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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 Industry, Inc. products more effectively. This course covers **Basics of Switchboards** and related products.

Upon completion of **Basics of Switchboards** you should be able to:

- Explain the role of switchboards in a distribution system
- Define a switchboard according to the *National Electrical Code®*
- Identify the main parts of a switchboard
- Identify various ways power can be brought into a switchboard service section
- Explain the difference between hot and cold sequence in relation to current transformers
- Identify the types of main and distribution devices available for Siemens switchboards
- Identify the various models of Siemens switchboards

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 of Circuit Breakers** before attempting **Basics of Switchboards**. An understanding of many of the concepts covered in these courses is required for **Basics of Switchboards.**

After you have completed this course, if you wish to determine how well you have retained the information covered, you can complete a final exam online as described later in this course. If you pass the exam, you will be given the opportunity to print a certificate of completion from your computer.

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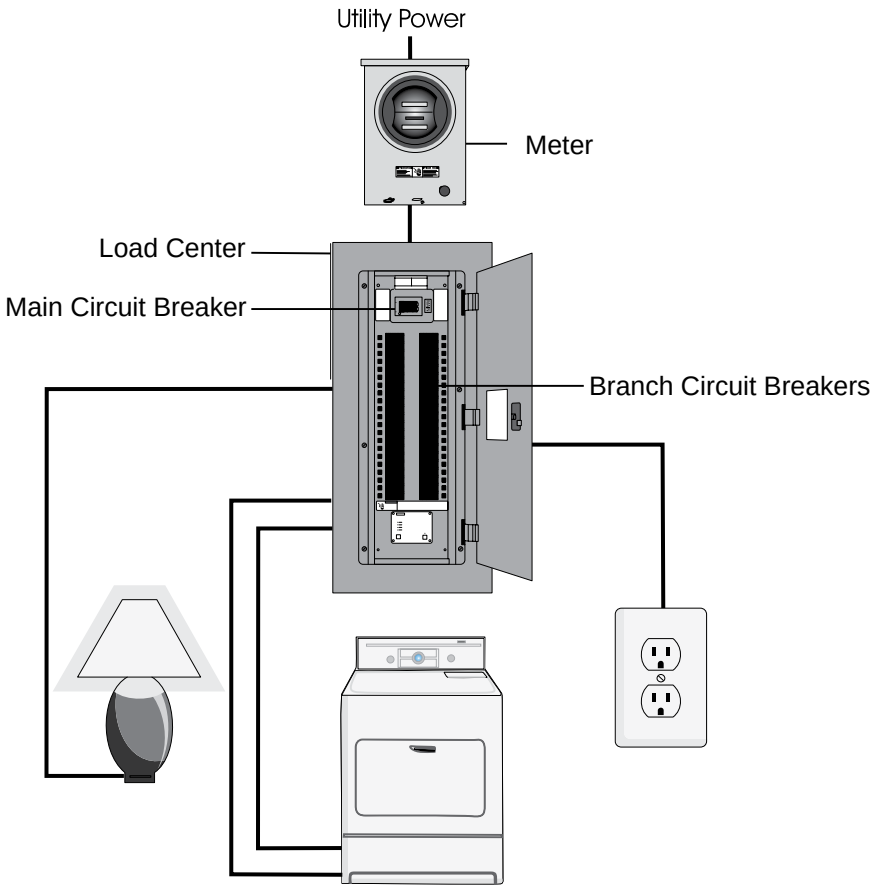
Distribution Systems

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

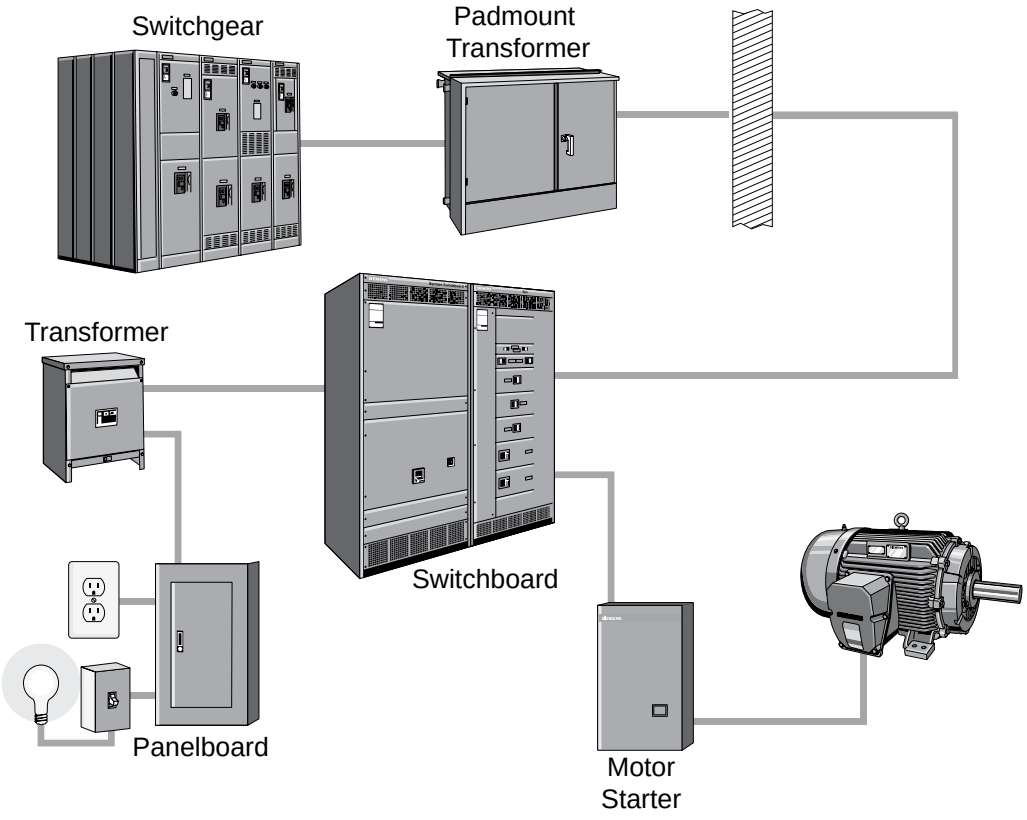
Most of us are familiar with the power distribution system found in the average home. Power purchased from a utility company enters the house through a metering device. The power is then distributed from a load center to various branch circuits for lighting, appliances, and electrical outlets.



Commercial and Industrial Power Distribution

Power distribution systems used in commercial and industrial facilities are more complex than those used in single-family homes and must be capable of handling higher levels of current and voltage. Although some small facilities usually do not require switchboards, medium and large facilities commonly use switchboards to safely distribute power to transformers, panelboards, control equipment, and, ultimately, to system loads.

Good power distribution systems don't just happen, however. Careful engineering is required to ensure that a power distribution system is capable of safely and efficiently supplying adequate electric service to existing loads and has expansion capacity for possible future loads.

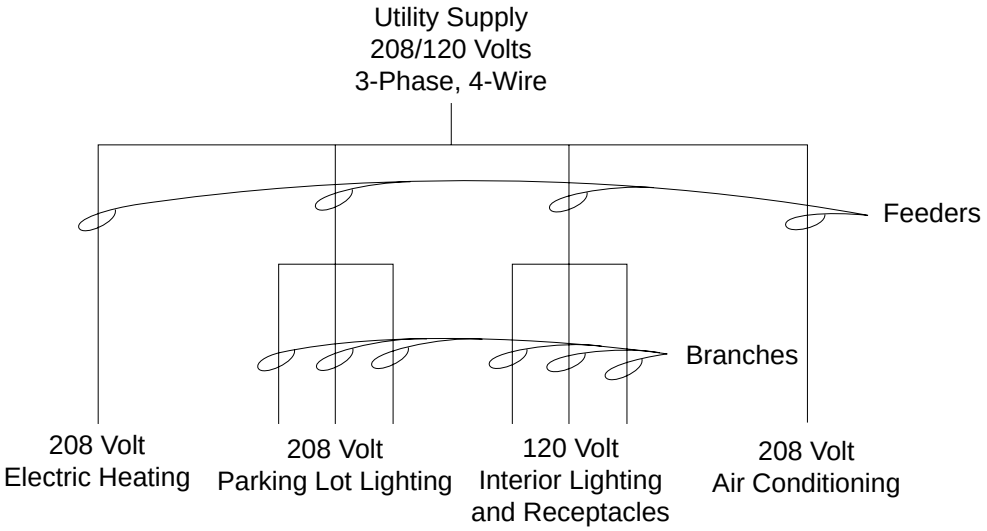


Distribution of Current

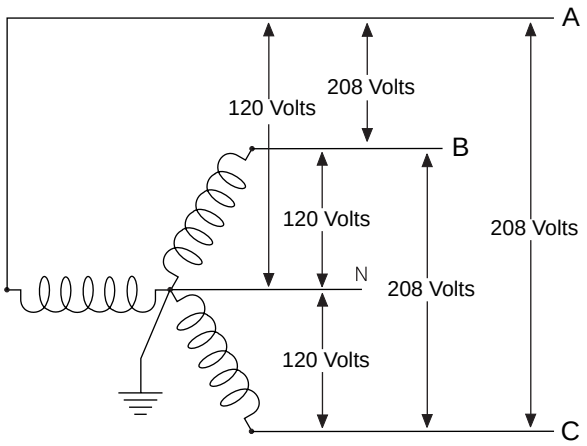
The role of a switchboard is to divide the main current provided to the switchboard into smaller currents for further distribution and to provide switching, current protection, and metering for these various currents. Although this applies to all switchboards, the voltages and currents involved vary with the size of the application.

Small Office Building Example

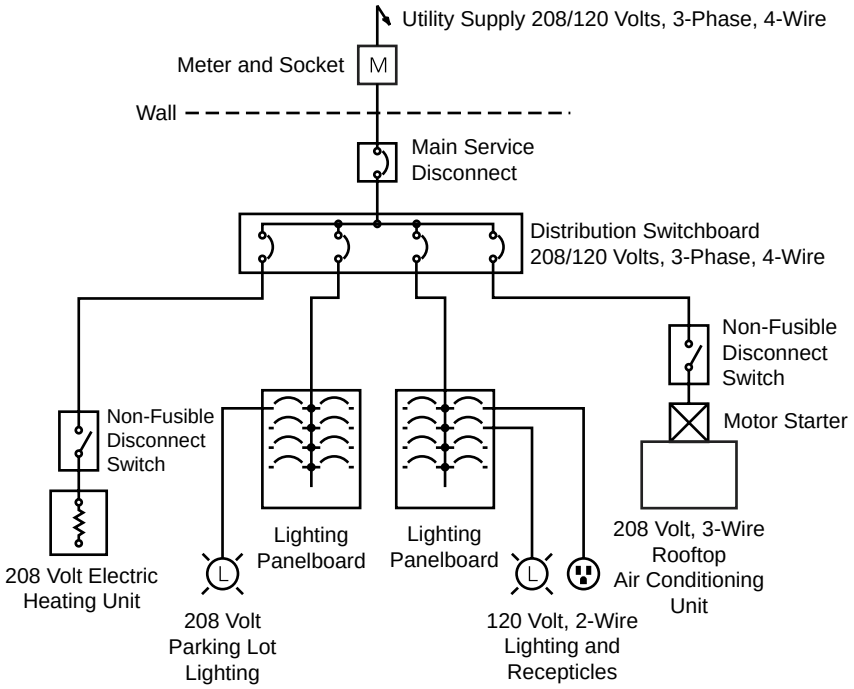
A small office building, for example, might require 120 volts for interior lighting and receptacles and 208 volts for heating, air conditioning, and exterior lighting. In this example, the utility company supplies 208/120 volt, three-phase, four-wire service. The main incoming line is divided into four feeders. The two outer feeders supply power directly to the 208 volt heating and air conditioning units. The two inner feeders are divided into a number of branch circuits. One set of branch circuits supplies power to exterior lighting. The second set of branch circuits supplies power to interior lighting and receptacles.



The electric utility uses a step-down transformer to supply power to a facility. There are a number of ways the secondary of the utility transformer could be configured. In the following example, the utility supplies power from a transformer with a wye-connected secondary. The secondary winding of the transformer produces 208/120 VAC. Single-phase 120 VAC is available between any phase wire and neutral. Single-phase 208 VAC is available between any two phases. All three phases are connected to any equipment requiring three-phase power.



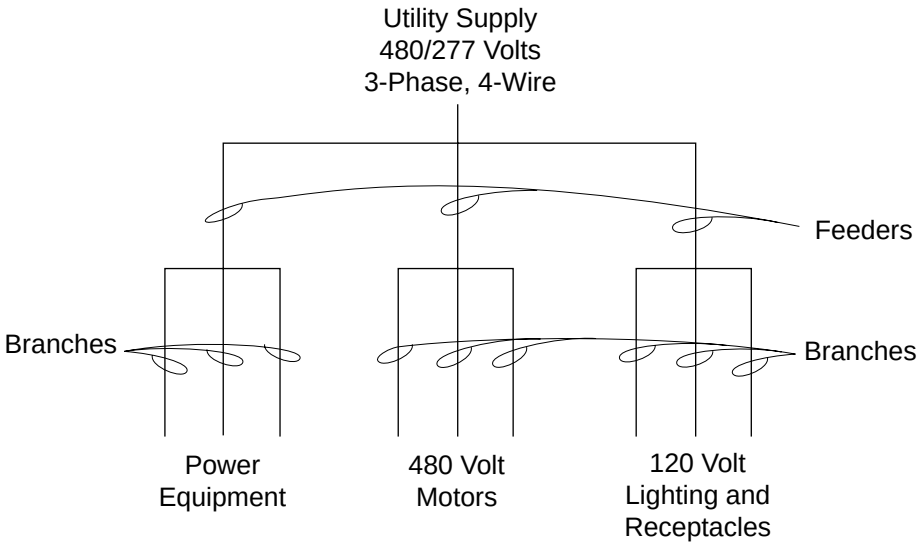
Incoming power is metered by the utility company. In this example, power is supplied to the building through a main service disconnect. A switchboard divides the power into four feeders for distribution throughout the building.



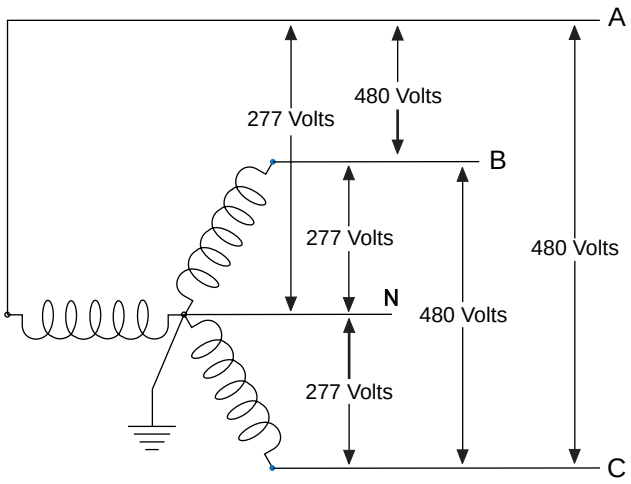
Medium-sized Industrial Plant Example

The next example is representative of the distribution system for a medium-sized industrial plant. In this example, the incoming power is provided by a 480/277 VAC, three-phase, four-wire system.

Three feeders are used. The first feeder is used for various types of power equipment. The second feeder supplies a group of 480 VAC motors. The third feeder is used for 120 volt lighting and receptacles.

