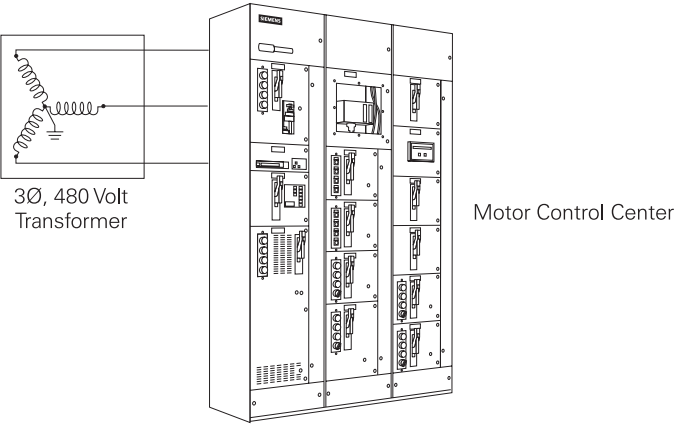


MCC Ratings

In addition to the various ratings of individual components used in motor control centers, the overall ratings of the motor control center must also be considered.

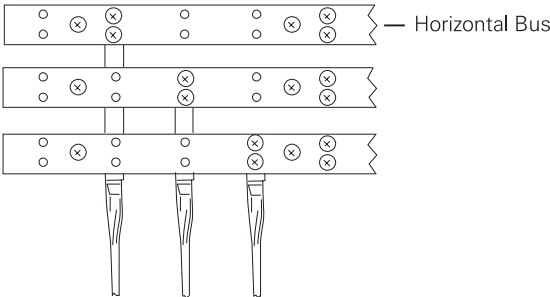
Voltage Rating

Motor control centers are rated for 600 volts. This is the maximum voltage that can be applied to a motor control center. A motor control center can be connected to a lower voltage. A motor control center, for example, might be connected to a three-phase, 480 VAC power supply.



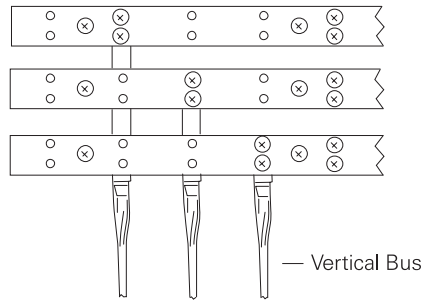
Horizontal Bus Current Rating

The horizontal bus on Siemens motor control centers are made of tin or optional silver plated copper. They are available with 600A, 800A, 1200A, 1600A, and 2000A current ratings.



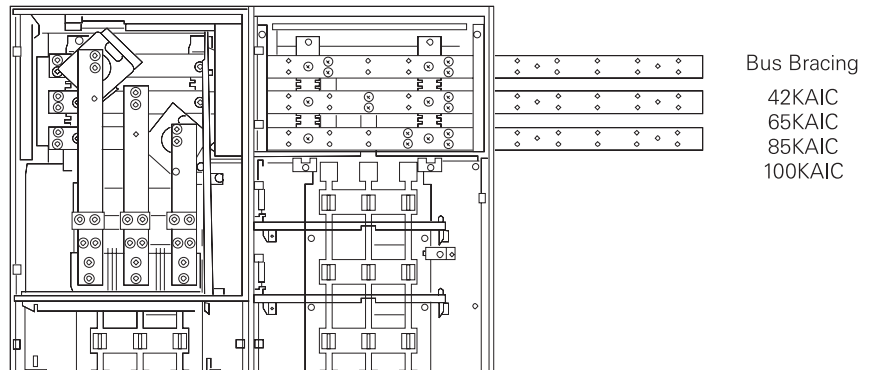
Vertical Bus

The vertical bus on the TIASTAR motor control centers are available with 300A and 600A ratings.



