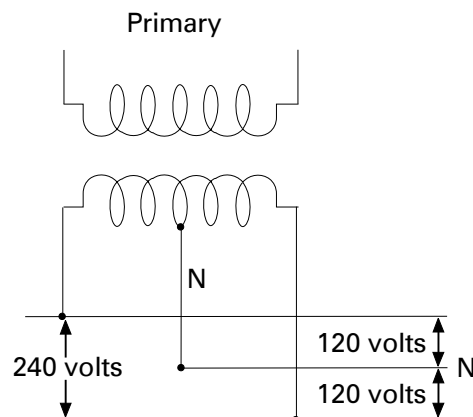


Power Supply Systems

Switchboards receive power from a variety of sources. Downstream switchboards may receive power from upstream switchboards or disconnect switches, however, power for the distribution system originates from a utility power company. Voltage from the power company is stepped down through transformers for distribution systems. The following are some examples of systems in use.

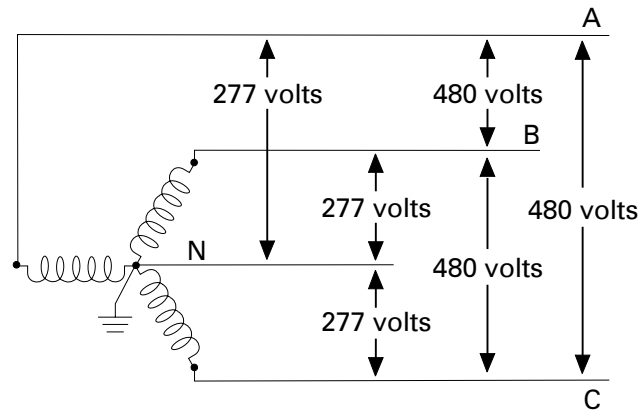
1Ø3W

The following diagram illustrates one of the most common single-phase, three-wire (1Ø3W) distribution systems in use today. There are 240 volts across the full secondary of the transformer and 120 volts between the neutral and either end of the transformer. The neutral is the third wire.



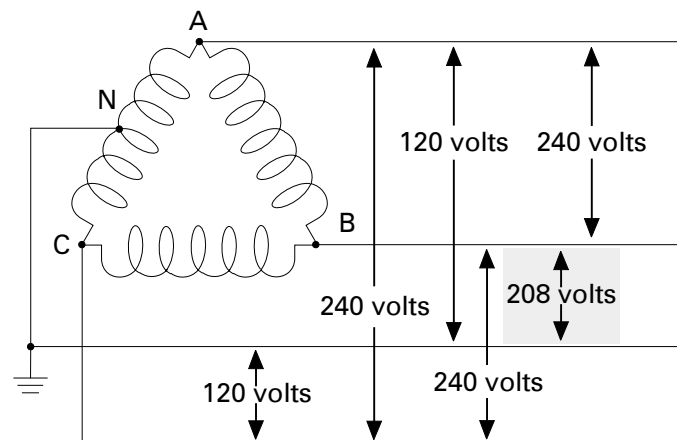
3Ø4W, wye-connected

The following illustration shows the secondary of a 480 Y/277 V three-phase, four-wire (3Ø4W), wye-connected transformer. The "480 Y" indicates the transformer is wye-connected and has 480 volts between any two phases. The "277 V" indicates there are 277 volts between any phase and neutral (N). Phase-to-phase voltage is 1.732 times phase-to-neutral voltage ($277 \times 1.732 = 480$). Neutral is the fourth wire.



3Ø4W, delta-connected

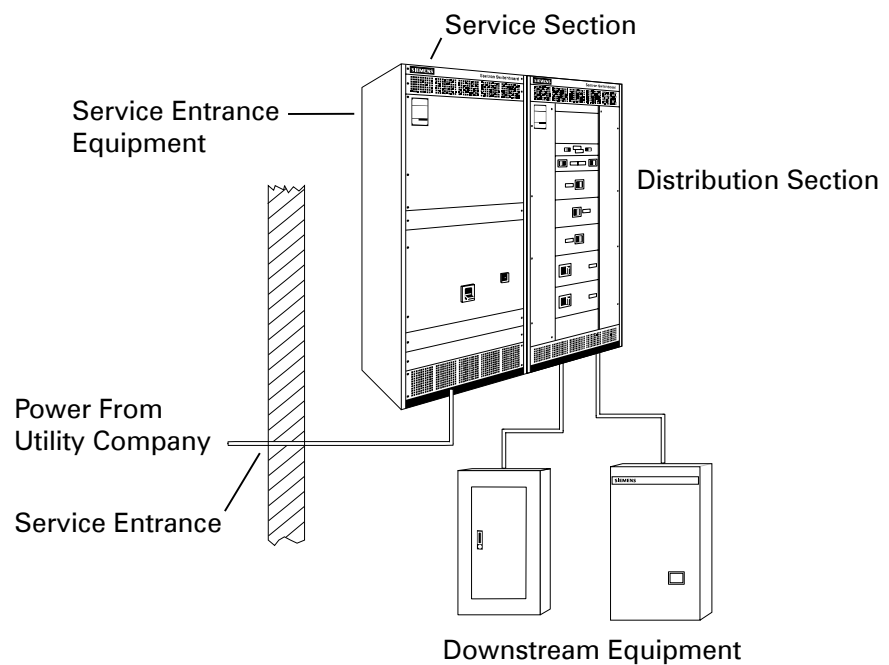
A three-phase, four-wire, delta-connected secondary works a little differently. The following illustration shows a delta-connected secondary with 240 volts phase-to-phase. The midpoint of one phase winding is grounded to provide 120 volts between phase A and neutral and 120 volts between phase C and neutral. Between phase B and neutral, however, the voltage is 208 volts. This is referred to as the high leg. The high leg can be calculated by multiplying the phase A to neutral voltage times 1.732 ($120 \times 1.732 = 208$). Single-pole breakers should not be connected to the high leg. *NEC*[®] Article 215-8 requires that the high leg bus bar or conductor be permanently marked with a finish that is orange in color. This will help prevent electricians from connecting 120 volt single-phase loads to the 208 volt high leg. Four-wire, delta-connected transformers should always be wired so that the B phase to neutral is the high leg.



Service Entrance Equipment

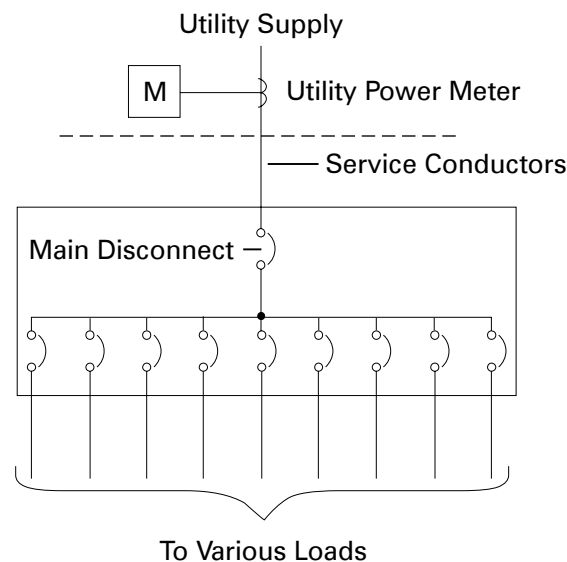
Switchboards are often used as service entrance equipment for a building. The service section of a switchboard refers to the section of a switchboard which receives incoming power. This power can be fed directly from utility power. Power can also be fed to the section from another source, such as switchboard or disconnect switch somewhere upstream.

Service entrance equipment refers to the equipment through which the power supply enters the building. The switchboard in the following drawing is considered service entrance equipment because it is where power enters the building. The incoming power supply is connected to this equipment which provides a means to control and cut off the supply. The *National Electrical Code*® discusses service entrance equipment in Article 230. Switchboards used as service entrance equipment must be approved and labeled as such. All Siemens Sentron™ Series switchboards are factory labeled as suitable for service entrance equipment when specified for service entrance.

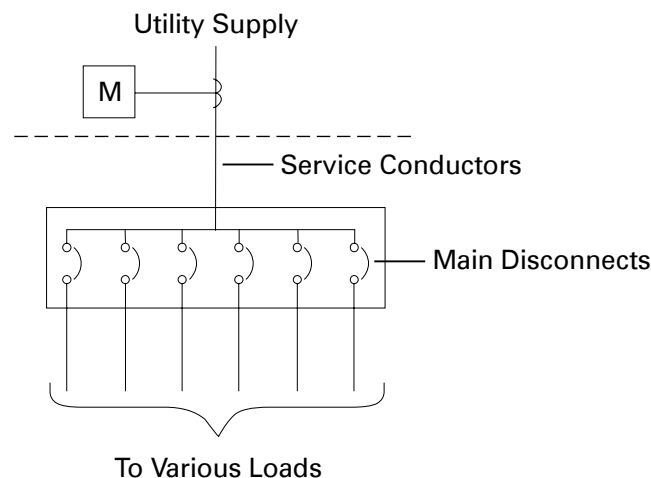


Six disconnect rule

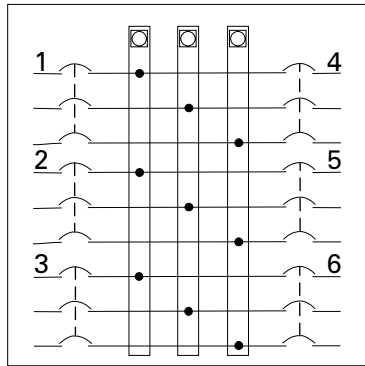
Service entrance conductors must have a readily accessible means of being disconnected from the power supply. *NEC*[®] Article 230-71a specifies that for each set of service entrance conductors no more than six switches or circuit breakers shall be used to disconnect and isolate the service from all other equipment. In the following example, a single main circuit breaker will disconnect power to all equipment being supplied by the service. 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 to all equipment being supplied by the service. In any case, the circuit breaker must be clearly labeled for the load it supplies.