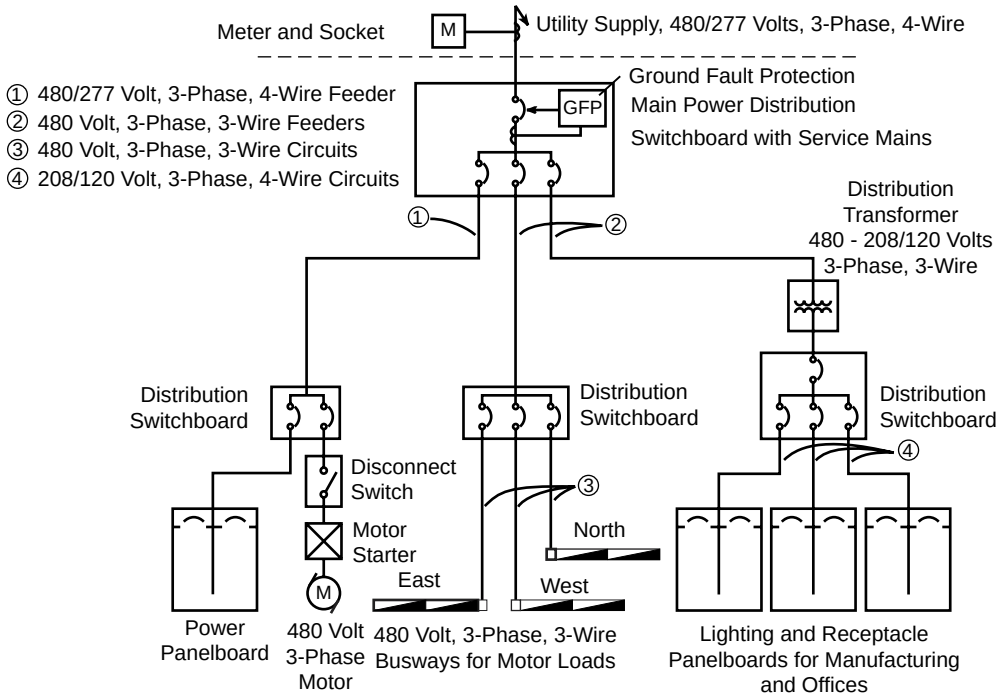


In this application, the secondary winding of the utility transformer provides the 480/277 VAC needed to power the system.



The power from the utility company is metered and enters the plant through a distribution switchboard. The switchboard incorporates a main circuit breaker and circuit breakers for each of the three feeders.

The feeder on the left powers a distribution switchboard, which, in turn, feeds a panelboard and a 480 volt, three-phase motor. The middle feeder powers another switchboard which divides the power into three, three-phase, three-wire circuits. Each circuit feeds a busway run to 480 volt motors. The feeder on the right supplies 208/120 volt power to panelboards connected to lighting and receptacles.



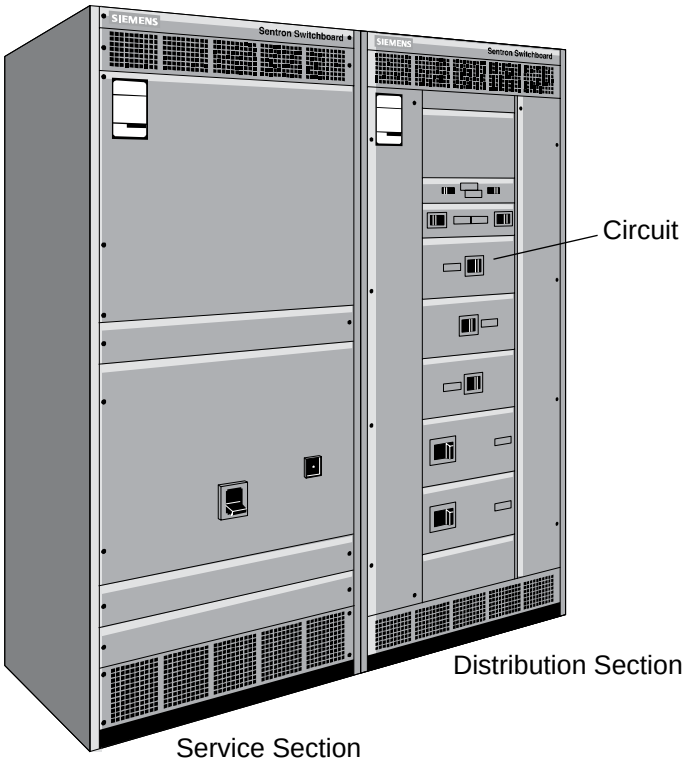
Switchboard Definition

Definition

The National Electrical Code® (NEC®) defines a switchboard as a large single panel, frame, or assembly of panels on which are mounted, on the face, back, or both, switches, overcurrent and other protection devices, buses, and usually instruments.

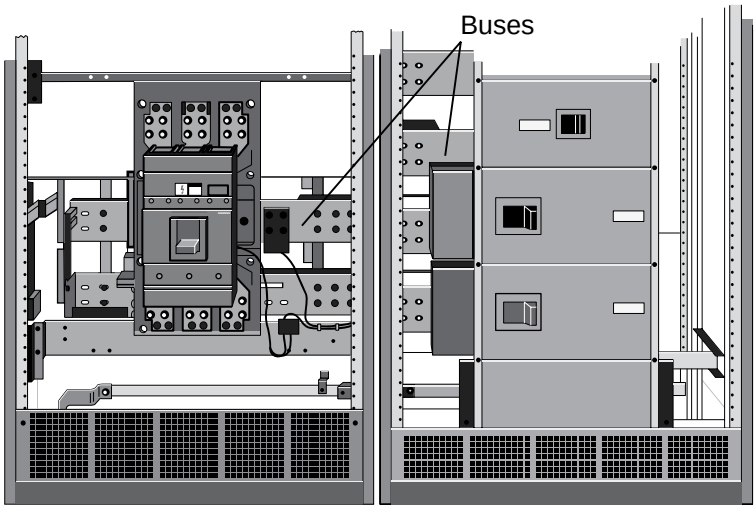
Enclosed Devices

As this definition indicates, switchboards enclose various devices. For example, the following illustration shows two switchboard sections, an incoming or service section and a distribution section that provides power to feeder and branch circuits. Circuit breakers mounted in these sections provide overcurrent protection. Some switchboards use fusible switches instead of circuit breakers



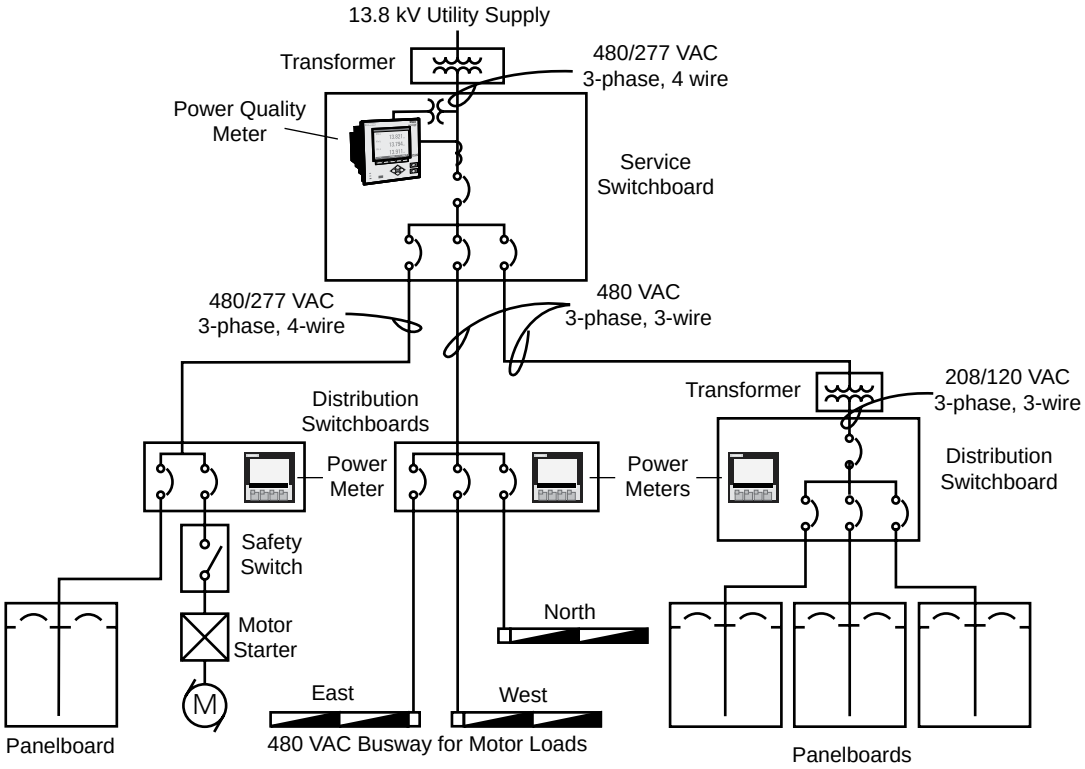
Buses

As the *NEC*® definition states, switchboards include buses, which are metal bars mounted inside the switchboard to conduct power to the switchboard's devices.



Instrumentation

The *NEC*® definition of a switchboard also indicates that the switchboard may have instrumentation. This instrumentation often includes one or more meters designed to accept signals from sensors and other equipment and display representative values for power monitoring and management.



May Be Accessible from Rear

Another characteristic of a switchboard identified in the *NEC*® definition is that it may be installed away from a wall to provide access to the rear of the switchboard. Keep in mind, however, that this is not a requirement of all switchboards.

Switchboard Standards

Switchboards are built according to standards set by **Underwriters Laboratory (UL 891)** and the **National Electrical Manufacturers Association (NEMA PB2)**. Basic requirements for switchboards are also covered in **National Electrical Code® Article 408**.

Review 1

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

2. The phase-to-neutral voltage of a wye-connected transformer with a phase-to-phase voltage of 208 volts is _____ volts.

3. The phase-to-neutral voltage of a wye-connected transformer with a phase-to-phase voltage of 480 volts is _____ volts.

4. Switchboards can include which of the following items?

   a. Overcurrent protective devices
   b. Buses
   c. Power meters
   c. All the above

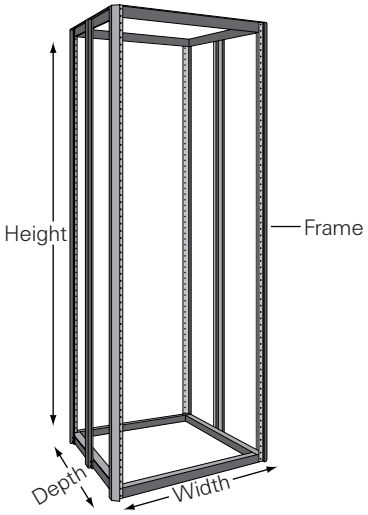
5. According to the *National Electrical Code*® definition, switchboards can be accessible from the _____.

Switchboard Construction

There are multiple elements that make up a switchboard. Included in the list of elements are a frame, buses, overcurrent protective devices, service metering, and outer covers.

Frame

The **frame** of the switchboard houses and supports the other components. The standard Siemens switchboard frame is 90 inches high and 32 or 38 inches wide. An optional height of 70 inches with widths of 32, 38, or 46 inches is also available. Siemens switchboards have a depth measurement ranging from 20 to 58 inches.

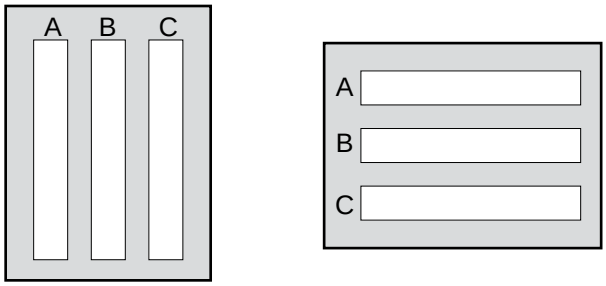


Buses

A **bus** is a conductor or set of conductors that serves as a common connection for two or more circuits. Switchboard buses are constructed from metal bus bars which are mounted inside the switchboard to conduct power to various devices.

NEMA Phase Arrangement

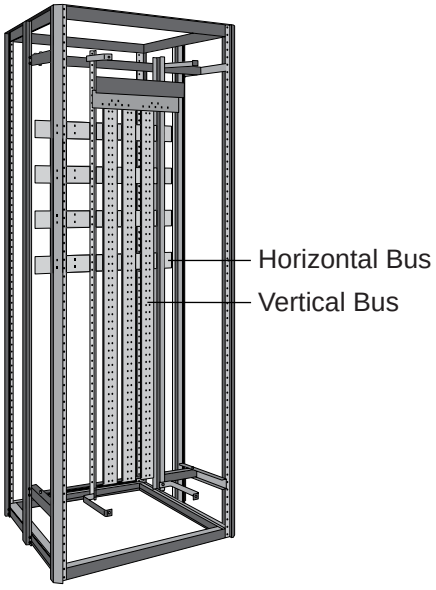
Bus bars are required to have phases in sequence so that an installer can have the same fixed-phase arrangement in each termination point in any switchboard. This is established by NEMA (National Electrical Manufacturers Association). If a non-NEMA phase sequence is used, it must be marked on the switchboard.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



Vertical (Left-to-Right) As Viewed from the Front

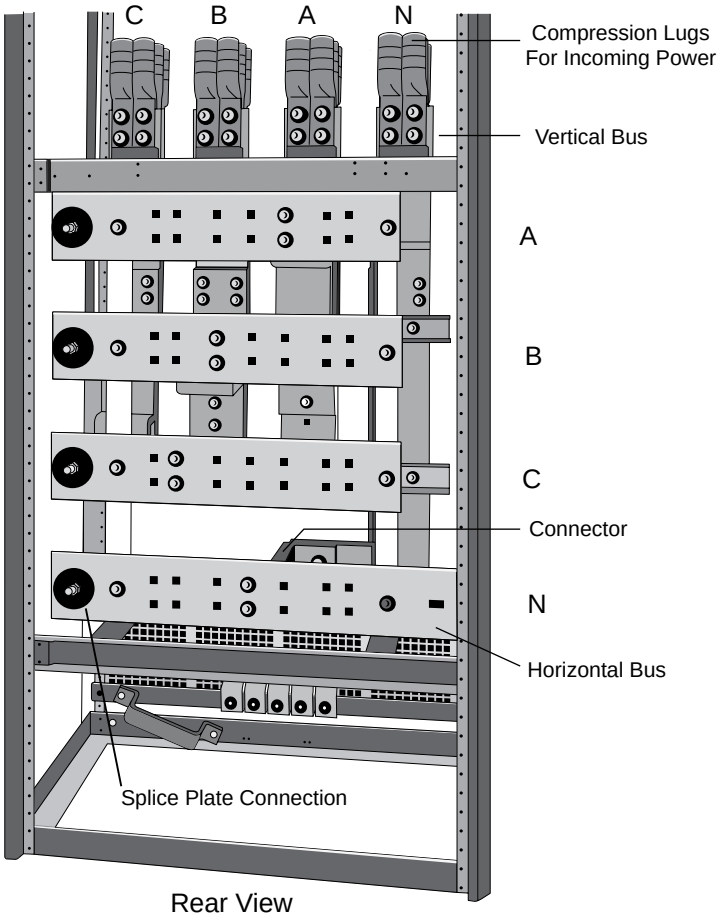
Horizontal (Top-to-Bottom)

Buses are mounted within the frame. **Horizontal bus bars** are used to distribute power to each switchboard section. **Vertical bus bars** are used to distribute power via overcurrent devices to the load devices. Bus bars in Siemens switchboards are made of tin-finished aluminum or silver-finished copper. Bus bars may either be temperature rated or current density rated. The current density rating specifies the maximum current per square inch of a bus bar cross section.



The following rear view drawing of a switchboard illustrates vertical and horizontal bus bar connections. The vertical phase bus bars appear to be in reverse order because they are viewed from the rear, but are in the proper NEMA order as viewed from the front.