Bus Bracing

Motor control centers must be capable of withstanding the largest potential short-circuit current which can occur in the selected application. The amount of short-circuit current available depends on the amount of power available to a facility. Short-circuit current can be thousands of times higher than normal current. Bus bars must be braced to withstand this potential current. Siemens bus bars are braced for 42,000 AIC (ampere interrupting capacity) with optional bracing available to 100,000 AIC.

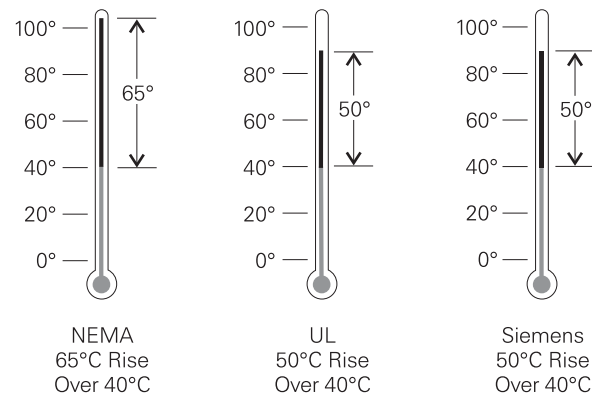


Temperature Rise

The bus bars are the major current carrying component of the motor control center. Before a motor control center is operated, bus bars are at the temperature of the surrounding air. This is known as ambient temperature. Temperature rises in the motor control center bus bars during operation. The combination of ambient temperature and allowed temperature rise equals the maximum temperature of the bus bars.

NEMA and UL both have standards concerning the maximum temperature rise of bus bars used in motor control centers. NEMA limits temperature rise to 65°C based on an ambient temperature of 40°C (104°F), for a maximum operating temperature of 105°C. UL limits temperature rise to 50°C based on an ambient temperature of 40°C (104°F), for a maximum operating temperature of 90°C. Electrical equipment bearing a UL mark must meet or exceed this standard.

Siemens motor control centers meet or exceed NEMA and UL standards. Bus bars in Siemens motor control centers are tested with a maximum temperature rise of 50°C over 40°C (104°F) ambient.



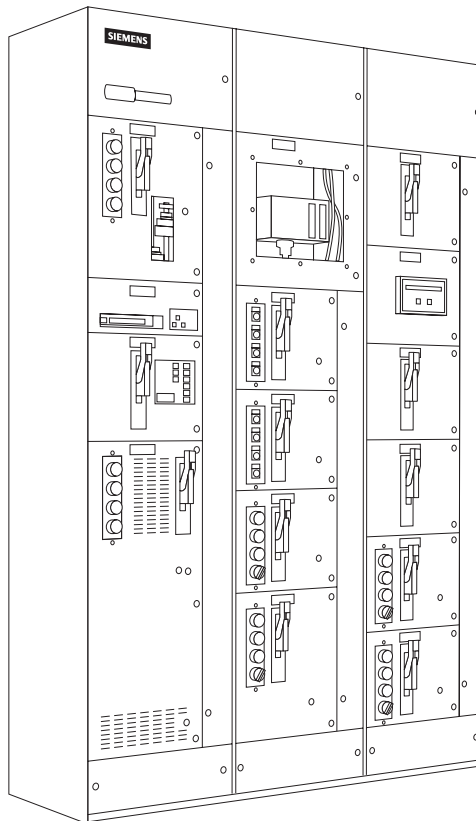
Enclosures

NEMA defines an enclosure as *a surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions* (NEMA Standard 250 - section 2, definitions).

The following brief descriptions cover enclosures available for Siemens motor control centers.

Type 1 Enclosure

Type 1 enclosures are intended for indoor use primarily to provide protection against limited amounts of falling dirt and contact with the enclosed equipment in locations where unusual service conditions do not exist.