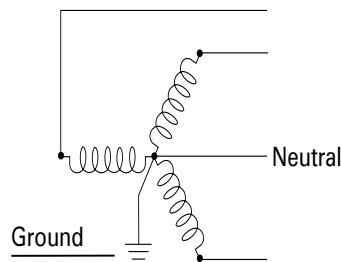
It is important to note that the "six disconnect rule" refers to the number of disconnects and not the number of poles. For example, in the illustration shown below there are 18 poles but only six circuit breakers. Three poles are mechanically linked together to form one disconnect device. In the illustrated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



Switchboard Grounding

Grounding is an important aspect of any electrical system and must be considered carefully. Article 250 of the *NEC* covers mandatory grounding requirements. The *National Electrical Code*® defines ground as *a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.*

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

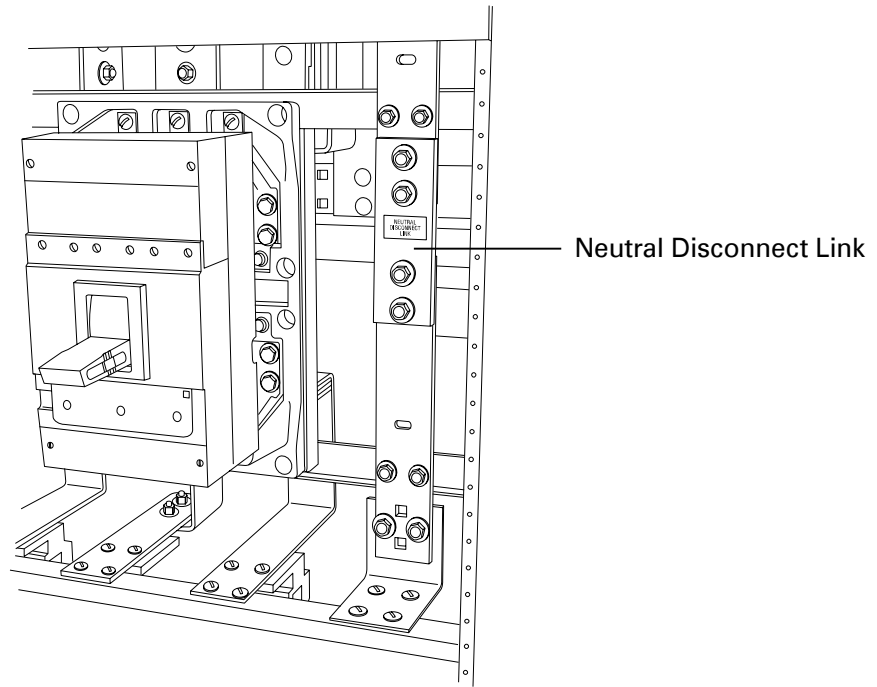


There are two objectives to the intentional grounding of electrical equipment:

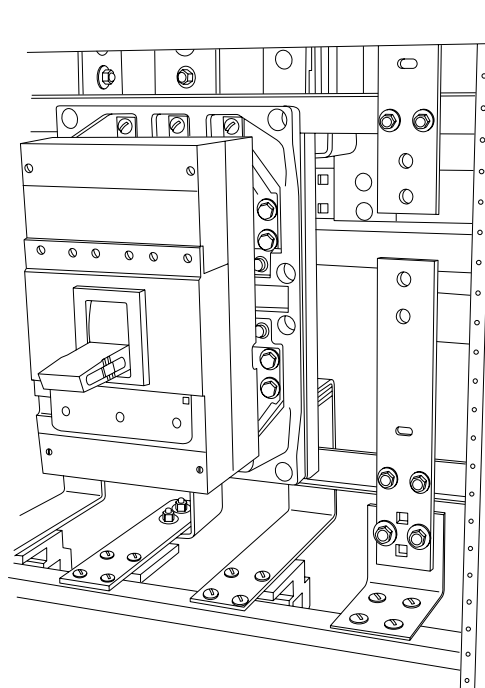
- Keep potential voltage differentials between different parts of a system at a minimum which reduces shock hazard.
- Keep impedance of the ground path to a minimum. The lower the impedance the greater the current is in the event of a fault. The greater the current the faster an overcurrent device will open.

Neutral disconnect link

If a switchboard service section is intended to be used as service entrance equipment, provision must be included to isolate the neutral bus from the grounded neutral bus. A neutral disconnect link is provided for this purpose. The following drawing shows the disconnect link in place.

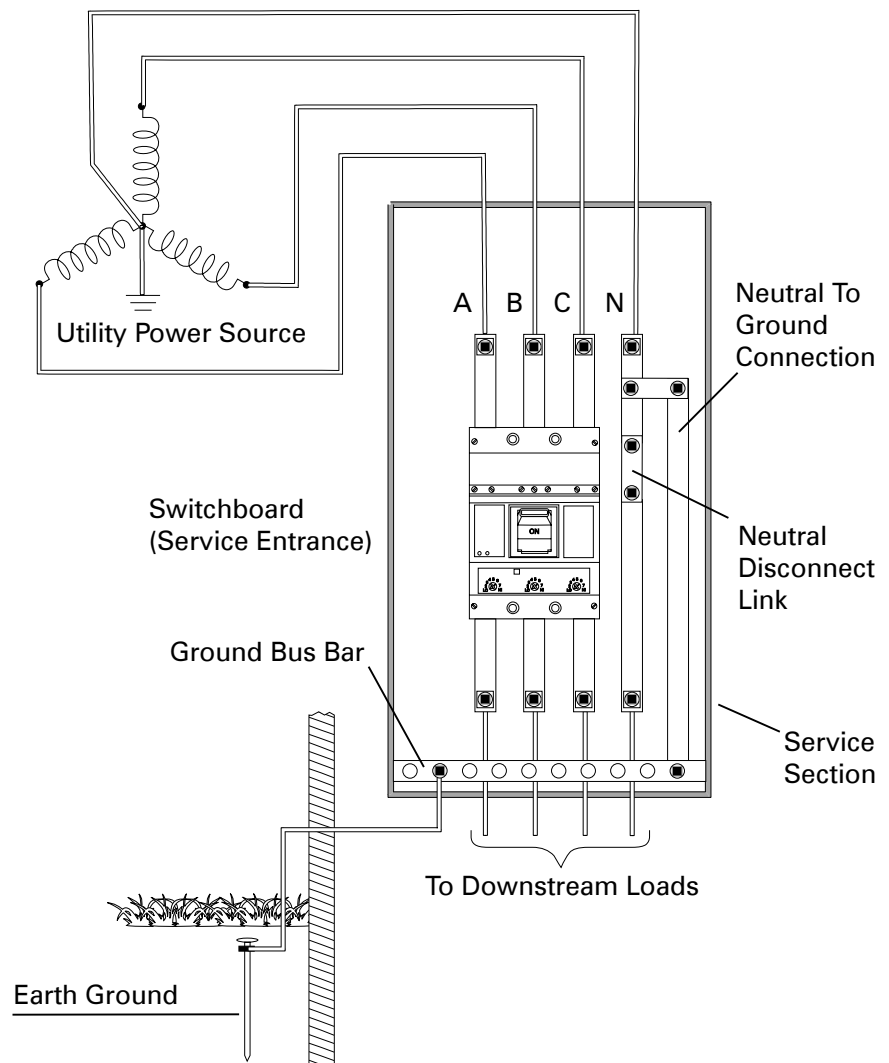


This removable link allows the branch neutral to be checked for continuity on the load side of the main disconnect. The following drawing shows the disconnect link removed.