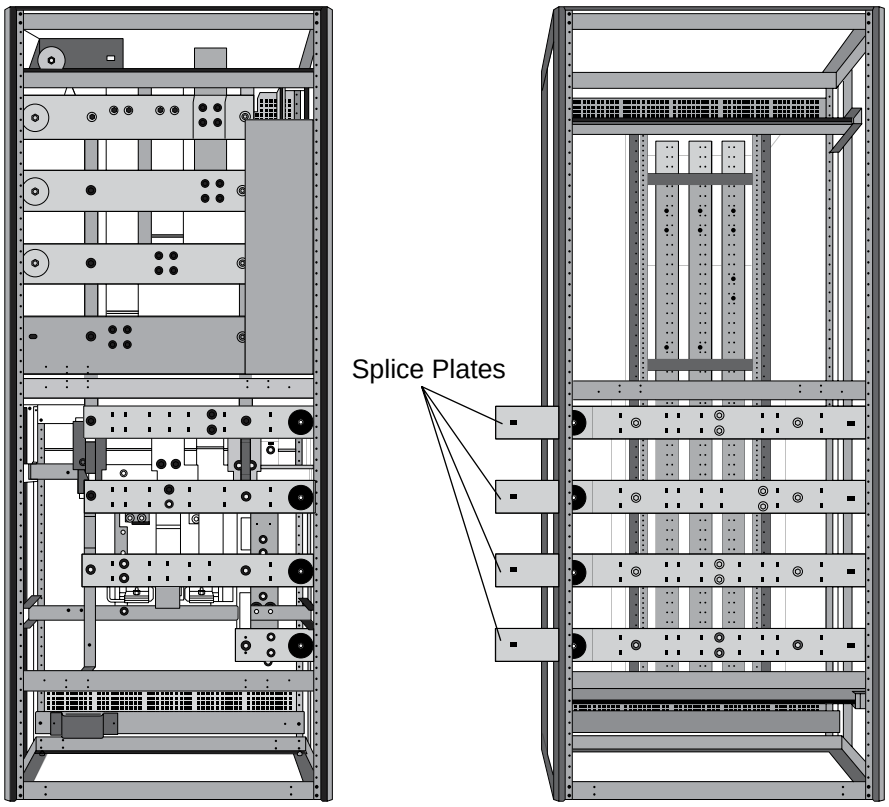
A **bus connector** makes a mechanical and electrical connection between a vertical bus bar and its corresponding horizontal bus bar. In this drawing the connector can be clearly seen on the neutral bus. **Compression lugs** provided on this switchboard accept properly sized incoming power cables.



Rear View

Splice Plates

Splice plates are used to join the horizontal bus bars of adjoining switchboard sections, as illustrated in the following rear view drawing. To make additional distribution sections easier to install when they are needed, the horizontal bus is extended and pre-drilled to accept splice plates. A new section is set flush against an existing section. The old and new sections are connected together with splice plates.



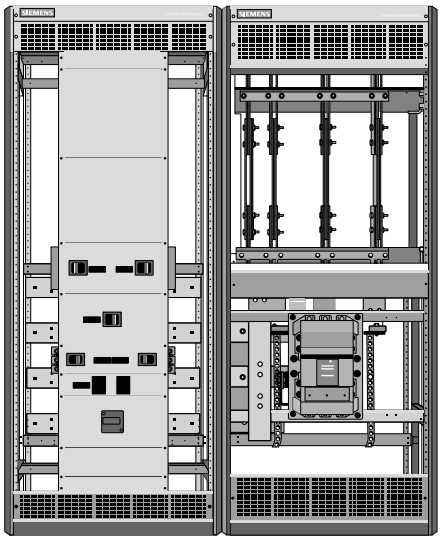
Rear View

Through-bus

The extended horizontal bus is also referred to as **through-bus**. Because the load requirements in downstream distribution sections are generally less than in upstream service sections, the capacity of the through-bus is tapered, or reduced, downstream as the load falls off. The through-bus is tapered to a minimum of one-third the ampacity of the incoming service mains. Full-capacity, or non-tapered, through-bus is available as an option. The ampacity of non-tapered through-bus remains constant throughout the switchboard.

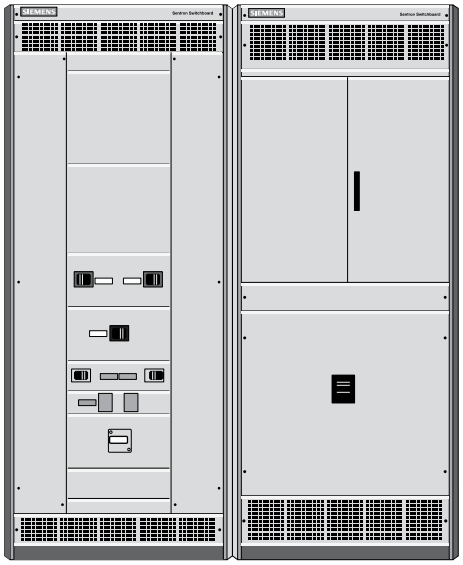
Overcurrent Protective Devices

Operator components are mounted on the front side of the switchboard. This includes **overcurrent protective devices**, such as circuit breakers and disconnect switches. These devices are mounted to the bus bars using straps connected to the line side of the devices.



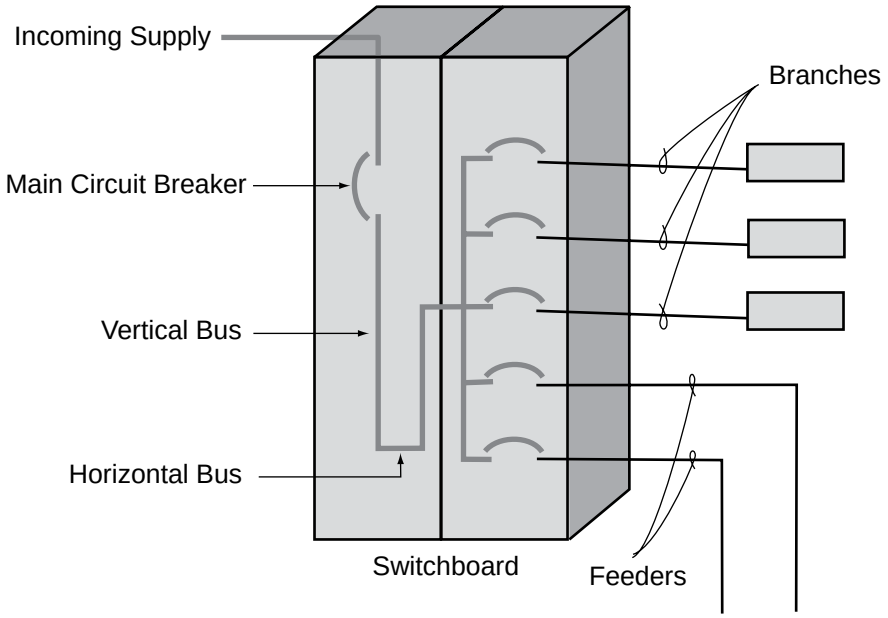
Outer Covers

Cover panels are installed on the switchboard so that no live parts are exposed to the operator. The front cover is referred to as the **dead front**. The panels are also used as trim to provide a finished look to the switchboard. A product information label identifies the switchboard type, catalog number, and voltage and current ratings.



Pictorial Diagram

Simplified drawings, such as one-line, block, or pictorial diagrams are often used to show the circuits associated with a power distribution system. For example, the following pictorial diagram shows a two section switchboard.



Review 2

1. The standard height of a Siemens switchboard frame is _____ inches.

2. A _____ is a conductor or set of conductors that serves as a common connection for two or more circuits.

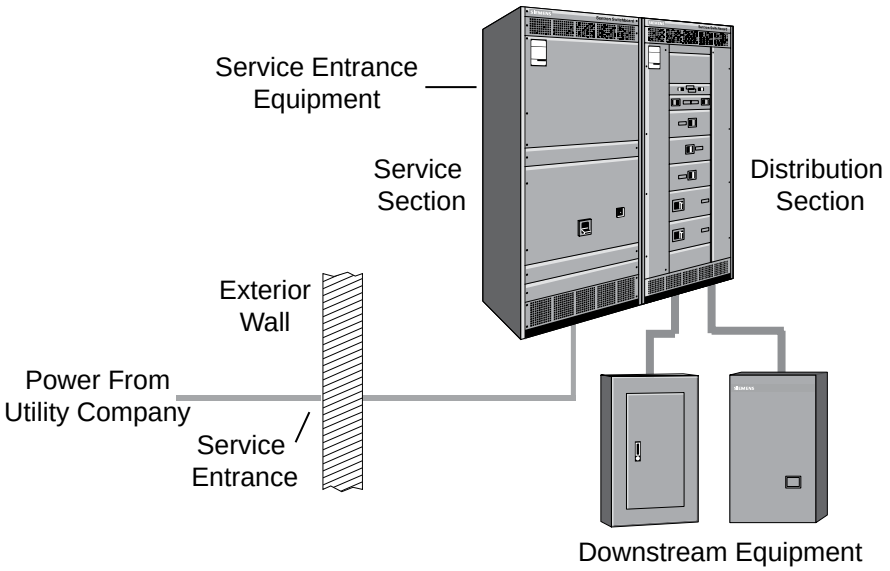
3. As viewed from the front of a switchboard, the NEMA bus bar phase sequence from left to right is _____.

4. Siemens switchboard bus bars are made of tin-finished _____ or silver-finished _____.

5. _____ are used to join the horizontal bus bars of adjoining switchboard sections.

Service Entrance Equipment

Switchboards are often used as **service entrance equipment** for a building. Service entrance equipment is the equipment through which power enters the building. For example, the following drawing shows a switchboard service section connected to a utility power source. This service section provides power to a switchboard distribution section and, subsequently, to downstream equipment.

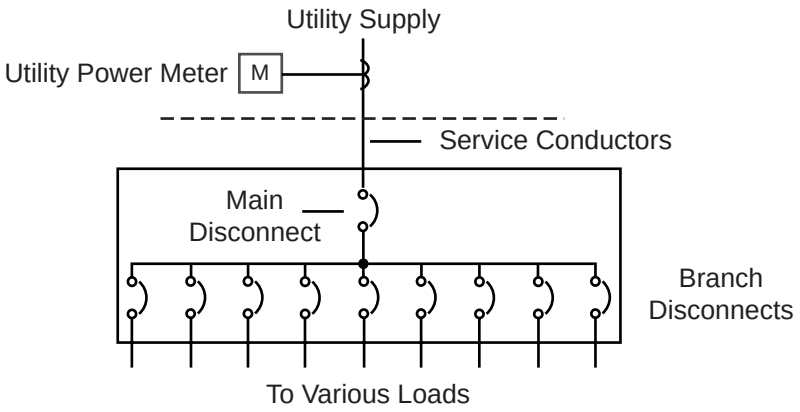


Switchboards used as service entrance equipment must be approved and labeled as such. Siemens switchboards are factory labeled as **suitable for use as service entrance equipment (SUSE)** when specified for service entrance application.

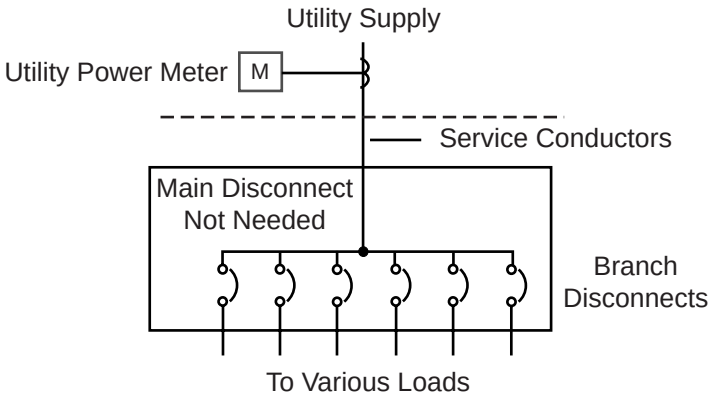
Six Disconnect Rule

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.

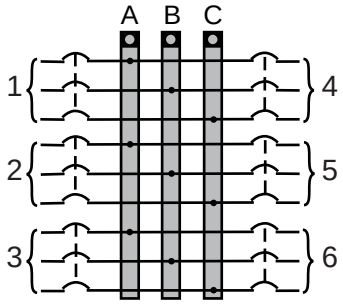
In the following example, a single main circuit breaker can disconnect power from all equipment being supplied by the service. In this example, there can be as many feeder and branch disconnect devices as needed.



In another example, a switchboard may be equipped with up to six circuit breakers to disconnect power from all equipment being supplied by the service.

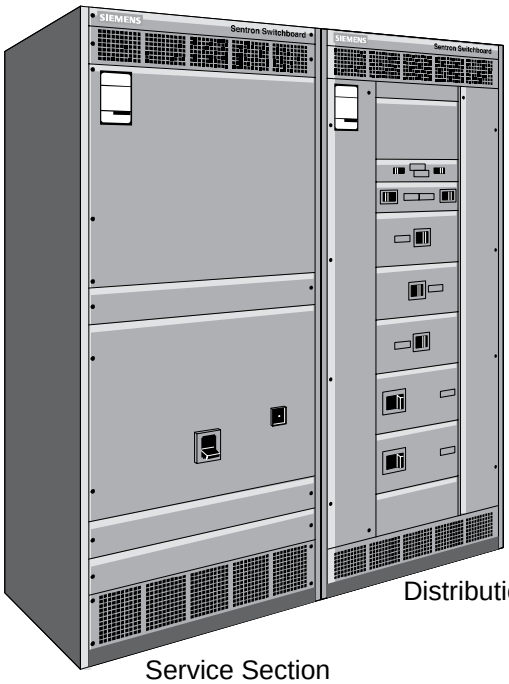


It is important to note that the **six disconnect rule** refers to the number of disconnects and not the number of poles. For example, in the following illustration there are 18 poles but only six circuit breakers. Three poles are mechanically linked together to form one disconnect device. This configuration allows the service to be disconnected with no more than six operations of the hand and complies with the six disconnect rule.



Service Section

A typical switchboard installation consists of a **service section**, also referred to as the main section, and one or more **distribution sections**. The service section can be fed directly from the utility transformer. In addition to the main disconnect, the service section usually contains utility or customer metering provisions.



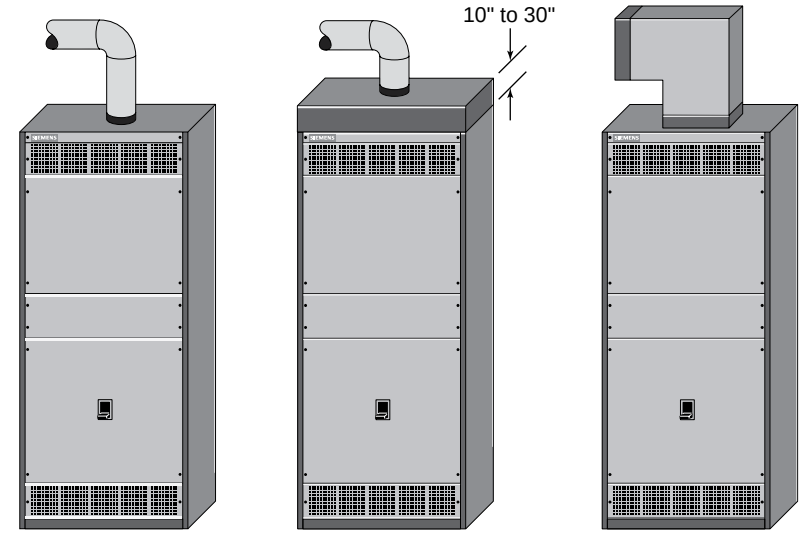
Distribution Section

Service Section

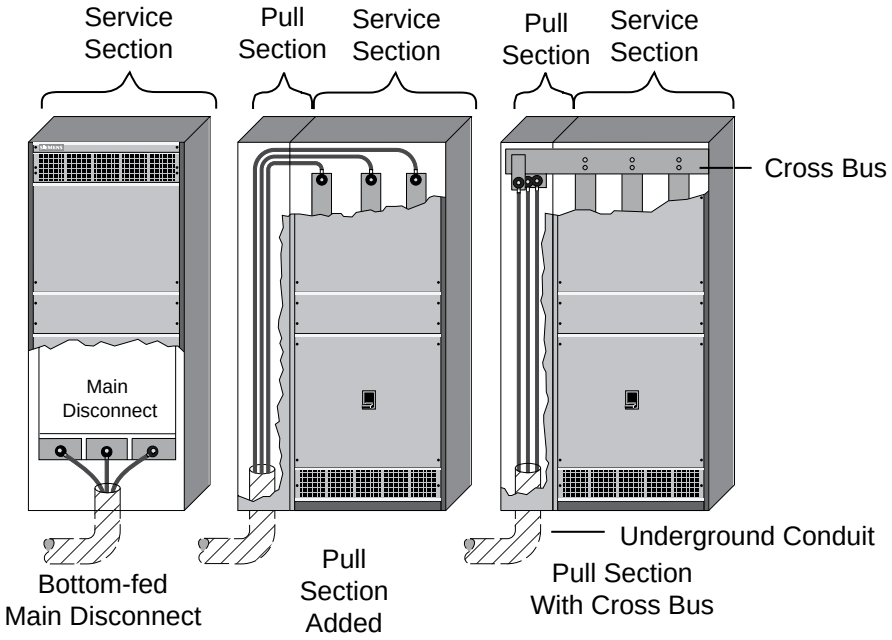
Service Entrance Methods

Several options are available to bring power into the switchboard service section. For example, cable can be brought into the switchboard from the top or the bottom.

