. Siemens Combination AFCI circuit breakers are intended to protect downstream wiring for which of the following categories of arc faults?

    a. Line-to-ground arcs
    b. parallel arcs greater than or equal to 75 A
    c. Series arcs greater than or equal to 5 A
    d. All the above

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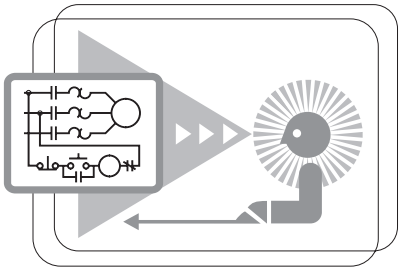

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The Downloads page provides links to the complete text of all STEP courses can be downloaded in PDF format. These files contain the most recent changes and updates to the STEP courses.

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