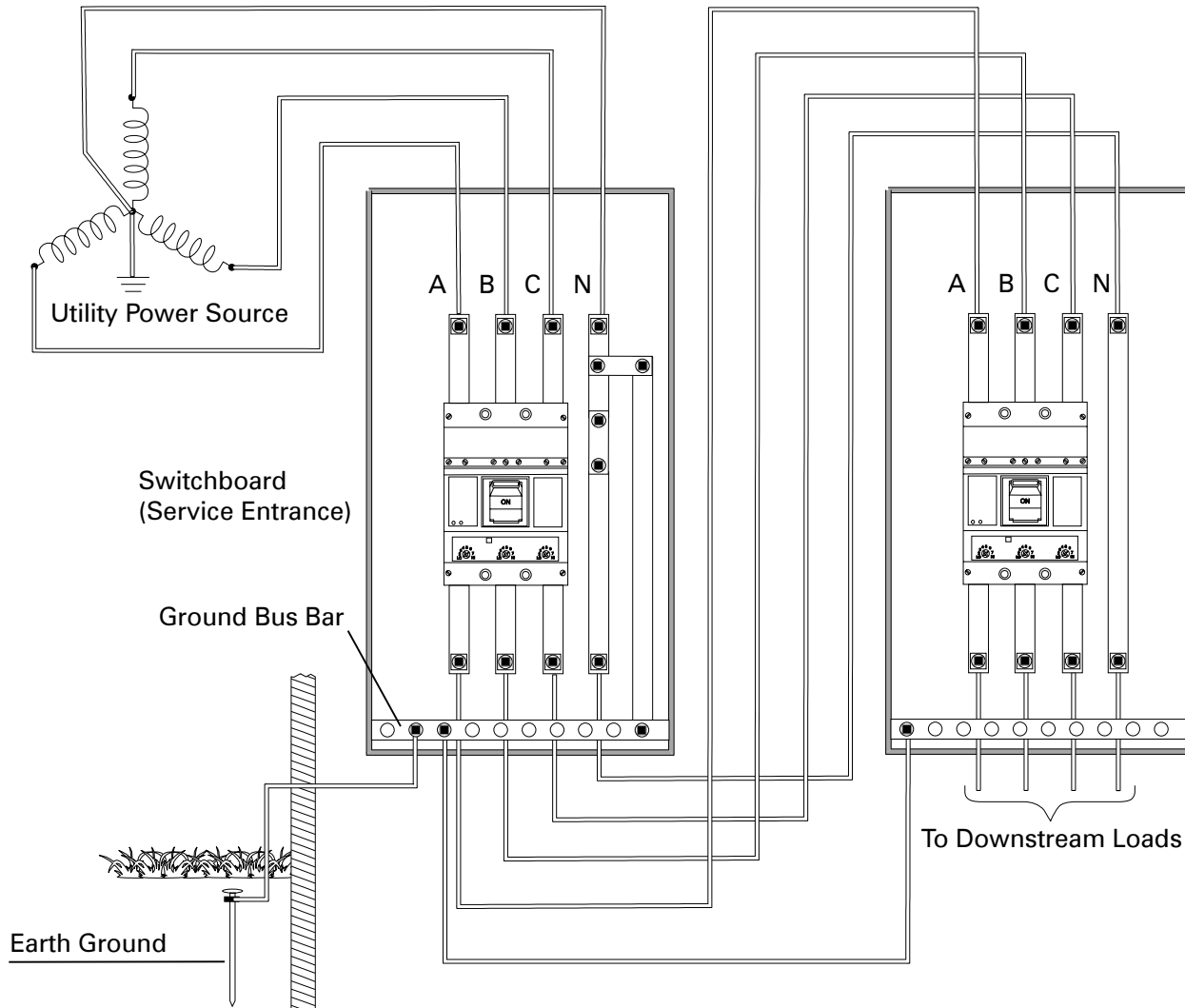
Service entrance grounding

In the following drawing a switchboard is used as service entrance equipment. Power to the service section is received from a 3Ø4W service. The neutral is always grounded in service entrance equipment. The neutral is connected to ground through a neutral to ground connection and ground bus bar. The ground bus bar is connected to the frame of the switchboard, which is connected to the system or earth ground. The neutral disconnect link is left in place to supply downstream loads. Three-phase, four-wire power is then supplied to downstream loads.



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. As shown in the following illustration, the neutral is connected to earth ground through the ground bus bar of the service entrance switchboard. In this example a second switchboard is used downstream of the service entrance switchboard. The enclosure of the downstream switchboard is connected to ground through a grounding conductor back to the service equipment. The neutral is not connected to ground in the downstream switchboard. Notice also that the second (downstream) switchboard does not have a neutral disconnect link. Neutral disconnect links are not required in switchboards used as non-service entrance equipment. Similarly the second switchboard will feed additional downstream loads.



Review 4

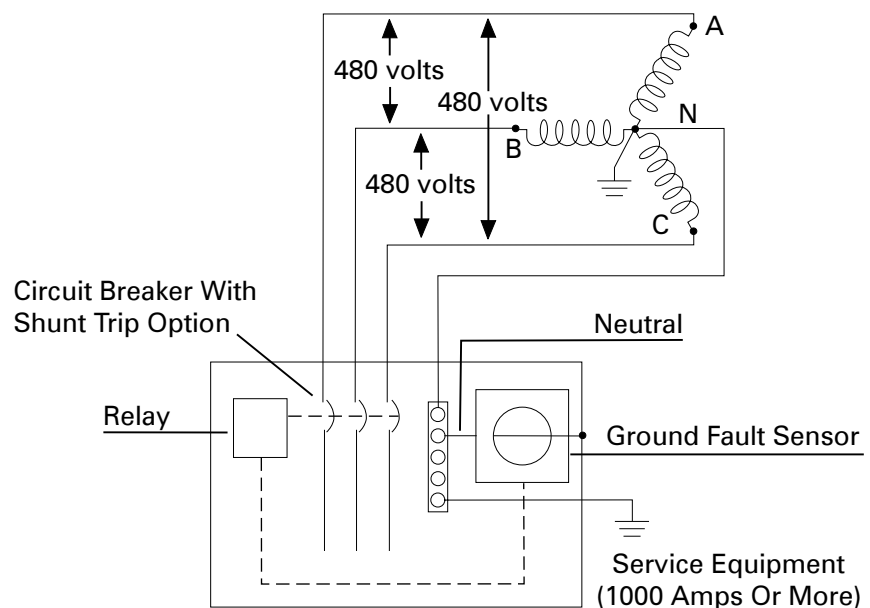
1. If the secondary of a four-wire, wye-connected transformer is 480 volts phase-to-phase, the phase to neutral voltage is _____ volts.
2. If the secondary of a four-wire, B phase high leg, delta connected transformer is 240 volts phase-to-phase, the phase-to-neutral voltage is
_____ volts A to neutral
_____ volts B to neutral
_____ volts C to neutral
3. The term service section refers to the section of a switchboard which receives incoming power. The term _____ equipment refers to equipment through which the power supply enters the building.
4. According to *NEC*[®] Article 230-71a, the maximum number of circuit breakers that can be used to disconnect and isolate the service from all other equipment is _____ .
5. A neutral _____ is supplied in switchboards used as service entrance equipment to allow the branch neutral to be checked for continuity on the load side of the main disconnect.

Ground Fault Protection

In addition to ensuring equipment is properly grounded, ground fault protection for people and equipment is also a concern. *NEC®* Article 230-95 states that *ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase for each service disconnecting means rated 1000 amperes or more.* Although ground-fault protectors are not required on service disconnects that are less than 1000 amperes, depending on the installation, they still may be desirable. Ground fault interrupters designed to provide life protection must open a circuit at 5 milliamps (± 1 milliamp). Ground fault protection for equipment must open a circuit when ground fault current reaches 30 milliamps. Health care facilities, such as hospitals, require additional ground fault protection. This is outlined in *NEC®* Article 517-17.

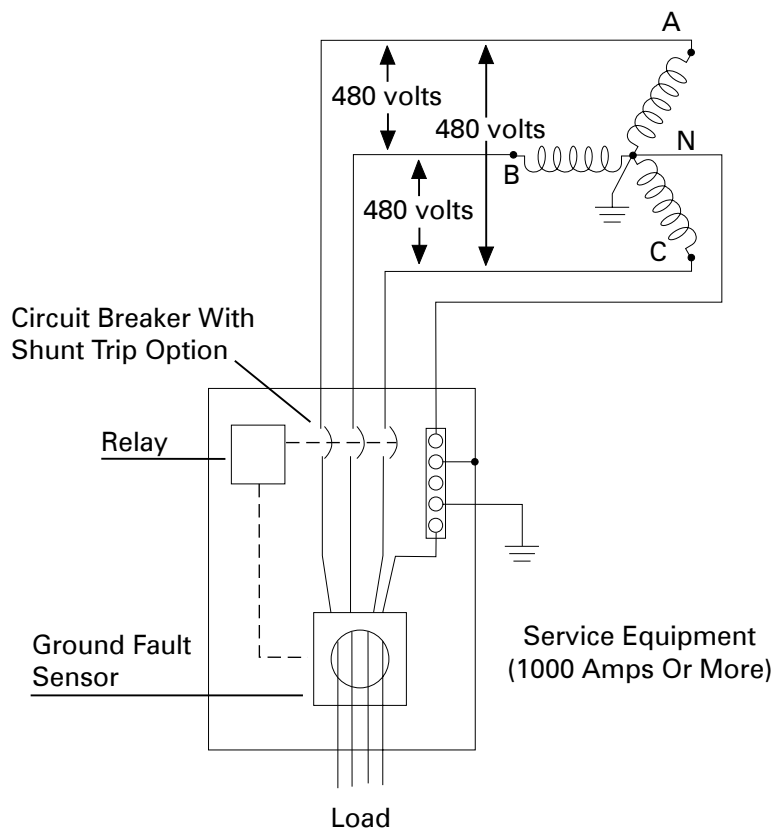
Direct method

One way a ground fault protector works is to install a sensor around one conductor, normally the neutral-to-ground strap. This is referred to as the direct method. When an unbalanced current from a line-to-ground fault occurs current will flow from ground to neutral. When the current reaches the setting of the ground-fault sensor the shunt trip opens the circuit breaker, removing the load from the line.