Cable can be brought into the top of the switchboard through conduit. If the cable has a large diameter and more room is needed, a **pull box**, available in 10” to 30” heights, can be added. In addition, a bus duct entrance can be provide when a busway connection is needed.

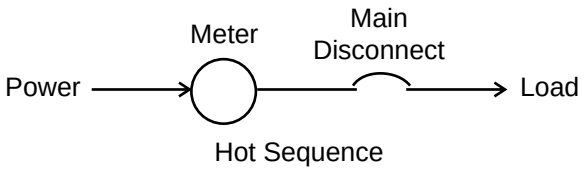


Cable may enter through a conduit to a disconnect that is fed from the bottom. If the disconnect is top-fed, a **pull section** can be added to the side of the service section to pass cable to the top of the switchboard. Depending on the cable bending space, cable can be connected directly to the lugs or to a **cross bus**. A cross bus brings the bus connections to the pull section eliminating the need to bend cables.



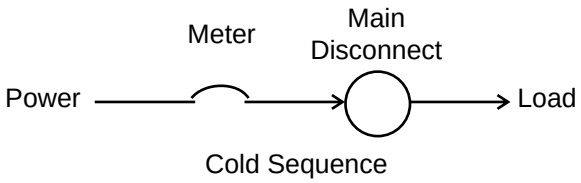
Hot Sequence

Metering can either be **hot sequence** or **cold sequence**. This refers to whether or not power is still applied to the utility meter when the main disconnect is switched off. The following drawing illustrates hot sequence metering. When the main disconnect is open, power is removed from the load, but power is still applied to the utility meter.

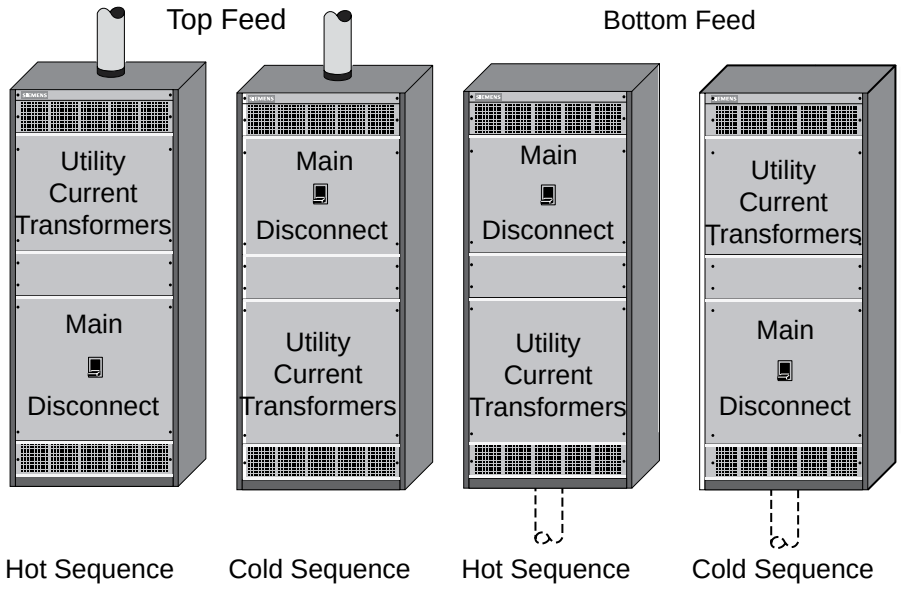


Cold Sequence

The following drawing illustrates cold sequence metering. When the main disconnect is open, power is removed from the utility meter and the load.



Hot sequence metering is normal, but cold sequence metering can also be provided.

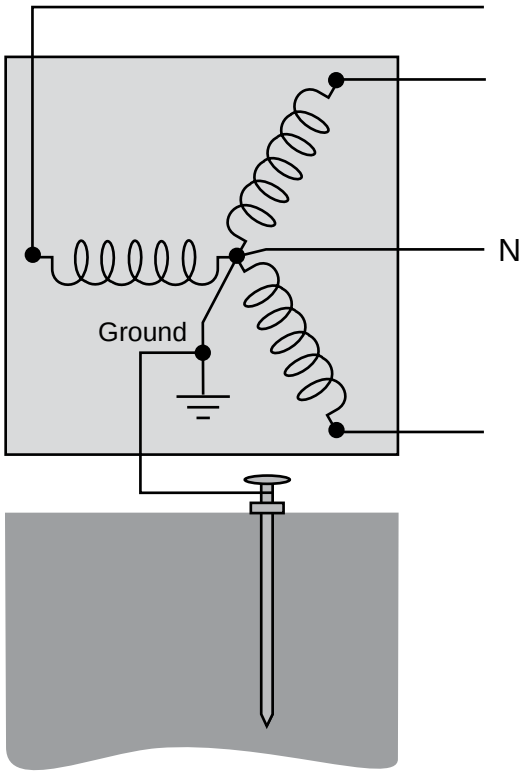


Switchboard Grounding

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.

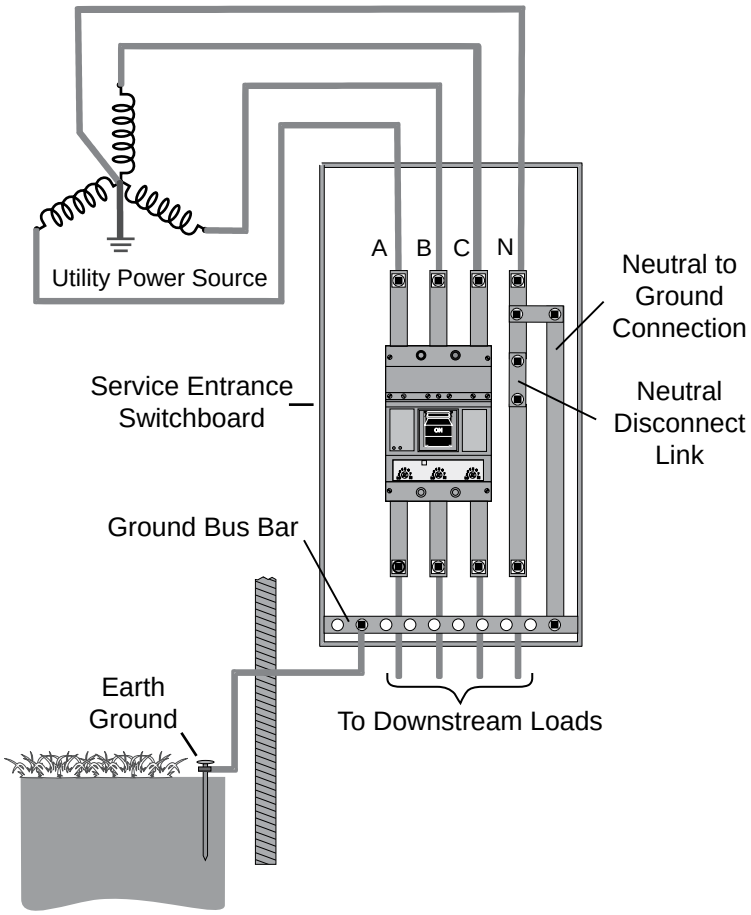
There are two primary reasons for intentionally grounding electrical equipment:

- Grounding reduces the shock hazard by minimizing the voltage differential between parts of a system.
- Grounding provides a low impedance path to ground for fault current. The lower the impedance, the greater the current in the event of a fault. The greater the current, the faster the overcurrent device opens and removes power from the load.



Service Entrance Grounding

In the following drawing, a switchboard is used as service entrance equipment and is connected to a three-phase, four-wire service. Note that the neutral is grounded at the service entrance. This is accomplished by connecting the neutral to a **ground bus bar**. The ground bus bar is connected to the frame of the switchboard and the frame is connected to ground. The **neutral disconnect link** is left in place to supply a ground connection to downstream loads. This link is provided so that downstream equipment can be disconnected from ground for testing and troubleshooting.

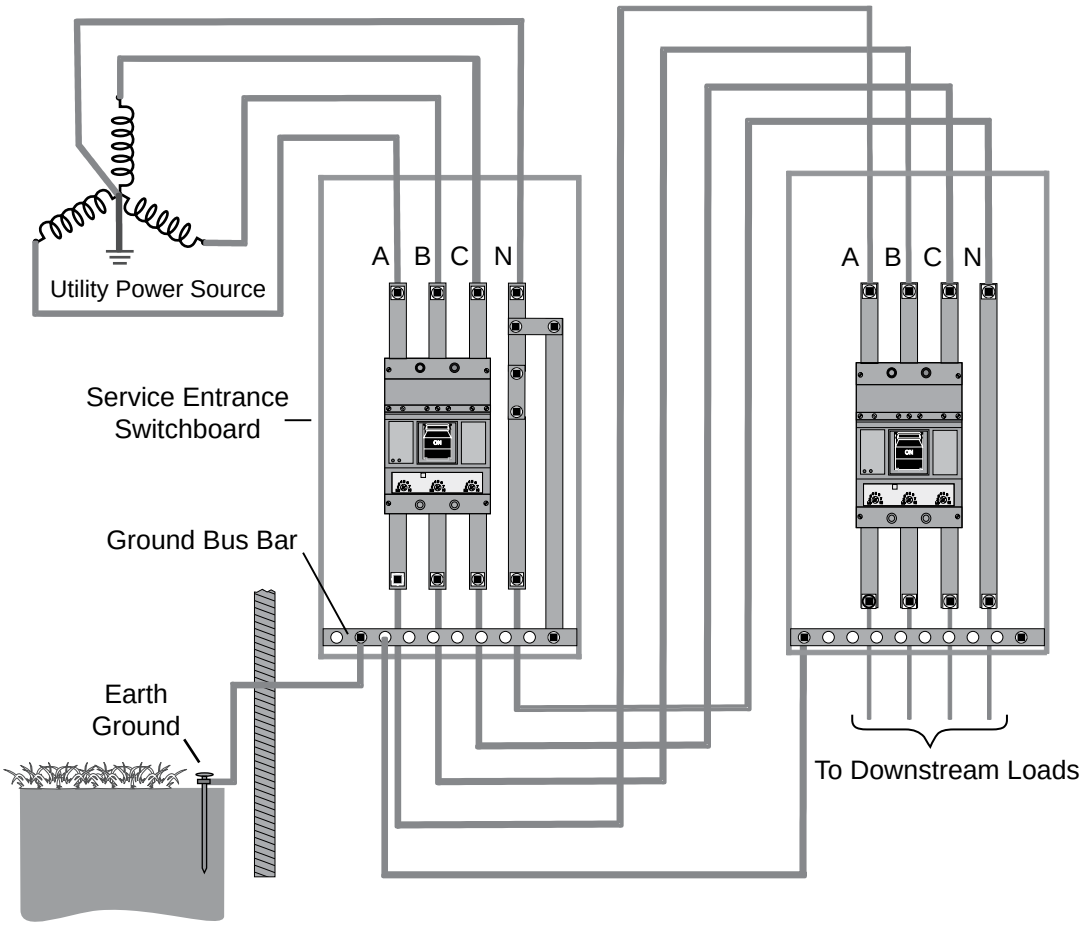


Downstream Equipment

The neutral is only connected to ground at the service entrance. When downstream equipment is used, the neutral is isolated in that equipment.

The following illustration shows a service entrance switchboard connected to a downstream section. The neutral of the downstream section is connected to ground through the ground bus bar of the service entrance switchboard. The neutral is **not** connected to ground in the downstream switchboard.

Notice also that the downstream switchboard does not have a neutral disconnect link. Neutral disconnect links are not required in switchboards used as non-service entrance equipment. Any downstream section fed from the second switchboard would also be connected to ground through the service entrance switchboard.



Ground Fault Protection

A **ground fault** is a condition in which electrical current takes an undesirable path to ground. Typically the current flows from a conductor to an adjacent grounded conductor or grounded surface. The most common type of ground fault is an arcing ground fault. In such cases, current often takes a high resistance path to ground and may flow intermittently or for a short duration. As a result, a ground fault often will not trip a circuit breaker unless it has been designed to sense ground faults. None the less, ground faults can still be dangerous.

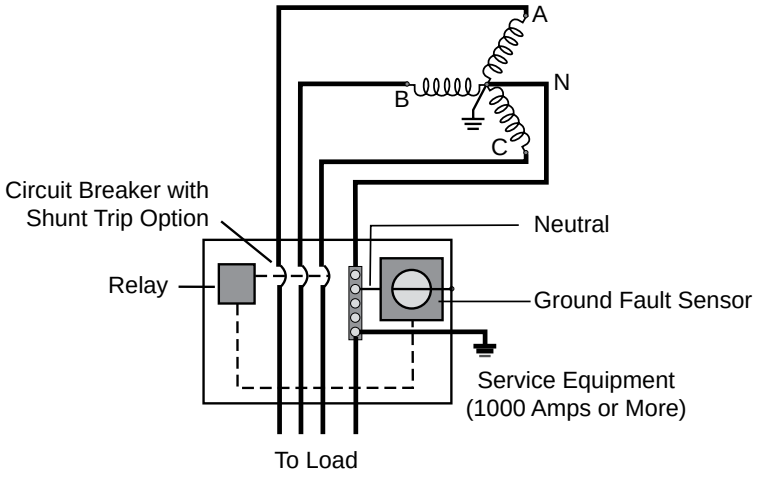
In some applications, such as for selected locations in a residence, ground fault protection is required for life protection. In many commercial or industrial applications, **ground fault protection** is required to protect equipment.

According to the *NEC*®, ground-fault protection of equipment must 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.

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

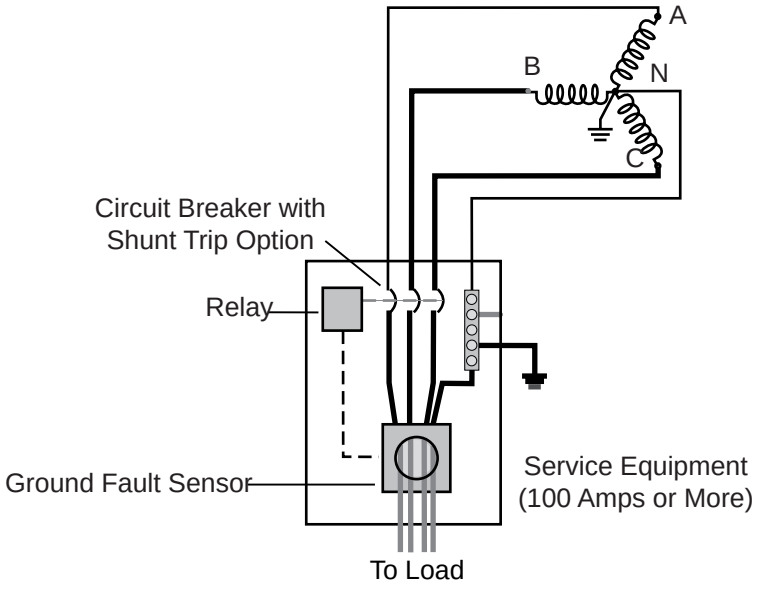
Direct Method

One way a ground fault protector works is with a sensor around a ground conductor, normally the neutral-to-ground strap. This is referred to as the **direct method**. When a line-to-ground fault occurs, current flows through the sensor. When the fault current reaches the threshold setting of the ground-fault protection equipment, a shunt trip opens the circuit breaker.