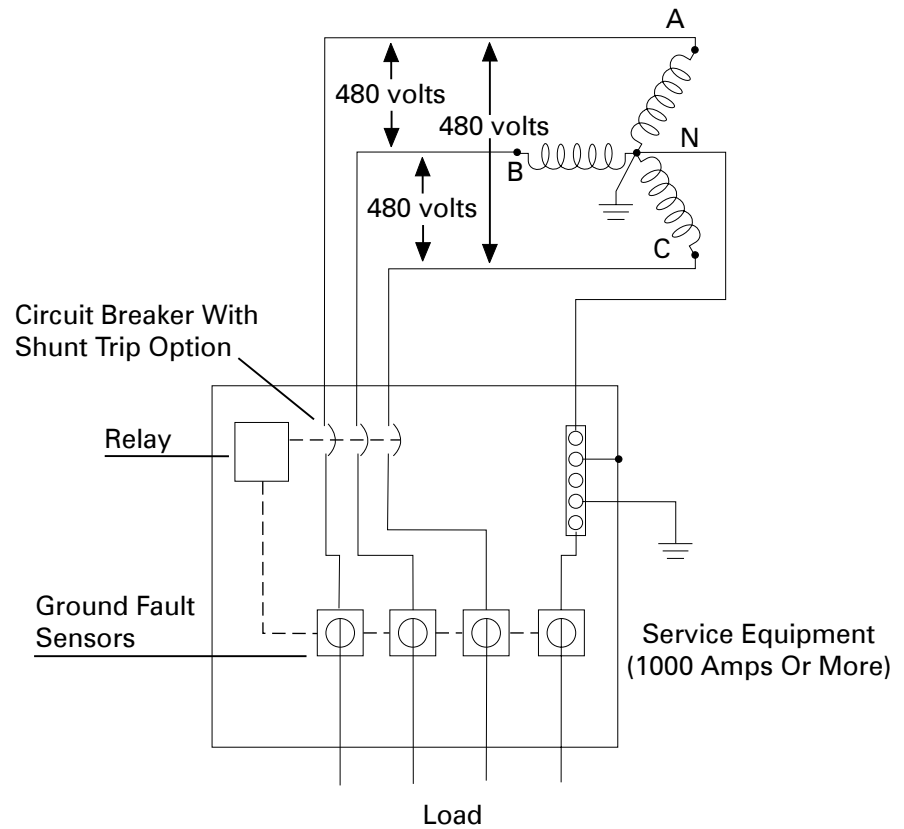
Zero sequencing method

Another way a ground fault protector works is with a sensor installed around all the circuit conductors, including the neutral on 4-wire systems. This is referred to as zero sequencing. During normal current flow the sum of all the currents detected by the sensor is zero. However, a ground fault will cause an unbalance of the currents flowing in the individual conductors. When this current reaches the setting of the ground-fault sensor the shunt trip opens the circuit breaker.



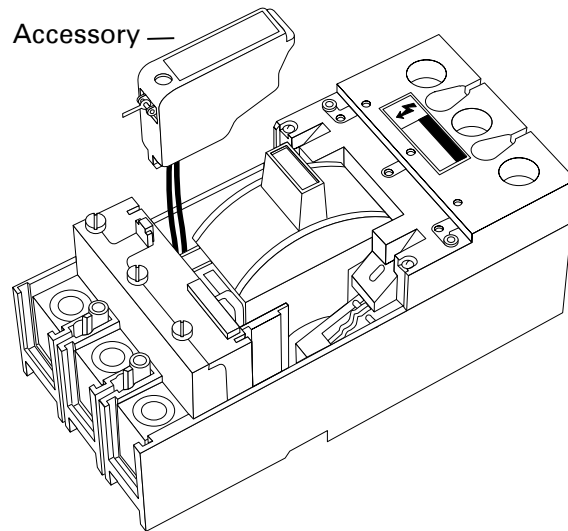
Residual method

Separate sensors monitor current on all three phases (and the neutral on a 4-wire system). If the vectorial sum of the currents on the secondary of the sensors does not equal zero the breaker will be tripped.



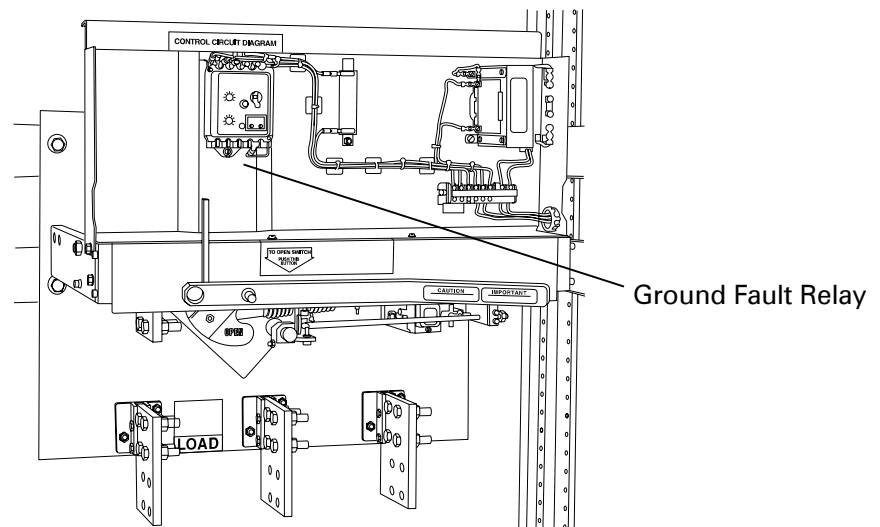
Ground fault protection devices

Ground fault protection is generally incorporated into a special type of protective device such as a molded case circuit breaker (shown below). Ground fault protection is also available in Siemens insulated case circuit breakers.



Accessory For FD - RD Frame
Molded Case Circuit Breakers

Ground fault protection can also be supplied on various disconnect switches, such as the bolted pressure switch.



Note: All main protective devices, except Vacu-Break[®] fusible switches, can be equipped with ground fault relays to comply with *NEC*[®] requirements.

Switchboard Ratings

When selecting switchboards and overcurrent protection devices it is extremely important to know both the maximum continuous amperes and available fault current along with several other rating terms.

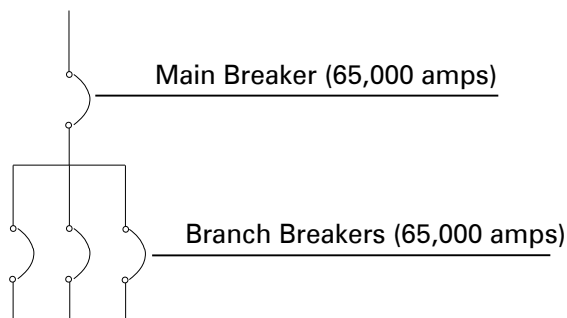
Interrupting rating

Interrupting rating refers to the current rating a protective device, such as a fuse or circuit breaker, can safely interrupt. Interrupting rating is also referred to as ampere interrupting capacity (AIC). *NEC*[®] article 110-9 states:

Equipment intended to break current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment. Equipment intended to break current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

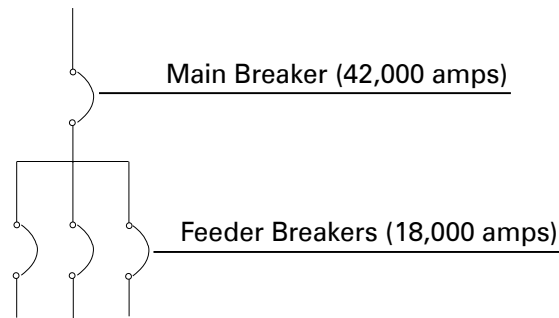
Full rating

There are two ways to meet this requirement. The full rating method is to select circuit protection devices with individual ratings equal to or greater than the available fault current. This means that, in the case of a building with 65,000 amperes of fault current available at the service entrance, every circuit protection device must be rated at 65,000 amperes interrupting capacity (AIC). Switchboards are available with short circuit withstand ratings up to 200,000 amps. However, a full-rated switchboard over 100,000 AIC can be expensive because of the necessary bus bracing.



Series-rated

A full-rated switchboard is not always required. Series-rated switchboards are UL listed and are adequate for many applications at a lower cost. The series-rated concept is 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. This is permitted as long as the series combinations shown have been tested and certified by UL. For example, a building with 42,000 amperes of available fault current might have the breaker at the service entrance rated at 42,000 AIC and additional downstream breakers rated at 18,000 AIC.



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 listed in the Speedfax catalog. Your Siemens sales engineer can provide more information on Siemens series-rated circuit breakers.

Keep in mind that it is the protection device mounted in the switchboard that interrupts current. Therefore, the interrupt rating applies to the protective devices.

Withstand rating

Short circuit withstand rating refers to the level of fault current a piece of equipment can withstand 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 amount of current for a specified amount of time. The short circuit withstand rating of a switchboard is determined by the combined withstand, interrupting, and current limiting capabilities of the bus, overcurrent protective devices in the switchboard, and any overcurrent protective devices within or ahead of the switchboard that may supply and protect it.

Ampere rating

The ampere rating refers to the current a switchboard or protective device will 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. For example, a 480 VAC switchboard could be used on a 240 VAC system. A 240 VAC switchboard could not be used on a 480 VAC system.