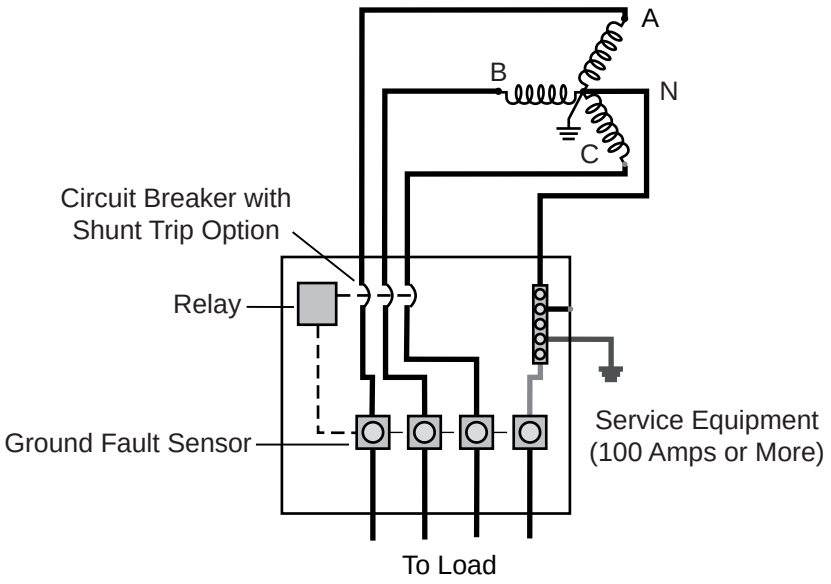
Zero Sequencing Method

Another way a ground fault protector works is with a sensor installed around all the circuit conductors, including the neutral on four-wire systems. This is referred to as the **zero sequencing method**. When there is no ground fault, the sum of all the currents detected by the sensor is zero. When a ground fault occurs, it causes a current imbalance that is sensed by the protection equipment. When the fault current reaches the threshold setting of the ground-fault protection equipment, a shunt trip opens the circuit breaker.



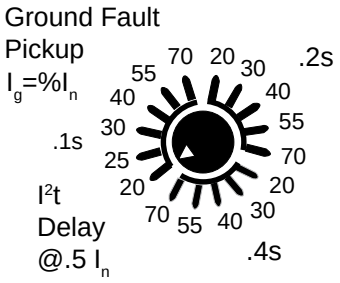
Residual Method

Another approach is the **residual method**, which requires separate sensors to monitor current on all three phases, and the neutral on a four-wire system. With this system, when there is no ground fault, the vectorial sum of the currents is zero. If a ground fault is sensed, however, a shunt trip opens the circuit breaker.

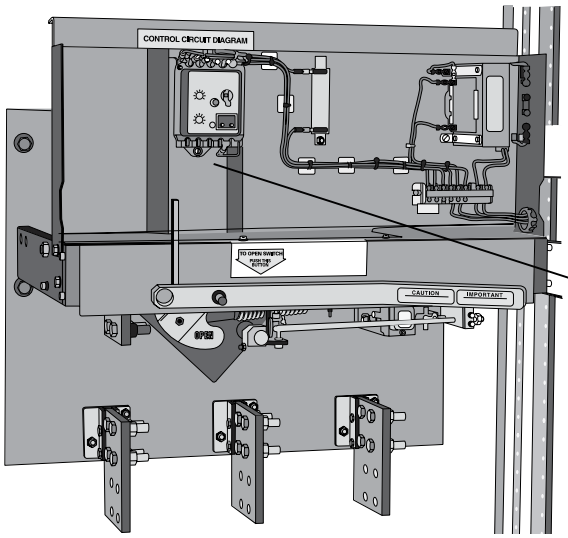


Ground Fault Protection Devices

Ground fault protection is often provided through an optional feature of a circuit breaker. In such cases, the circuit breaker is frequently equipped with fixed or variable settings for ground fault pick-up (I_g), the level of ground fault current required to trip the breaker, and ground fault time delay (t_g), the interval of time the breaker will remain closed after a ground fault is sensed. These settings are useful for coordinating protection throughout a facility.



Ground fault protection can also be supplied with some disconnect switches, such as the bolted pressure switch shown below.



Review 3

1. _____ is the equipment through which power enters a building.

2. According to *NEC*® Article 230.71, no more than _____ switches or circuit breakers shall be used to disconnect and isolate the service.

3. Typical switchboards consist of a _____ section and usually one or more _____ sections.

4. A _____ can be added to a switchboard to accommodate cable entering the bottom of the switchboard and connected to the bus at the top.

5. _____ metering means that power is still applied to the utility meter when the main disconnect is open.

6. _____ metering means that power is removed from the utility meter when the main disconnect is open.

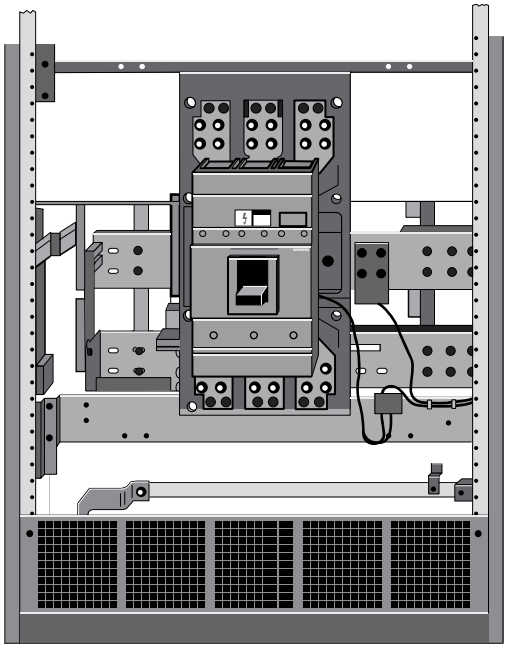
7. Which of the following ground fault detection methods involves sensing current in only one conductor?

   a. Direct method
   b. Zero sequencing method
   c. Residual method

Service Section Main Disconnect Devices

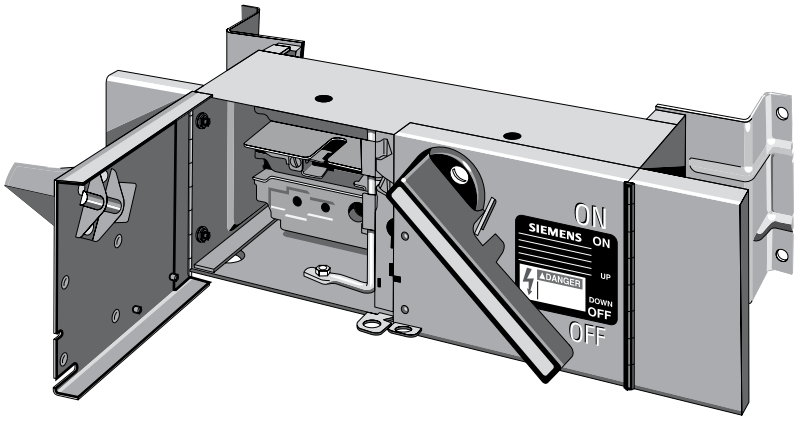
Typically, a switchboard service section requires one or more service main disconnect devices. A main disconnect device is mounted into a service section and feeds one or more distribution sections. In some applications, the main service disconnect is required to be located remote to the distribution portion of the equipment and is considered a remote main.

The service section of Siemens switchboards can accommodate a variety of main protective devices. Depending on the switchboard model and customer requirements, the main protective device may be a Vacu-Break fusible switch, high contact pressure (HCP) fusible switch, fusible bolted pressure switch (BPS), molded case circuit breaker (MCCB), insulated case circuit breaker (ICCB), or low voltage (LV) power circuit breaker.



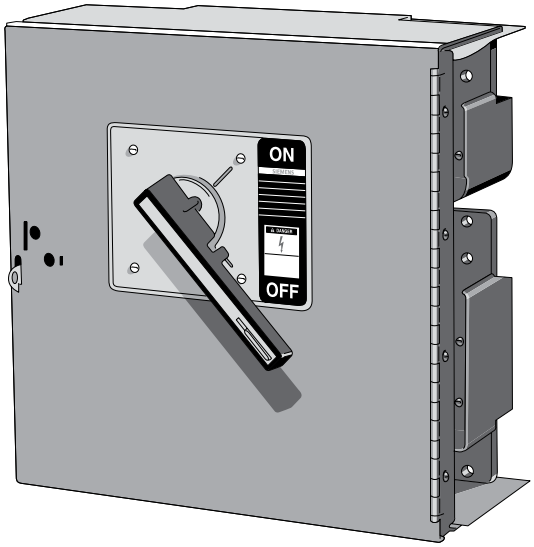
Vacu-Break Fusible Switches

One type of protective device is the Siemens **Vacu-Break fusible switch**. Vacu-Break fusible switches are available in ampere ratings up to 1200 amps.



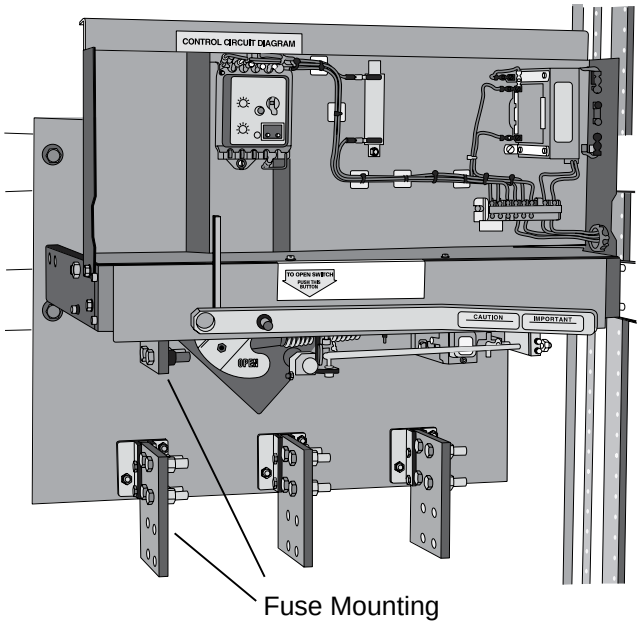
HCP Fusible Switches

Siemens **high contact pressure (HCP) fusible switch** is another device that can be used in the service section as a disconnect device. Visible contacts provide a visual indication concerning the state of the switch before servicing. HCP fusible switches are available with ampere ratings from 400 to 1200 amps. HCP fusible switches are suitable for use on systems with up to 200,000 amps of available fault current when used with Class J or Class L fuses.



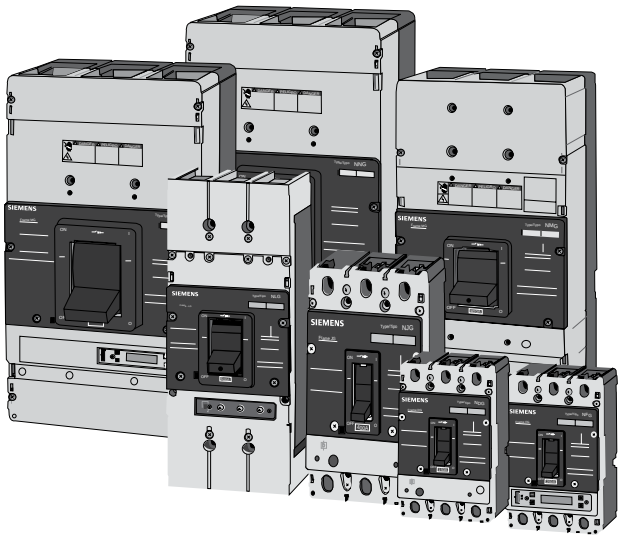
Fusible Bolted Pressure Switches

A **fusible bolted pressure switches (BPS)** can also be used as a main disconnect. Bolted pressure switches are available with ampere ratings from 800 to 6000 amps.



Molded Case Circuit Breakers

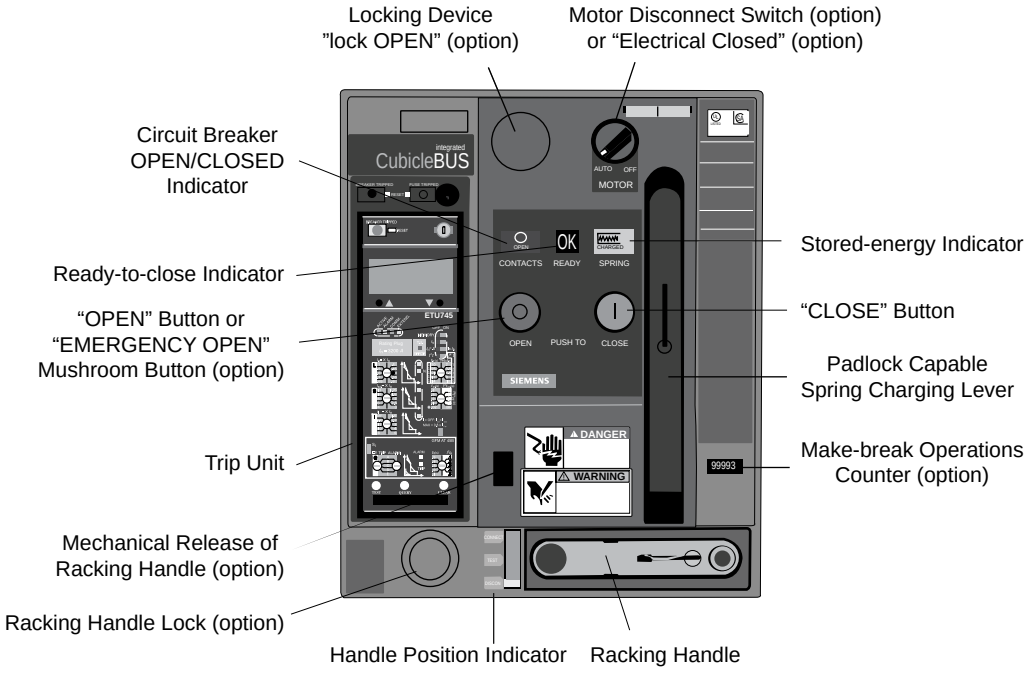
Siemens offers a variety of thermal-magnetic and solid state **molded case circuit breakers** with continuous current ratings up to 2000 amps. These circuit breakers are available with a wide range of features and accessories. For additional information about Siemens molded case circuit breakers, refer to **Basics of Circuit Breakers**.



WL Circuit Breakers

Siemens WL family of circuit breakers has been designed to address the increasingly demanding requirements of today's electrical power distribution systems and incorporates the following characteristics.

- High reliability
- Compact size
- Ease of use
- Modularity of design
- Flexibility of system communications
- Safety-oriented features



The circuit breakers discussed thus far in this course are molded case circuit breakers that conform to the UL 489 specification. This specification also covers a category of molded case circuit breaker commonly referred to as an **insulated case circuit breaker (ICCB)**. ICCBs are generally used in switchboards and may be fixed-mounted or drawout-mounted.

Another category of large circuit breakers is the **low voltage (LV) power circuit breaker**. LV power circuit breakers are generally drawout-mounted and may be used in switchboards or switchgear. LV power circuit breakers intended for the U.S. market conform to American National Standards Institute (ANSI) standards (C37.13, C37.16, C37.17, and C37.50) and National Electrical Manufacturers Association (NEMA) standard SG3. The corresponding UL specification for LV power circuit breakers is UL 1066.

Siemens WL family of circuit breakers includes both ICCBs that conform to the UL 489 specification and LV power circuit breakers that conform to UL 1066 and corresponding ANSI and NEMA specifications.

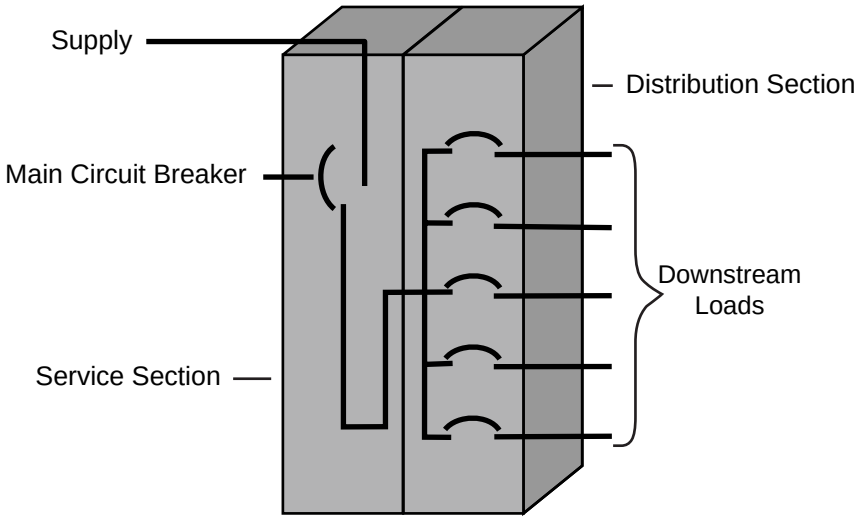
WL UL 489 circuit breakers have a rated maximum operating voltage of 600 V and are available in three frame sizes with frame ratings from 800 to 5000 A. All three frame sizes have fixed-mounted and drawout-mounted versions.