Review 5

1. Ground fault protection is required for grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase when service disconnecting devices are rated at _____ amps or more.
2. All main protective devices except _____ - _____ can be equipped with ground fault relays to comply with *NEC*[®] requirements.
3. Ground fault protection is discussed in *NEC*[®] Article _____.
4. _____ rating refers to the level of fault current a piece of equipment can withstand without sustaining damage.
5. _____ rating refers to the maximum current a protective device such as a fuse or circuit breaker can safely interrupt.
6. A switchboard is said to be _____ - _____ when the main upstream circuit protection device is equal to or greater than the available fault current, but subsequent downstream circuit protection devices connected in series are rated at a lower AIC.
7. _____ refers to the current a switchboard or protective device will carry continuously without deterioration and without exceeding temperature rise limits.

SB1, SB2, and SB3 Switchboards

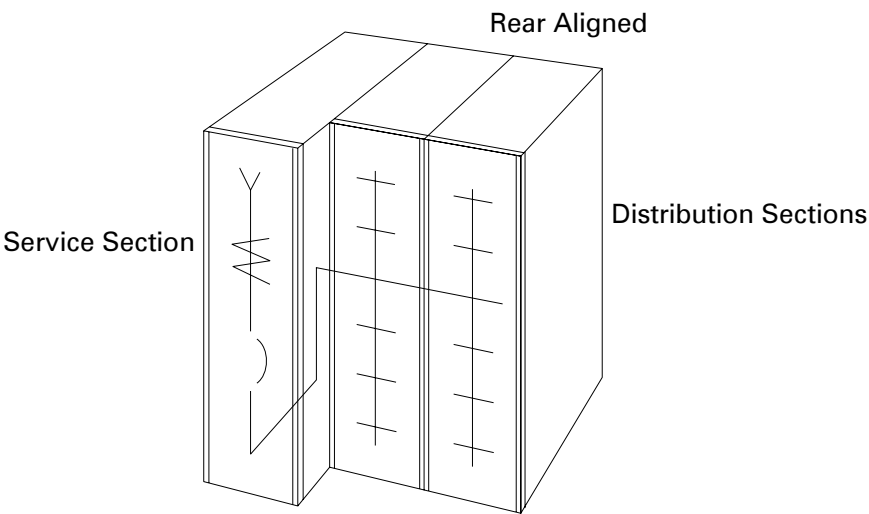
Siemens manufactures a variety of switchboards. The type of switchboard selected is determined by a variety of factors such as space, load, and environment. In addition to meeting present loads, the switchboard should be sized to accommodate reasonable future load additions. The continuous rating and 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. Siemens switchboards are available in Type 1 (indoor) or Type 3R (outdoor) enclosures.

SB1, SB2, and SB3 Sentron™ switchboards can be found in a variety of industrial plants, hospitals, and commercial buildings.



SB1 switchboards

SB1 switchboards are designed to be used in an application where space is a consideration. SB1 switchboards are rear aligned. The service section can be deeper than the distribution sections. By aligning the rear the switchboard can be installed against a wall.



SB1 ratings and devices

The SB1 switchboard contains front-connected main protective devices and through-bus ratings up to 2000 amps at 480 VAC. SB1 switchboards are front accessible with front connected devices. Main devices, used in the service section, are available from 400 - 2000 amps. Branch devices, used in the distribution section, are available from 15 - 1200 amps.

Main device
individually mounted

Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch
400-2000 A	800-1200 A	800-2000 A	400-1200 A

Main device
panel mounted

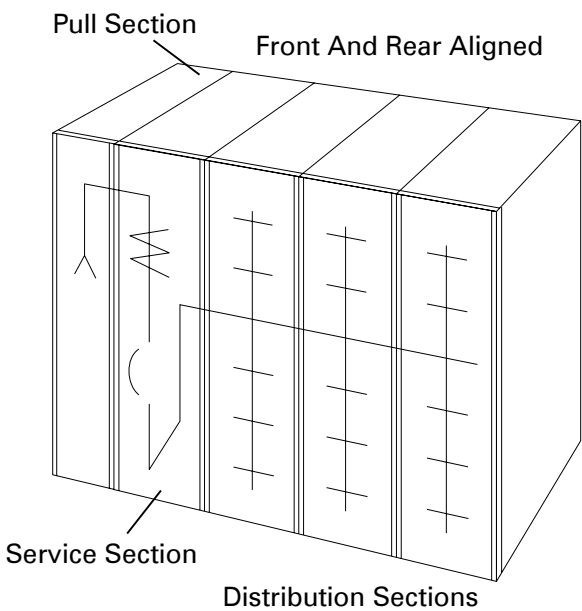
400-1200 A	400-600 A		400-1200 A
------------	-----------	--	------------

Branch device
panel mounted

15-1200 A	30-600 A		400-1200 A
-----------	----------	--	------------

SB2 switchboards

The rear of SB2 switchboards align as standard. Front and rear alignment is available as an option. SB2 switchboards are front accessible and front connected. The following switchboard pictorial illustrates an SB2 that is front and rear aligned. In this example a pull section has been added to allow room to pull cable up from the bottom to connections in the top of the service section. Bottom feed without a pull section is also available. SB2 switchboards may be mounted against a wall.



SB2 ratings and devices

The SB2 contains through-bus ratings up to 4000 amps at 480 VAC. Main devices are available from 400 - 4000 amps. Branch devices are available from 15 - 1600 amps.

Main device
individually mounted

Molded Case Circuit Breaker	Vacu-Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch	Insulated Case Circuit Breaker
400-3200 A	400-1200 A	800-4000 A	400-1200 A	800-4000 A Fixed

Main device
panel mounted

400-1200 A	400-600 A		400-1200 A	
------------	-----------	--	------------	--

Branch device
individually mounted

	800-1200 A	800-1600 A	400-1200 A	
--	------------	------------	------------	--

Branch device
panel mounted

15-1200 A	30-600 A		400-1200 A	
-----------	----------	--	------------	--

SB3 switchboards

SB3 switchboards are front and rear aligned. SB3 switchboards are designed for special configurations, such as incoming and outgoing busway connections, and automatic transfer schemes. Through-bus ratings are available up to 6000 amps. Branch devices are available from 15 - 2000 amps (custom configurations with higher ratings are available).

Main device
individually mounted

Molded Case Circuit Breaker	Vacu- Break Fusible Switch	Bolted Pressure Switch	HCP Fusible Switch	Insulated Case Circuit Breaker	LV Power Circuit Breaker
400-3000 A	400-1200 A	800-4000 A	800-1200 A	800-5000 A Fixed or Drawout	800-5000 A Drawout

Main device
panel mounted

400-1200 A	400-600 A		800-1200 A		
------------	-----------	--	------------	--	--

Branch device
individually mounted

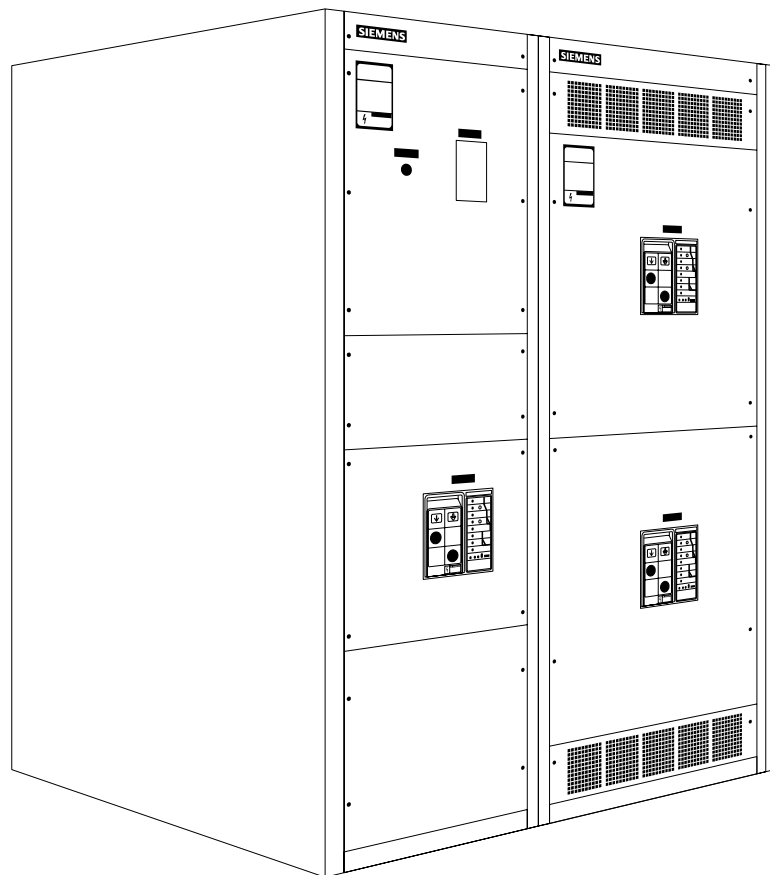
400-2000 A	800-1200 A	800-2000 A			
------------	------------	------------	--	--	--