WL UL 1066 circuit breakers are generally used in low voltage (LV) switchgear as drawout-mounted breakers, but may also be used in switchboards. They have a rated maximum operating voltage of 635 V, and are available in two frame sizes with frame ratings from 800 to 5000 A.

For additional information about WL circuit breakers, refer to **Basics of Circuit Breakers**.

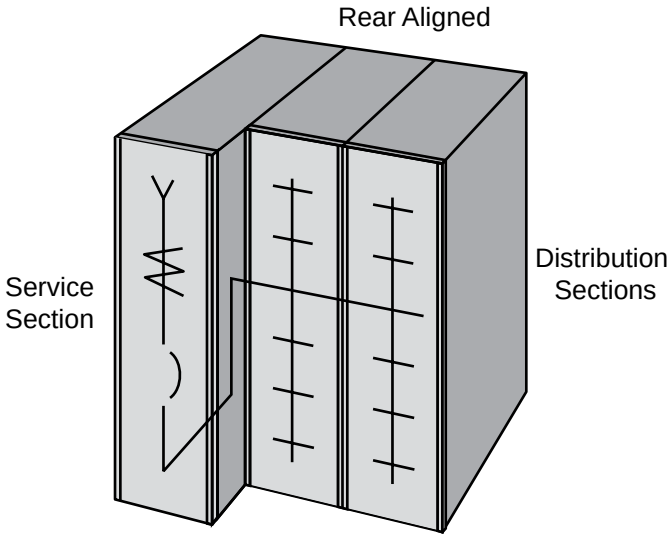
Distribution Section

The distribution section receives power from the service section and distributes it to various downstream loads.



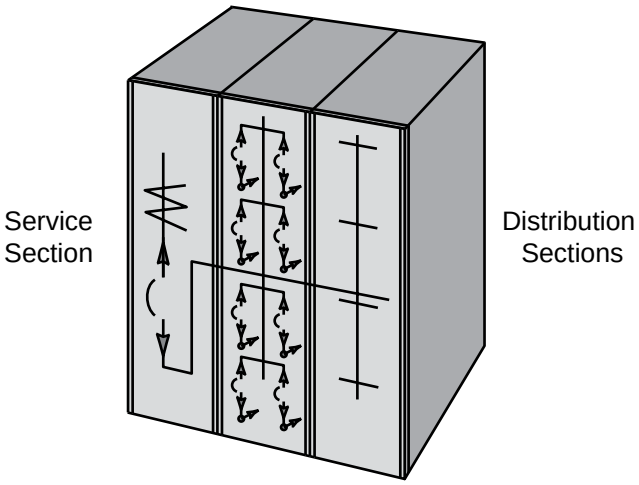
Rear Alignment

Depending on the design of a specific switchboard, the service section cabinet may be deeper than the distribution section. This is due to the size of the main disconnect device and associated bus requirements. The rear of all sections align so the switchboard may be installed against a wall. This is referred to as rear alignment.



Front and Rear Aligned

Switchboards can also be front and rear aligned, if the depth of the service section and distribution section are the same. In some switchboards, the circuit protection devices and bus may require a deeper cabinet. In other switchboards, extra depth may be added as an option.



Front and Rear Aligned

Protective Devices

Like the service section, the distribution section will accommodate a variety of protective devices. Selection depends on the characteristics of the electrical system. The chart below shows the range of disconnect devices that can be installed in the distribution sections of Siemens switchboards. In addition to disconnect devices, motor starters can also be installed.

Device	Current Rating
Vacu-Break Fusible Switches	30-1200 amps
HCP Switches	400-1200 amps
Bolted Pressure Switches	800-6000 amps
Molded Case Circuit Breakers	15-2000 amps
Insulated Case Circuit Breakers	400-5000 amps
LV Power Circuit Breakers	400-5000 amps

Switchboard Ratings

When selecting switchboards and overcurrent protection devices, it is important to know both the maximum continuous current required and the available fault current. These factors are critical to determining the various ratings for this equipment.

Interrupting Rating

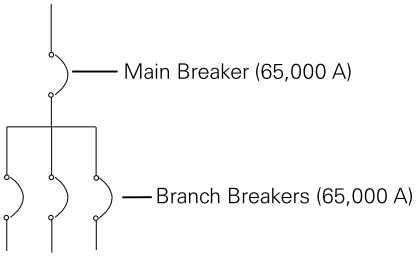
Interrupting rating is the level of current that a protective device (fuse or circuit breaker) can safely interrupt without damage under specified conditions. The interrupting rating of the switchboard depends on the interrupting rating of the circuit protection devices and the rating method used.

According to the *NEC*® Article 110.9, equipment designed to interrupt current at fault levels must have an interrupting rating sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment.

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

Full Rating

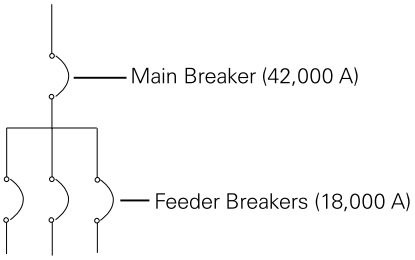
The full rating method requires selecting circuit protection devices with individual ratings equal to or greater than the available fault current. For example, if 65,000 amperes of fault current are available at the service entrance, every circuit protection device must have an interrupting rating of 65,000 amperes.



Series Rating

Because the full rating method adds expense to a switchboad design, UL listed series-rated switchboards are available for many applications at a lower cost. The series rating method also requires the interrupting rating of the main circuit protection device to be equal to or greater than the available fault current, but subsequent downstream circuit protection devices connected in series can be rated at lower values.

For example, a building with 42,000 amperes of available fault current might use a breaker at the service entrance with an interrupting rating of 42,000 amperes and additional downstream breakers with a lower interrupting rating, such as 18,000 amperes.



Series-rated breaker combinations must be tested in series in order to be UL listed. Siemens series-rated breakers are listed in the **UL Recognized Components Directory (yellow books) Volume 1**. Selected series-rated breakers are also listed in the Speedfax catalog.

Short Circuit Withstand Rating

Short circuit withstand rating refers to the level of fault current a piece of equipment can withstand for a specified time without sustaining damage. The standards for short circuit withstandability are set by Underwriters Laboratories (UL Standard 891). Bus structures and bracing are designed to withstand a specified current for a specified time. The short circuit withstand rating of a switchboard is determined by the combined withstand, interrupting, and current limiting capabilities of the bus and overcurrent protective devices in the switchboard and any overcurrent protective devices ahead of the switchboard that may supply and protect it.

Ampere Rating

The **ampere rating** refers to the current a switchboard or protective device can carry continuously without deterioration and without exceeding temperature rise limits.

Voltage Rating

The **voltage rating** of a switchboard must be at least equal to the system voltage. The voltage rating of a switchboard can be higher than the system voltage, but never less.

Review 4

1. Which of the following devices can be used as main protective device in a Siemens switchboard?

   a. Vacu-Break fusible switch
   b. HCP fusible switch
   c. MCCB
   d. ICCB
   e. LV power circuit breaker
   f. All the above

2. Siemens WL family of circuit breakers includes both ICCBs that conform to the _____ specification and LV power circuit breakers that conform to the _____ specification.

3. The _____ section of a switchboard receives power from the service section and distributes it to various downstream loads.

4. The _____ rating refers to the maximum current a protective device, such as a fuse or circuit breaker, can safely interrupt.

5. The _____ rating refers to the level of fault current a piece of equipment can withstand for a specified time without sustaining damage.

6. A _____ rated switchboard has a main circuit protection device that is equal to or greater than the available fault current, but subsequent downstream circuit protection devices connected in series have a lower interrupting rating.

7. _____ refers to the current a switchboard or protective device can carry continuously without deterioration and without exceeding temperature rise limits.

SB1, SB2, and SB3 Switchboards

Siemens manufactures a variety of switchboards. The type of switchboard selected is determined by a variety of factors such as space, load, and environment. In addition to meeting present loads, the switchboard should be sized to accommodate reasonable future load additions. The continuous rating and through-bus can be sized on the basis of anticipated future load demand. Trip units or fuses of lower ratings can be installed to meet present load demands and changed in the future as load increases.

SB1, SB2, and SB3 switchboards are built to UL 891 and NEMA PB-2 standards and provide the rugged construction and service flexibility necessary in systems for industrial plants, high-rise complexes, hospitals, and commercial buildings.

SB1 Switchboards

SB1 switchboards are designed to be used in applications where floor space is at a premium. SB1 distribution sections are 20 inches deep. All sections are rear aligned so that they can be installed against a wall. The main protective devices are front-connected. Through-bus ratings up to 2000 amps at 600 VAC are available.

SB2 Switchboards

Like SB1 switchboards, SB2 switchboard distribution sections have a standard depth 20 inches, but SB2 switchboard distribution sections can have optional depths or 28 or 38 inches to provide extra space behind the vertical bus. All sections are rear aligned as standard. Front and rear alignment is available as an option. SB2 main protective devices and through-bus are rated up to 4000 amps at 600 VAC.

SB3 Switchboards

SB3 distribution sections have a standard depth of 20 inches, but can have an optional depth up to 58 inches, when additional space is required. SB3 switchboards with depths of 38 inches or less may be installed against a wall. Rear access is required to make use of the additional depth for SB3 switchboards that are deeper than 38 inches. All sections are rear aligned as standard. Front and rear alignment is available as an option.
SB3 switchboards are available with a main bus rating up to 6000 amps.

	SB1	SB2	SB3
Maximum Bus Rating	2000 A	4000 A	6000 A
Main Devices*	MCCB, VB, HCP, BPS	MCCB, VB, HCP, BPS, WL (Fixed Mounted)	MCCB, VB, HCP, BPS, WL
Feeder Devices*	MCCB, VB, HCP, BPS	MCCB, VB, HCP, BPS, WL (Fixed Mounted)	MCCB, VB, HCP, BPS, WL
Solid State MCCB*	No	100,000 A Interrupting Rating	200,000 A Interrupting Rating
Customer Metering	Yes	Yes	Yes
Utility Metering	Yes	Yes	Yes
Density Rated Bussing	No	Yes	Yes
Accessible	Front	Front	Front up to 38" deep. Front & Rear above 38" deep.
Alignment	Rear	Rear Standard. Front & Rear Optional.	Rear Standard. Front & Rear Optional.

* molded case circuit breaker (MCCB), Vacu-Break switch (VB), high contact pressure switch (HPS), bolted pressure switch (BPS), WL circuit breaker (WL)

SB1, SB2, SB3 Service Sections

Typical switchboards require one or more service main disconnects. These main disconnects are mounted into a service section that typically feeds one or more distribution sections. In some applications, the main service disconnect is required to be located remote to these distribution sections and is considered a remote main.

In addition to the main disconnect, the service section usually contains utility metering provisions. Hot sequence metering (current transformers on the line side of the main disconnect) is normal, but cold sequence metering (current transformers on the load side of the main disconnect) can also be furnished.

For either hot or cold sequence metering, the current transformers provided by the utility company are mounted in a separate compartment. This compartment is built to utility company standards with hinged doors and provisions for metering equipment provided by the utility.

The service section can provide space for customer metering. Either analog or digital metering can be mounted in the service section along with the main disconnect. A separate section is only needed if a large instrument or an unusual number of instruments are required.

Main Devices

	Mounting		Molded Case	Vacu-Break	HCP	Bolted Pressure	WL UL 489
	Individual	Panel	Circuit Breaker	Fusible Switch	Fusible Switch	Fusible Switch	Circuit Breaker
SB1	Yes		400-2000 A	800-1200 A	400-1200 A	800-2000 A	
		Yes	400-1200 A	400-600 A	400-1200 A		
SB2	Yes		400-2000 A	800-1200 A	400-1200 A	800-4000 A	400-4000 A (Fixed Mounted)
		Yes	400-1200 A	400-600 A	400-1200 A		
SB3	Yes		400-2000 A	800-1200 A	400-1200 A	800-6000 A	400-5000 A (Fixed Mounted or Drawout)
		Yes	400-1200 A	400-600 A	400-1200 A		

Notes: 5000 A and 6000 A bolted pressure switches are not UL listed.
Service disconnect 1200 A Vacu-Break switches are not available at voltages above 240 V.
Vacu-Break branch devices are available at all voltages when protected by a main device.

Voltage Chart

Compatible with SB1, SB2, SB3		Compatible with SB3 Only
230 3Ø3W Delta AC	208Y/120 3Ø4W AC	240/120 2Ø5W Single Neutral AC
240 3Ø3W Delta AC	220Y/127 3Ø4W AC	240/120 1Ø3W Ground Neutral AC
347 3Ø3W Delta AC	380Y/220 3Ø4W AC	125 1Ø2W Ground Neutral AC
380 3Ø3W Delta AC	415Y/240 3Ø4W AC	240 1Ø2W No Neutral AC
480 3Ø3W Delta AC	480Y/277 3Ø4W AC	125 2W DC
600 3Ø3W Delta AC	440Y/250 3Ø4W AC	240 2W DC
240/120 3Ø4W Delta B Phase High Leg	600Y/347 3Ø4W AC	500 2W DC
240/120 3Ø4W Delta C Phase High Leg		

SB1, SB2, SB3 Distribution Sections

SB1, SB2, and SB3 distribution sections are constructed with generous top and bottom gutters. In cable entrance sections, no obstruction is less than eight inches above the floor and no live bus bars are located less than 10 inches off the floor. So there is plenty of room to run cables into a distribution section.

Standard bolted gutter covers give complete access to load conductors. Hinged gutter covers can be furnished where quick access to load conductors is desired.

All distribution sections contain louvers at both the top and bottom to assure cool operation.

Because all distribution sections can accommodate any combination of panel-mounted branch devices, future system modifications are easier to handle without adding switchboard sections.

When it is necessary to install additional distribution sections, this task has been simplified because the through-bus in each distribution section is extended, and the end is pre-drilled to accept splice plate bolts.

Branch Devices

	Mounting		Molded Case	Vacu-Break	HCP	Bolted Pressure	WL UL 489
	Individual	Panel	Circuit Breaker	Fusible Switch	Fusible Switch	Fusible Switch	Circuit Breaker
SB1	Yes		400-2000 A	400-1200 A	400-1200 A	800-2000 A	
		Yes	15-1200 A	30-600 A	400-1200 A		
SB2	Yes		400-2000 A	400-1200 A	400-1200 A	800-2000 A	400-4000 A (Fixed Mount)
		Yes	15-1200 A	30-600 A	400-1200 A		
SB3	Yes		400-2000 A	400-1200 A	400-1200 A	800-6000 A	400-5000 A (Fixed Mounted or Drawout)
		Yes	15-1200 A	30-600 A	400-1200 A		

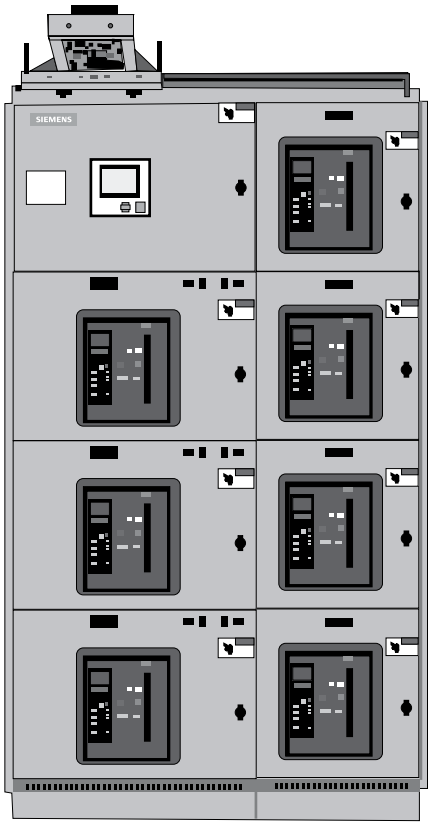
The same notes as shown for main devices also apply to this chart.

Rear Connected Switchboards

Siemens **Rear Connected (RCS) switchboards** feature individually mounted branch and feeder devices. Because of this method of mounting, access to outgoing cable terminations must be from the rear of the switchboard. Bus bar extensions from the feeder devices are run back to the rear of the unit for easy access. The front and rear of all sections align. Both indoor (NEMA 1) or outdoor (NEMA 3R) construction are available.