Branch device
panel mounted

15-1200 A	30-600 A		800-1200 A		
-----------	----------	--	------------	--	--

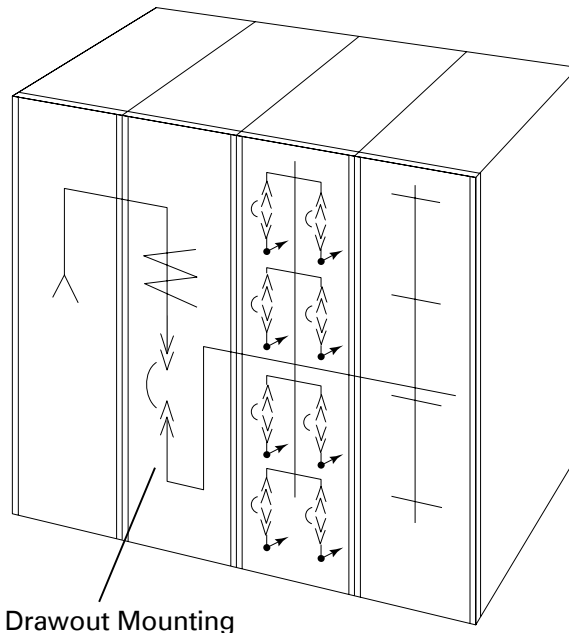
RCIII Switchboards

The branch and feeder devices in the Siemens type RCIII switchboards are individually mounted. This mounting method requires access to outgoing cable terminations from the rear. Type RCIII switchboards are rear connected and require rear access. Bus bar extensions from the feeder devices are run back to the rear of the switchboard for easy access. RCIII switchboards are front and rear aligned. The following drawing illustrates a type RCIII switchboard with Siemens insulated case circuit breakers (ICCB) in the service and distribution sections.



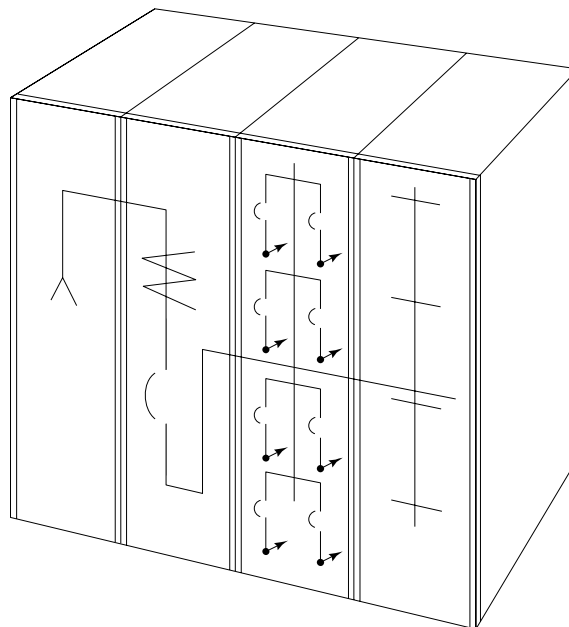
Drawout or fixed mounting

Depending on the protective device, it may be either drawout or fixed mounted. Insulated case circuit breakers (ICCB), for example, may be either drawout or fixed mounted. Vacu-break[®] fusible switches are fixed mounted.



Drawout Mounting

Drawout Mounted Devices



Fixed Mounted Devices

Ratings and devices

Main device
individually mounted

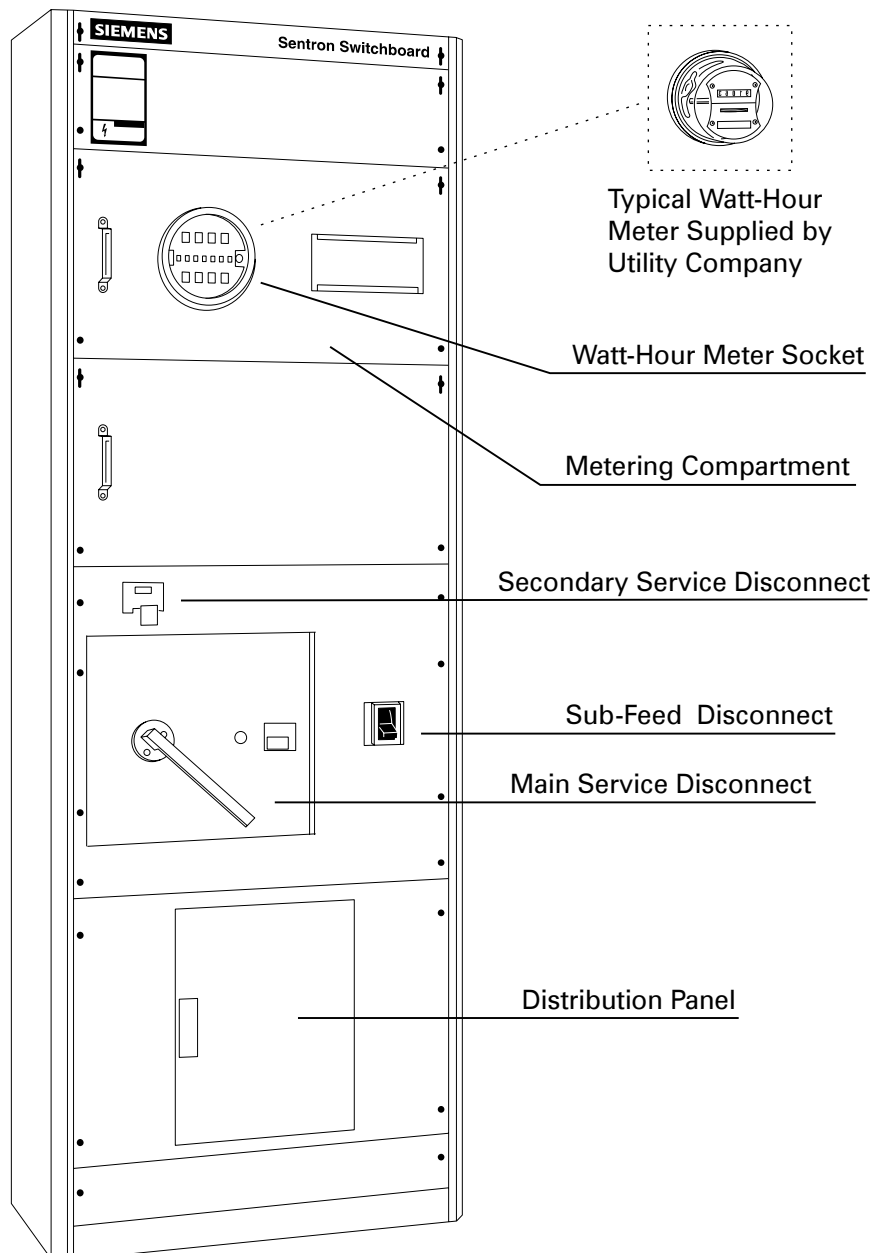
Molded Case Circuit Breaker	Vacu- Break Fusible Switch	Bolted Pressure Switch	Insulated Case Circuit Breaker	LV Power Circuit Breaker
400-3200 A	400-1200 A	800-4000 A	800-5000 A Fixed or Drawout	800-5000 A Drawout

Branch device
individual (rear) and
panel mounted

15-3200 A	30-1200 A	800-4000 A	800-4000 A Fixed or Drawout	800-4000 A Drawout
-----------	-----------	------------	-----------------------------------	-----------------------

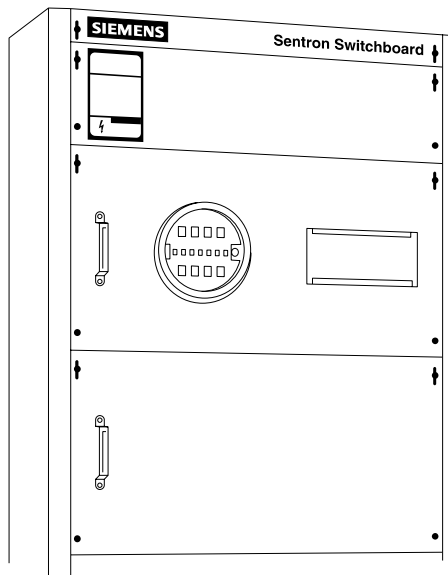
Super Blue Pennant Switchboards

The Super Blue Pennant™ switchboard is designed as a service entrance switchboard. The main service disconnect and distribution devices are contained in a single unit. The metering provisions meet EUSERC (an electrical standardization coalition) specifications. Super Blue Pennant 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.



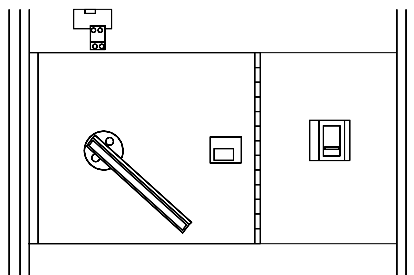
Metering compartment

The metering compartment has provisions for mounting a utility meter on the door. Super Blue Pennant uses hot sequence metering. Incoming power is connected to the main lugs.



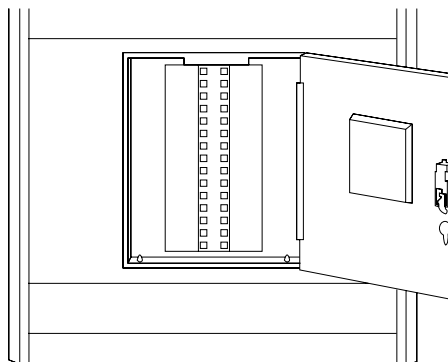
Service disconnect

The service disconnect can be a fusible Vacu-Break switch through 200,000 AIC, or a circuit breaker with a maximum rating of 65,000 AIC at 240 volts and 35,000 AIC at 480 volts.



Distribution panel

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

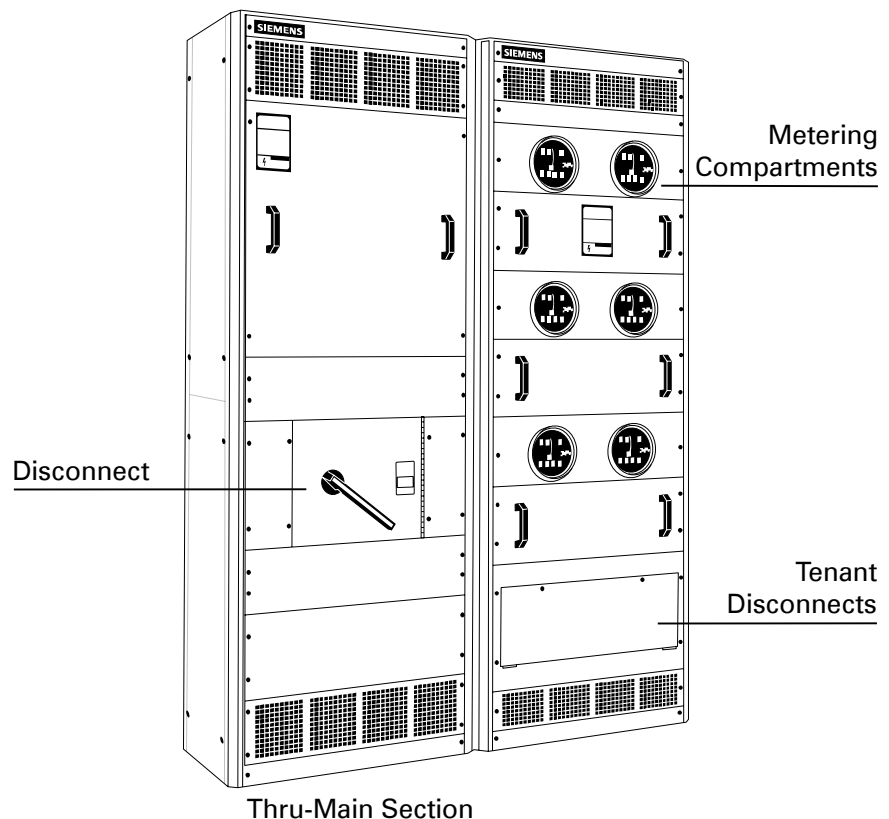


Commercial Metering Switchboards

Commercial metering switchboards are designed for commercial applications where multi-metering is required. These applications include shopping centers, office buildings, and other commercial buildings with multiple tenants.

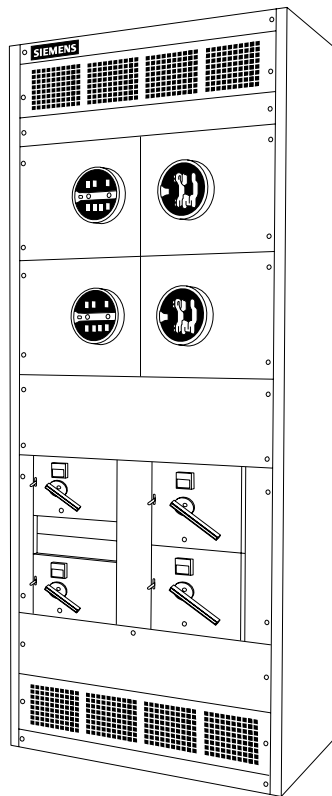
Type SMM switchboards

Type SMM switchboards are designed to meet west coast utility and EUSERC specifications. The switchboard main service is rated up to 4000 amps at 480 volts. Service mains can be circuit breakers (up to 2000 amps), insulated case circuit breakers (up to 3000 amps), bolted pressure switches (up to 4000 amps), or Vacu-Break[®], and HCP fusible switches (up to 1200 amps). Tenant mains, rated at 100 and 200 amps, are interchangeable. Tenant mains can be circuit breakers, fusible switches, or T-fuse pullouts. The bus is braced for 65,000 amps. Higher bracing is available as an option. Metering sockets are rated for 200 amps continuous duty. The Type SMM switchboard shown below has a thru-main section.



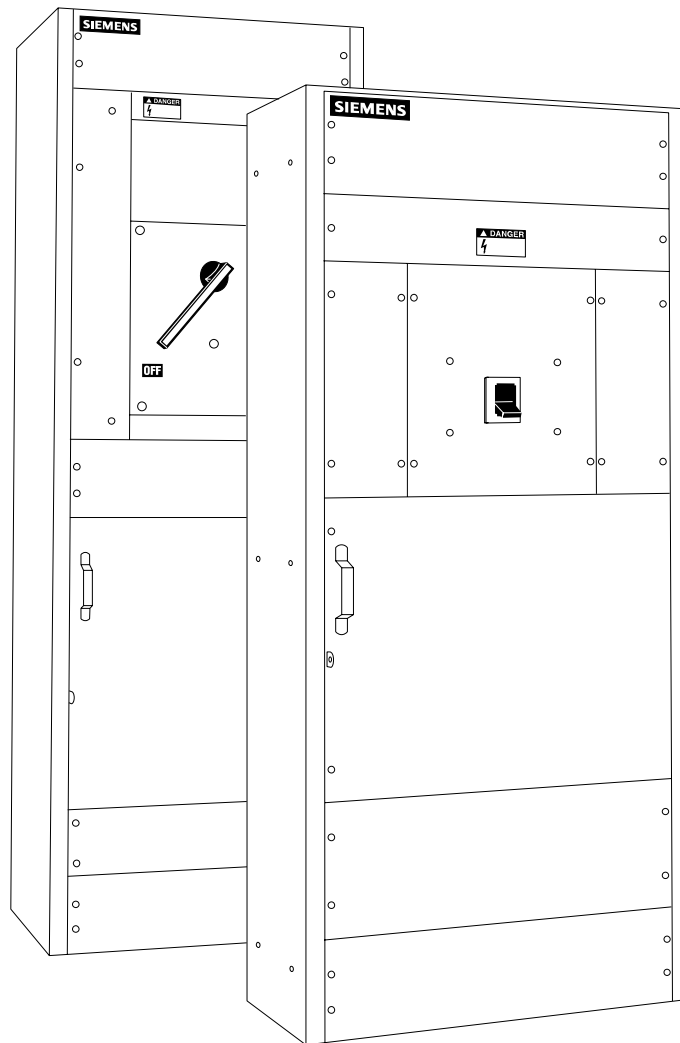
Type MMS switchboards

The MMS switchboard is similar to the SMM, however, it is not designed to meet west coast specifications. The main service is rated up to 4000 amps. Service mains can be circuit breakers (up to 2000 A), insulated case circuit breakers (up to 4000 A), bolted pressure switches (up to 4000 A), or Vacu-Break fusible switches (up to 1200 A). Tenant mains, rated at 100 and 200 amps, are interchangeable. Tenant mains can be circuit breakers, fusible switches, or T-fuse pullouts. All meter sockets are rated at 200 amps. Wiring is for 100 amps or 200 amps, depending on the tenant main device. Depending on the tenant main device, MMS switchboards are available with 2, 3, 4, or 6 sockets. The bus is braced for 50,000 amps. Higher bracing is available as an option.



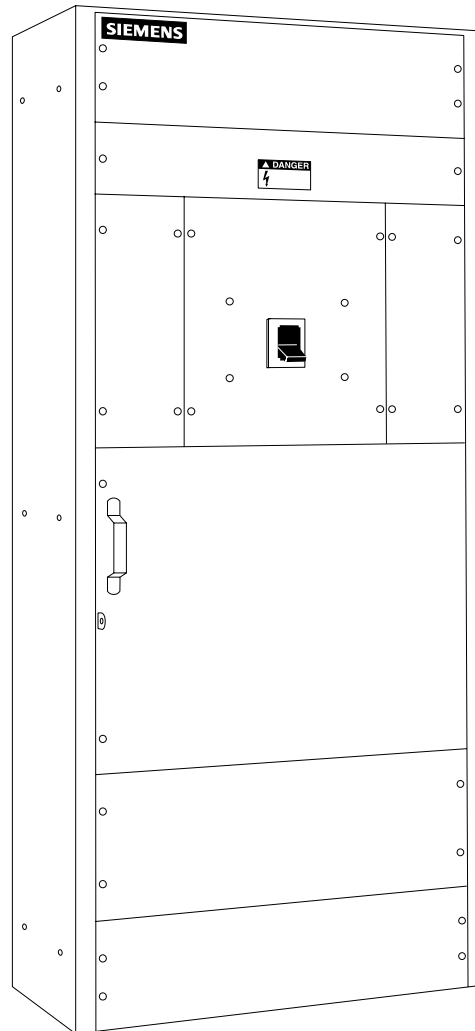
Speciality Service Entrance Switchboards

Specialty service entrance switchboards can be used in various applications. A specialty service entrance switchboard may, for example, be placed ahead of a main switchboard. The specialty switchboard serves as the disconnect for the main switchboard. Specialty service entrance switchboards are available with a single molded case circuit breaker, Vacu-Break[®] fusible switch, or bolted pressure switch (not shown).