RCS switchboards accommodate systems up to 6000 amperes, 600 volts maximum in any three-phase three-wire or three-phase four-wire configuration. The main bus can be specified for 600 to 6000 ampere rating.

RCS Switchboards use WL insulated case (UL 489) or LV power (UL 1066) circuit breakers with drawout mountings and continuous current ratings from 400 to 5000 A for main and branch devices.



Integrated Power System Switchboards

The modular design of Siemens **Integrated Power System (IPS) switchboard** allows the customer to integrate electrical distribution equipment, power monitoring, and environmental controls that typically mount in multiple enclosures into one switchboard line-up. Customers have the freedom to configure an arrangement that best fits their individual needs. Optional factory installed interconnection wiring is available to further reduce installation time.

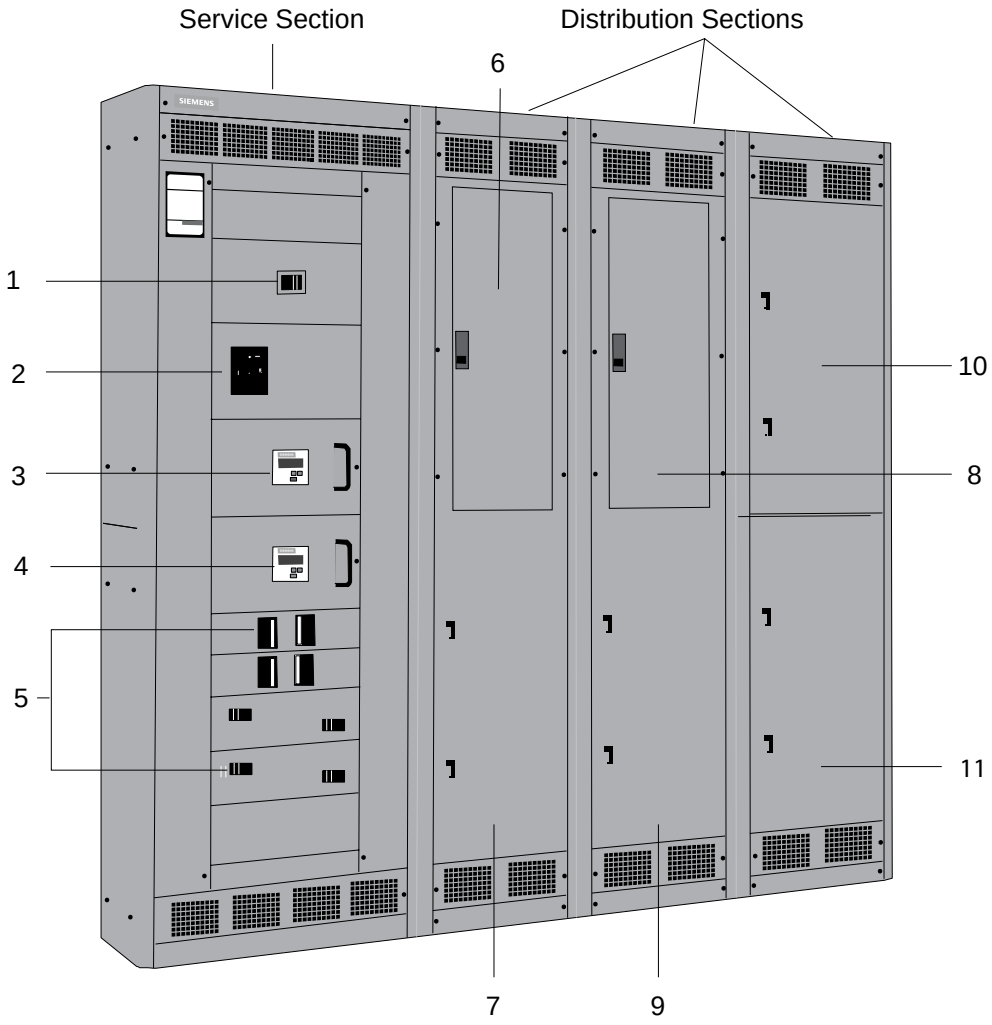
IPS switchboards are built to UL 891 and NEMA PB-2 standards. IPS sections have a standard height of 90 inches. Optional 70 inch high sections are available. The minimum depth of IPS sections is 13.75 inches. Optional depths of 20, 28, and 38 inches are available and these optional depths may be required depending upon the components installed.

Numerous components are available to fit customer requirements:

- Lighting panelboards (MLO and main device)
- Power monitoring devices
- Distribution transformers
- ACCESS communication
- Lighting contactors
- Lighting control
- Heating ventilation and air condition (HVAC) control
- Building management equipment
- Programmable logic controller (PLC)
- Automatic transfer switch (ATS)
- Motor starters
- Backup generators

IPS switchboards consist of one service section and one or more distribution sections that are cable connected. However, IPS switchboards are also available with through-bus and pull sections.

IPS switchboards accommodate systems up to 4000 amps, 600 VAC maximum in 1-phase, 3-wire; 3-phase, 3-wire; and 3-phase, 4 -wire configurations.

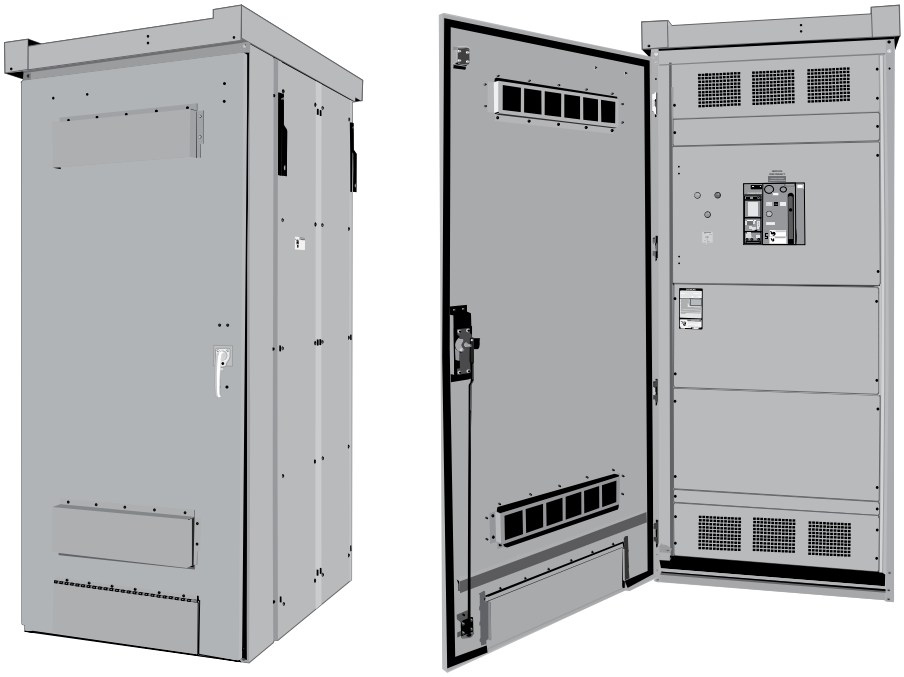


1. Panel mounted main breaker or switch up to 4000 A. Main lug only to 2000 A.
2. Transient Voltage Surge Suppressor (TVSS)
3. Digital meter
4. Local display unit (ACCESS communication)
5. - Feeder breaker or switch up to 4000 A
   - Motor starter module up to NEMA size 4
   - Lighting contactor (30 to 225 A)
   - Programmable Logic Controller (PLC)
   - Time clock
6. Lighting panelboard
7. Distribution transformer
8. Lighting control
9. Space for additional devices:
   - Lighting contactors
   - PLC
   - Time clocks
   - Automatic Transfer Switch (ATS)
   - Telephone cabinet
10. HVAC control
11. Customer supplied components

Generator Ready Switchboards

Siemens Generator Ready, Quick Connect Switchboards meet the market need for quick connection of a generator for temporary back-up power.

The most common applications of these switchboards are retail stores with perishable goods, nursing homes, and hospitals. However, these switchboards should also be applied to many other commercial applications where a power outage can result in increased cost or loss of revenue.



Generator Ready Switchboard in NEMA 3R Enclosure

Features

Siemens Generator Ready Switchboards have the following features:

- All standard switchboard features
- Crouse-Hinds quick-connect Cam-Locks for a quick primary connection method
- Standard mechanical lugs suitable for Type W welding cable for a secondary connection method
- NEMA 1 and NEMA 3R enclosures
- Trap door on NEAM 3R enclosure to maintain rating with cables connected
- Labeled phases and ground connections
- Bus connection between generator breaker and plug-in quick connects
- Mechanical interlocking with normal breaker
- Removable screw cover for covering quick-connects when not in use
- May be provided as stand alone unit or hard bussed in traditional switchboard lineup

Generator Breaker Compartment

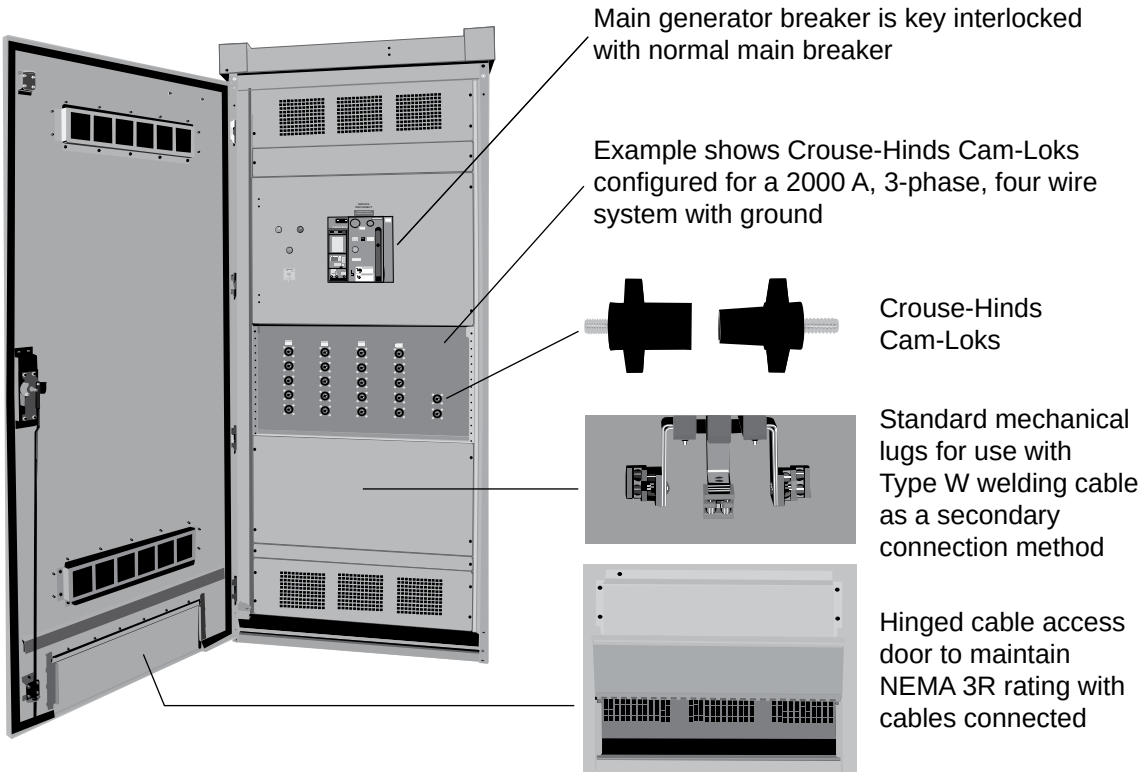
The generator breaker can be connected to the normal main switchboard by cable in retrofit applications or hard bussed in new construction applications. The generator breaker is key-interlocked with the main breaker in the normal switchboard lineup. The switchboard can be rated Suitable for Service Entrance.

Quick-Connect Compartment

Crouse-Hinds quick-connect Cam-Locks are provided in a compartment with a screw cover that can be easily removed to gain access to the quick-connects. One end of each quick-connect is the switchboard and the other end is attaches to the generator cable. In addition to the quick-connects, **standard mechanical lugs** are provided as a secondary method of connection. The mechanical lugs are rated for Type W welding cable, which is common in generator applications.

Generator Connection

The switchboard generator breaker can be connected to a new or existing switchboard lineup either by cable or hard bussing.



Siemens Generator Ready Switchboards are constructed in accordance with the following standards or certifications: UL 891, NEMA PB-2, NEC Article 702, Florida Building Code section 420.4.2.9.7 and are seismically qualified and UL listed (where applicable). These switchboards are available with ampere ratings from 400 to 4000 A. The following chart shows additional ratings and dimensions.

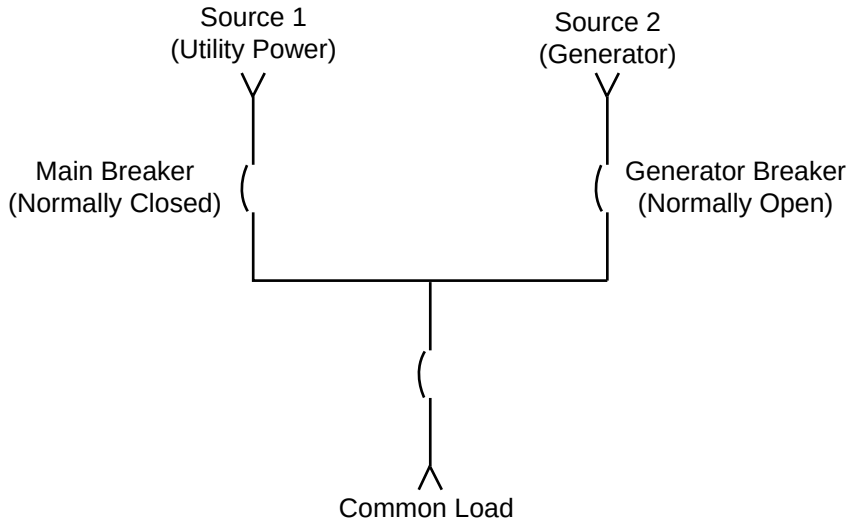
Configuration Information				Dimension in inches			Maximum kW Rating[2]			
Ampere Rating	Pull Section Required	Standard Main Device	Depth[1]	Pull Section Width	Main Section Width	Total Width	80% Rated Disconnect		100% Rated Disconnect	
							480V	208V	480V	208V
400	No	Sentron JD	20	-	32	32	213	92	266	115
600	No	Sentron LD	20	-	32	32	319	138	399	173
800	No	VL MG	20	-	32	32	425	184	531	230
1200	No	VL NG	20	-	32	32	638	276	797	345
1600	No	VL PG	38	-	32	32	850	365	1063	461
2000	No	WL	38	-	38	38	-	-	1329	576
2500	Yes	WL	38	32	38	70	-	-	1661	720
3000	Yes	WL	38	32	38	70	-	-	1993	864
4000	Yes	WL	38	32	38	70	-	-	2657	1151

1) NEMA 3R rating rquires a front extension that increases depth by 11.25 inches

2) Assumed power factor (PF) = 0.8 and calculated using max. kW = (V*A*1.73*PF)/(1000)*(Disconnect Rating)

Sequence of Operation

The following sequence of operation steps are associated with Siemens Generator Ready Switchboards. These are intended to represent typical procedures, some steps may vary depending on the installation. Appropriate safety procedures should also be followed.