BCT service cubicle

BCT service cubicles use molded case circuit breakers. They are available in current ratings from 400 - 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.

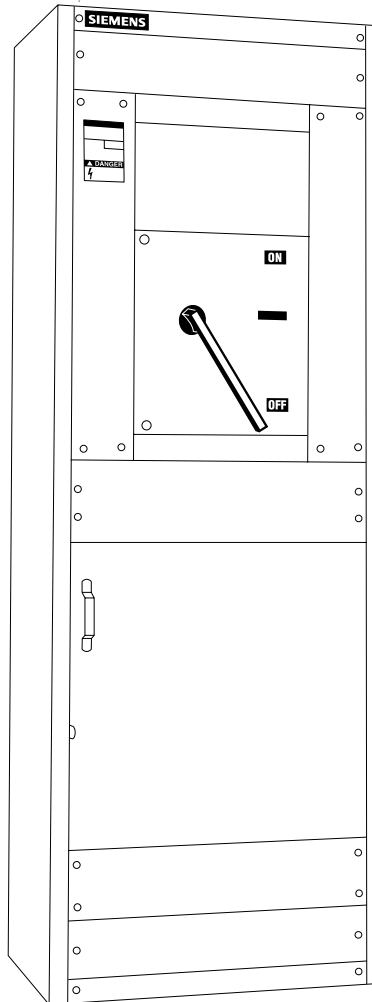


SCT service cubicle

SCT service cubicles use Vacu-Break[®] fusible switches. They are available with the following current ratings:

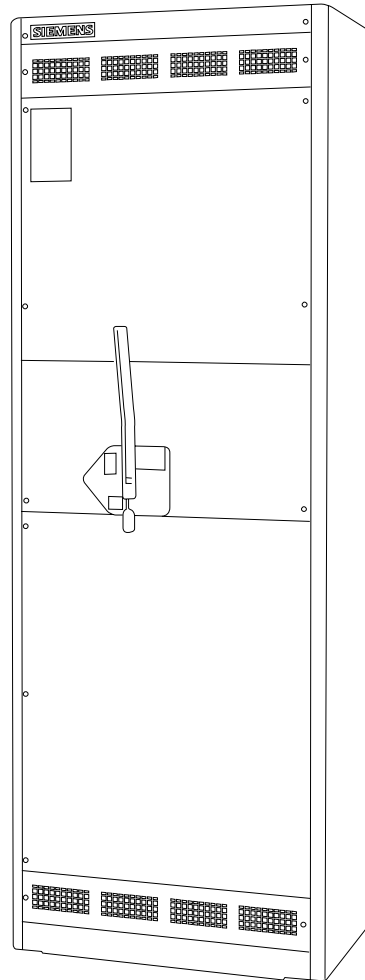
120/240, 480 Y/277 volts	400, 600, and 800 amps
208 Y/120, 240, 480, 600 volts	600 and 800 amps
208 Y/120, 240 volts	800 and 1200 amps

SCT service cubicles use cold sequence metering. Hot sequence metering is available.



Enclosed bolted

Enclosed bolted pressure switch specialty switchboards can be used when metering is not required and are available with top or bottom feed. The following drawing illustrates a top feed enclosed bolted pressure switch. Current ratings are available from 800 - 4000 amps.



Information Needed To Order Switchboards

When ordering a switchboard several questions need to be answered.

1. What are the power system specifications (voltage, phases, number of wires)?
2. What is the AIC rating (ampere interrupting capacity)?
3. Will full or series rated be required?
4. What is the NEMA Type enclosure desired?
5. How many circuits are required?
6. What types of overcurrent protective devices (MCCB, ICCB, Vacu-Break[®] fusible switch, bolted pressure switch) are required?
7. Does the switchboard need to be suitable for service entrance?
8. What amperage is the switchboard rated at?
9. Will the switchboard be top or bottom fed?
10. Will the switchboard be hot or cold metering?
11. What will the alignment be?
12. What type of bus material is required (temperature/density)?
13. What special modifications are needed (serial communications, pull sections, corner sections)?

Review 6

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. Super Blue Pennant switchboards are rated up to _____ amps with a circuit breaker and _____ amps with a Vacu-Break® fusible switch.
6. Up to _____ branch circuit provisions are available in the distribution panel of the Super Blue Pennant switchboard.
7. The type of commercial metering switchboard used on the west coast is Type _____ .
8. The type of specialty service entrance switchboard that uses a molded case circuit breaker as a main disconnect is a Type _____ service cubicle.
9. The type of specialty service entrance switchboard that uses a Vacu-Break fusible switch as a main disconnect is a Type _____ service cubicle.

Review Answers

- Review 1** 1) 120; 2) 277; 3) 100; 4) NEMA, UL; 5) 384.
- Review 2** 1) ampacity; 2) Time; 3) 200,000; 4) 90; 5) bus; 6) Splice; 7) through-bus.
- Review 3** 1) service, distribution; 2) pull box; 3) pull section; 4) 4300; 5) Hot sequence; 6) Cold sequence; 7) f; 8) distribution; 9) Rear aligned.
- Review 4** 1) 277; 2) 120, 208, 120; 3) service entrance; 4) six; 5) disconnect link.
- Review 5** 1) 1000; 2) Vacu-Break fusible switches; 3) 230-95; 4) Withstand; 5) Interrupting; 6) series-rated; 7) Ampere rating.
- Review 6** 1) rear; 2) 2000; 3) 4000; 4) 6000; 5) 800, 600; 6) 40; 7) SMM; 8) BCT; 9) SCT.

Final Exam

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

Questions

1. The requirements for switchboards are covered in *NEC*[®] Article _____.
 - a. 210
 - b. 318
 - c. 384
 - d. 770
2. Two causes of overcurrent are _____.
 - a. overloads and heat
 - b. overloads and short circuits
 - c. short circuits and heat
 - d. ground fault and heat
3. The AIC rating of a Class R fuse is _____ amps.
 - a. 10,000
 - b. 50,000
 - c. 100,000
 - d. 200,000
4. The standard height of a Siemens switchboard is _____ inches.
 - a. 32
 - b. 38
 - c. 72
 - d. 90
5. The correct NEMA phase sequence for a vertical bus, as viewed from the front, left to right is _____.
 - a. A-B-C
 - b. A-C-B
 - c. C-A-B
 - d. C-B-A

6. Two adjoining switchboard sections are connected together with _____ .
- a. vertical bus bars b. compression lugs
 - c. splice plates d. cross bus
7. A _____ is used when cables fed from the bottom of a switchboard need to be routed to the top of the switchboard.
- a. service section b. pull section
 - c. pull box d. distribution section
8. _____ is when power is still applied to the utility meter when the service main is switched off.
- a. Hot sequence b. Cold sequence
 - c. Top feed d. Bottom feed
9. A switchboard with a service section that is deeper than the distribution section would be _____ aligned.
- a. front b. rear
 - c. front and rear d. front or rear
10. On a three-phase, four-wire, wye-connected transformer with a secondary voltage of 480 volts phase-to-phase, the phase-to-neutral voltage is _____ volts.
- a. 138 b. 240
 - c. 277 d. 480
11. On a three-phase, four-wire, B phase high leg, delta connected transformer delta-connected transformer the high leg is _____ .
- a. A - N b. B - N
 - c. C - N d. A - B
12. The maximum number of switches or circuit breakers used to disconnect and isolate the service from all other equipment on service-entrance equipment is _____ .
- a. 1 b. 2
 - c. 4 d. 6

13. The neutral conductor is _____ grounded at the service-entrance switchboard.
- a. always
 - b. never
 - c. rarely
 - d. often
14. All main protective devices, except _____, can be equipped with ground fault relays to comply with *NEC*[®] requirements.
- a. Molded case circuit breakers
 - b. Vacu-Break fusible switches
 - c. Insulated case circuit breakers
 - d. Bolted pressure switches
15. The _____ is a removable link that isolates the neutral bus from, the grounded neutral bus.
- a. neutral disconnect link
 - b. ground bus bar
 - c. vertical neutral bus
 - d. horizontal neutral bus
16. Article 230-95 of the *NEC*[®] states that *ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase for each service disconnecting means rated _____ amperes or more.*
- a. 5 milliamps
 - b. 10 amps
 - c. 1000 amps
 - d. 200,000 amps
17. The rating which refers to the level of short circuit fault current a piece of equipment can withstand without sustaining damage is the _____ rating.
- a. interrupting
 - b. full
 - c. ampacity
 - d. withstand
18. The SB2 contains through-bus ratings up to _____ amps.
- a. 1200
 - b. 2000
 - c. 4000
 - d. 6000

19. The maximum rating for an insulated case circuit breaker used as a main device for an RCIII switchboard is _____ amps.
- | | | | |
|----|------|----|------|
| a. | 1200 | b. | 2000 |
| c. | 3000 | d. | 5000 |
20. Super Blue Pennant switchboards are rated up to _____ amps with a fusible Vacu-Break switch main.
- | | | | |
|----|------|----|------|
| a. | 600 | b. | 800 |
| c. | 1200 | d. | 2000 |

Notes

Notes