On Loss of Utility Power

1. Open all distribution breakers
2. Open main (normal) breaker and rotate key interlock to open position
3. Connect generator cables to quick connects or standard mechanical lugs
4. Rotate key interlock to closed position on generator breaker
5. Start generator and verify connections and phasing
6. Close generator breaker and appropriate distribution breakers

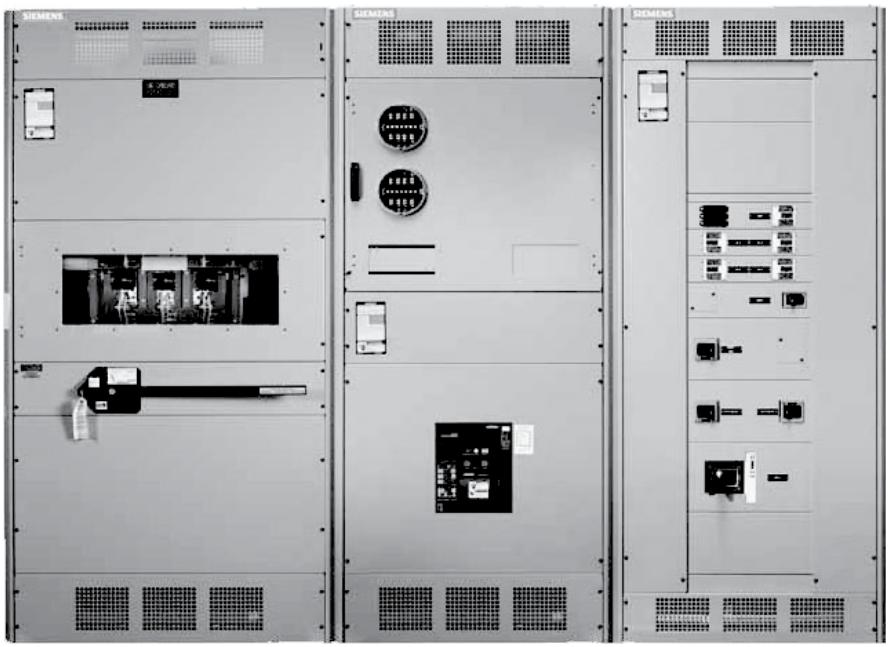
On Return of Utility Power

1. Open all distribution breakers
2. Open generator breaker and rotate key interlock to open position
3. Insert key into main (normal) breaker
4. Shutdown generator
5. Rotate key interlock on main breaker
6. Close main breaker
7. Close appropriate distribution breakers

Solar Ready Switchboards

Siemens solar ready switchboards provide a solution for both AC and DC commercial solar applications.

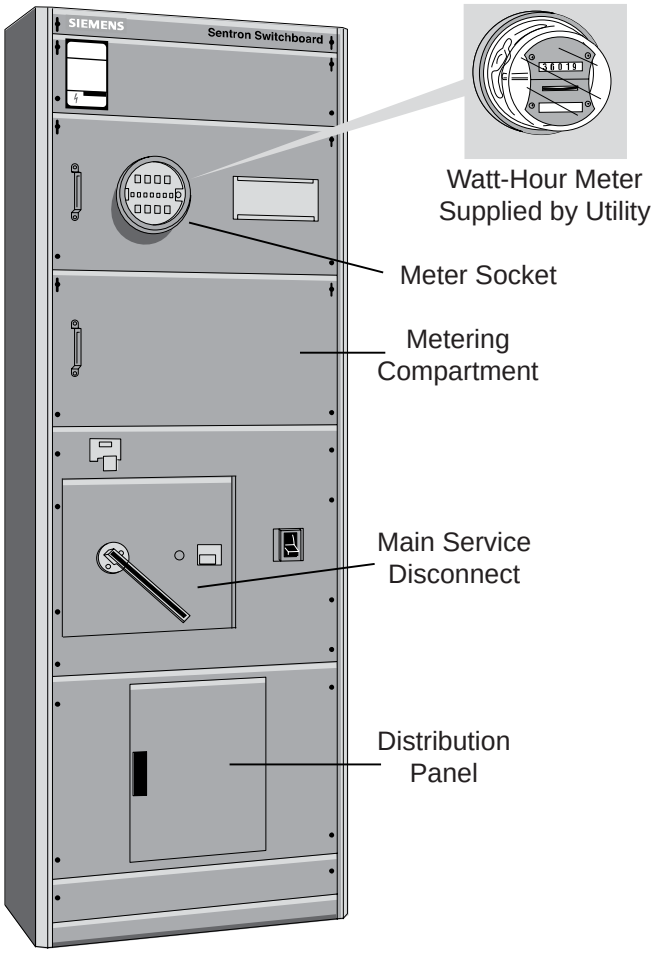
In addition to all standard switchboard features, optional viewing windows are also available for an additional level of safety when working with inverter inputs. Siemens switchboards meet all utility and code requirements.



Ratings	Standards and Certifications	Features
• 600 VAC (max.) • 500 VDC (max.) • 6000 A (max.) Main Bus	• UL891 • NEMA PB-2 • Seismically Qualified • NFPA 70 (NEC®) • cUL (Also Complies with CSA C22.2 No. 244) • Other Equipment is UL Listed as Applicable)	• Optional Solar Viewing Window (with Bolted Pressure Switches) • UL489 Circuit Breakers Suitable for Reverse Feed • Customer Metering • Utility Metering Provisions • All Standard Switchboard Features

Super Blue Pennant Switchboards

Siemens **Super Blue Pennant switchboard** is a service entrance switchboard with the main service disconnect and distribution devices contained in a single unit. Super Blue Pennant switchboards meet **Electric Utility Service Equipment Requirements Committee (EUSERC)** specifications. These switchboards are rated for 400, 600, or 800 amps with a circuit breaker main and 400 or 600 amps with a fusible Vacu-Break switch main.

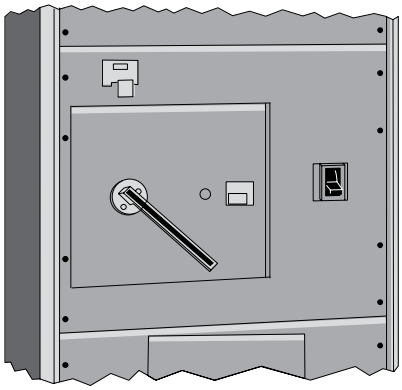


Metering Compartment

The metering compartment has provisions for mounting a utility meter on the door. Super Blue Pennant switchboards have metering and test block provisions, use barriered hot sequence utility metering, and have a fully-bussed power company current transformer compartment in compliance with EUSERC specifications.

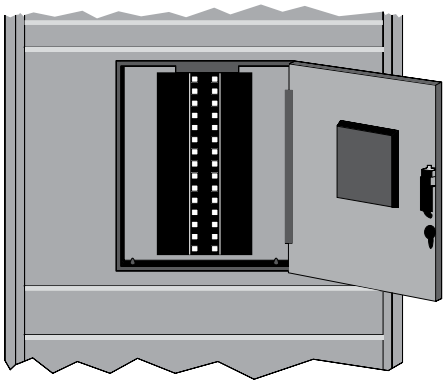
Service Disconnect

The service disconnect can be a fusible Vacu-Break switch through 200,000 amps interrupting rating or a circuit breaker with a maximum interrupting rating of 65,000 amps at 240 volts and 50,000 amps at 480 volts.



Distribution Panel

Distribution kits are optional and field adaptable with ratings of 400 to 800 amps. Up to 40 branch circuit provisions are available with an 18 branch circuit minimum.



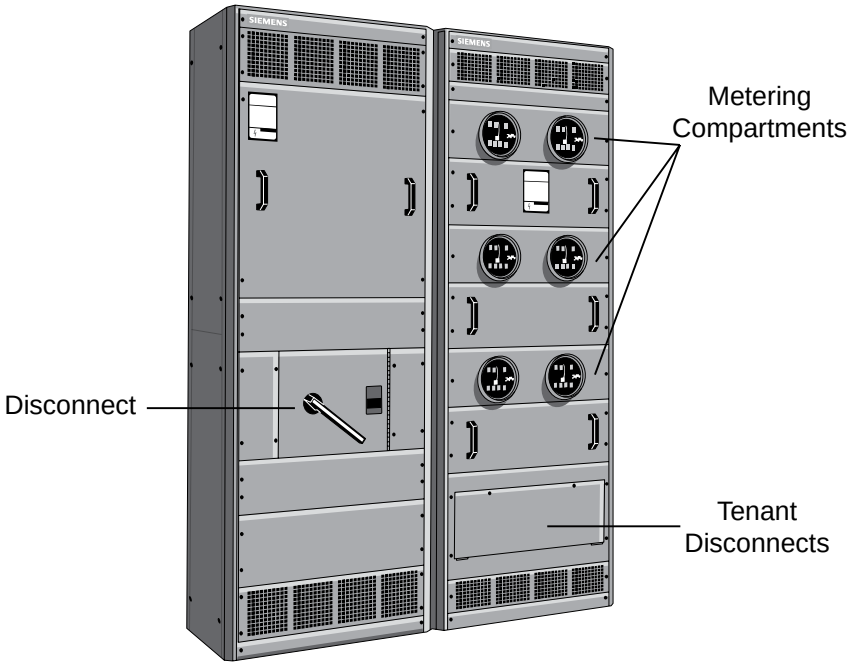
Multi-Metering Switchboards

Siemens **multi-metering switchboards** are designed for applications where multiple utility meters are required. These applications include shopping centers, office buildings, and other buildings with multiple tenants.

SMM Switchboards

Siemens **SMM switchboards** are designed to meet EUSERC specifications. The switchboard main service is rated up to 4000 amps for the following services: 120/240 V 1-phase, 3-wire; 240/120 V three-phase, four-wire, 208Y/120V three-phase, four-wire; and 480Y/277 V three-phase, four-wire. SMM Switchboards have the following additional characteristics:

- UL listed and labeled
- Hot sequence meeting standard, cold sequence optional
- Test blocks are standard
- Copper or aluminum bus available
- 65,000 amps symmetrical bracing standard (higher bracing available)
- Type NEMA 1 or NEMA 3R enclosure
- Meets UL 891 adn NEMA PB2 standards
- Ring type meter cover design



Thru-Main Section

MMS Switchboards

Siemens **MMS switchboards** provide a high-quality, multi-metering solution for areas where EUSERC compliance is not necessary. The switchboard main service is rated up to 4000 amps for the following services: 208Y/120V three-phase, four-wire and 480Y/277 V three-phase, four-wire. SMM Switchboards have the following additional characteristics:

- Hot sequence meeting standard, cold sequence optional
- 50,000 amps symmetrical bracing standard (higher bracing available)
- All meter sockets are pre-wired for 100 A, 200 A, or 300 A sockets
- Copper or aluminum bus available
- Units are front-accessible
- Type NEMA 1 or NEMA 3R enclosure
- Available with optional cable pull sections
- Meter sockets include lever type manual bypass
- Common depth for main and metering sections available on request.
- Ring-less type meter cover design

Speciality Service Entrance Switchboards

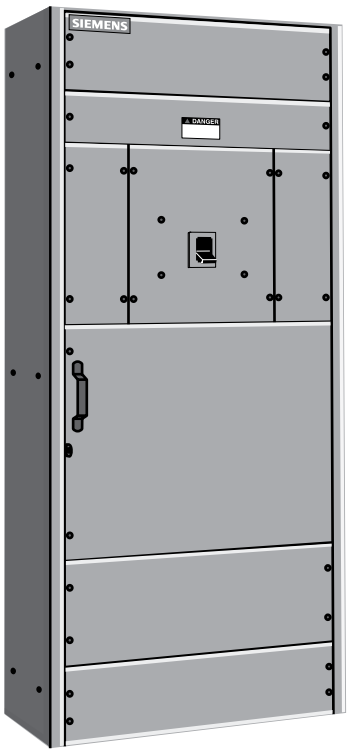
Specialty service entrance switchboards can be used in various applications. One of these switchboards may, for example, be placed ahead of a main switchboard to serve as a remote main disconnect. Specialty service entrance switchboards are available with a single molded case circuit breaker or fusible switch and are UL listed as suitable for use as service entrance equipment. These units use indoor construction for floor mounting only. Current transformer provisions are adjustable for use with 12" or 14.5" primary bar type current transformers.

BCT Service Cubicle

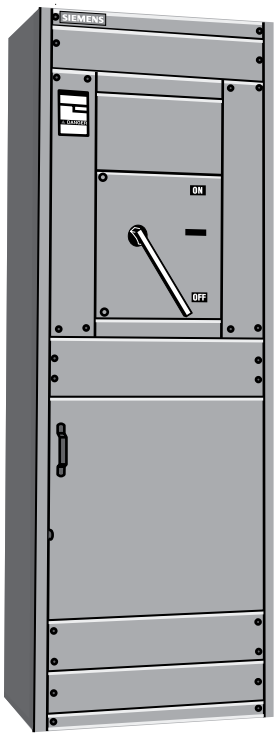
BCT service cubicles enclose a main molded case circuit breaker. They are available in current ratings from 400 to 1200 amps. BCT specialty service entrance switchboards use cold sequence metering as standard and are top-fed. For hot sequence metering the unit and circuit breaker can be inverted.

SCT Service Cubicle

SCT service cubicles enclose a quick-make, quick-break main fusible switch. They are available in current ratings from 400 to 1200 amps.



BCT Service Cubicle



SCT Service Cubicle

Things to Consider

The items listed below are examples of things you need to know when planning a switchboard purchase. Other information may also be required, but these are some of the basic requirements. Keep in mind that the specifications developed for an application should consider both present requirements and future needs.

- The incoming voltage and configuration
- Incoming power protection requirements
- Available space and environmental considerations
- System certification requirements
- Number and types of sections required
- Enclosure requirements: NEMA type, section alignment, accessibility, and paint
- Shipping and lifting considerations
- Bus material, ratings, and tapering
- The routing and connecting means for the incoming service
- Utility and customer metering requirements
- Indicating light requirements
- Shunt trip requirements
- Key interlock requirements
- Types and ratings of the main and branch protective devices
- Fuse requirements
- Ground fault protection requirements
- Requirements for additional equipment to be mounted in the switchboard
- Installation and service requirements

Review 5

1. SB1 switchboards are _____ aligned.

2. The maximum main bus rating of an SB1 switchboard is _____ amps.

3. The maximum main bus rating of an SB2 switchboard is _____ amps.

4. The maximum main bus rating of an SB3 switchboard is _____ amps.

5. The modular design of Siemens _____ switchboards allows the user to integrate electrical distribution equipment, power monitoring, and environmental controls that typically mount in multiple enclosures into one switchboard line-up.

6. Super Blue Pennant switchboards are rated up to _____ amps with a circuit breaker and _____ amps with a Vacu-Break fusible switch.

7. Siemens _____ multi-metering switchboard is designed to meet EUSERC specifications.

8. Siemens _____ multi-metering switchboard is intended for use in areas where EUSERC specification compliance is not necessary.

9. The type of specialty service entrance switchboard that uses a quick-make, quick-break fusible switch as a main disconnect is a/an _____ service cubicle.

Review Answers

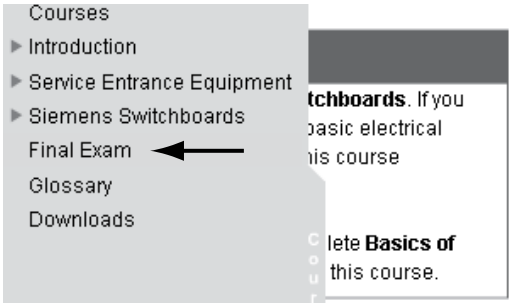
Review 1	1) Power distribution; 2) 120; 3) 277; 4) c; 5) front and rear.
Review 2	1) 90; 2) bus; 3) ABC; 4) aluminum, copper; 5) Splice plates.
Review 3	1) Service entrance equipment; 2) six; 3) service, distribution; 4) pull section; 5) Hot sequence; 6) Cold sequence; 7) a.
Review 4	1) f; 2) UL 489, UL 1066; 3) distribution; 4) interrupting; 5) short circuit withstand; 6) series; 7) Ampere rating.
Review 5	1) rear; 2) 2000; 3) 4000; 4) 6000; 5) Integrated Power System; 6) 800, 600; 7) SMM; 8) MMS 9) SCT.

Final Exam

Before taking the final exam, it is recommended that you delete the temporary internet files from your computer's web browser. For most versions of **Internet Explorer**, you can do this by selecting **Internet Options** from the **Tools** menu and then clicking on the **Delete Files** button. If you do not perform this step, you may see a score of 0% after you submit your exam for grading.

The final exam for this is course is available online at **http://www.usa.siemens.com/step**. This web page provides links to all our quickSTEP online courses. To complete the final exam for this course, click on the **Basics of Switchboards** link.

Next, move your mouse over to the left so that the navigation bar pops out and select the **Final Exam** link. The final exam page will appear.



After you complete the final exam, click on the **Grade the Exam** button at the bottom of the page. Your score on the exam will be displayed along with the questions that you missed.

If you score 70% or better on the exam, you will be given two options for displaying and printing a certificate of completion. The **Print Certificate** option allows you to display and print the certificate without saving your score in our database and the **Save Score** option allows you to save your score and display and print your certificate. **The Save Score option is primarily intended for use by our distributors and Siemens employees.**