Type 1 Gasket Front

Type 1 gasketed front, general purpose, indoor enclosure has the same use as Type 1 except the front of the enclosure is gasketed. In addition the following parts are gasketed:

- Unit separator angles
- Right-hand side of front of units
- Bottom horizontal cross ties
- Lip on top plate
- Pilot-device panel
- Handle mechanism
- Bottom horizontal wireway cover plate
- Side holes are plugged

Type 2, Drip-Proof

Type 2, drip-proof is an indoor enclosure intended to protect equipment from falling noncorrosive liquids and dirt. The enclosure prevents the entrance of dripping liquid at a higher level than the lowest live part within the enclosure. This design is a Type 1 gasketed front, or Type 12, with a drip shield mounted on top of the enclosure.

Type 12 Enclosure

Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids. They are not intended to provide protection against conditions such as internal condensation.

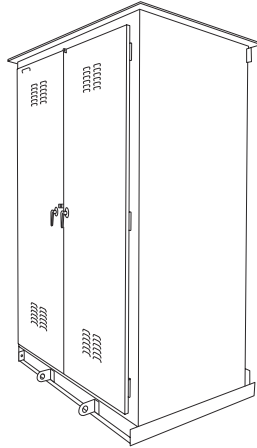
The Type 12 will provide a greater degree of protection than a Type 1 gasketed enclosure. The following additional parts are gasketed:

- Hinged side of doors
- Top plates
- Wireway end-covers
- Rear plates

There is no gap between sections, allowing for much greater dust resistance. In addition, interconnection holes in the side sheet assemblies are sealed. Bottom plates are included.

Type 3R Enclosure

Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain and sleet and protection from contact with the enclosed equipment. They are not dust, snow, or sleet (ice) proof. They will prevent entrance of rain at a level higher than the lowest live part. The enclosure has provisions for locking and drainage.



The enclosure entirely surrounds the motor control center for outdoor operation. The Type 3R enclosure is designed to accommodate bottom cable entry and exit only. The 3R enclosure is not a walk-in type design.

NEMA and IEC

The International Electrotechnical Commission (IEC) is another organization that defines the degree of protection provided by enclosures. NEMA is primarily associated with equipment used in North America. IEC is associated with equipment sold in many countries including the United States.

The IEC designation consists of the letters IP followed by two numbers. The first number indicates the degree of protection provided by the enclosure with respect to persons and solid objects entering the enclosure. The second number indicates the degree of protection against the ingress of water. The following chart provides an equivalent conversion between NEMA and IEC designations.

NEMA	IEC
1	IP10
2	IP11
3R	IP14
12	IP52

Classification and Types of Wiring

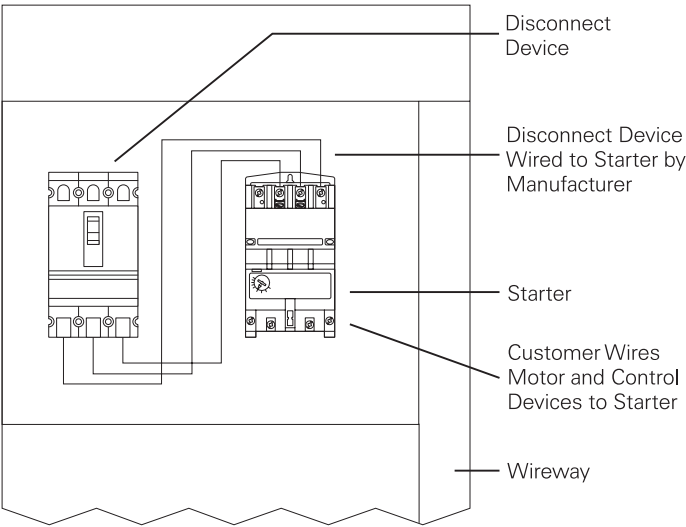
NEMA has established two classification standards (Class I and Class II) and three types of wiring (A, B, and C) used in the construction of motor control centers. These are specified by the customer.

Class I

Class I consists of a grouping of combination motor control units in which each starter and motor operates independently of the other starters. The factory connects the combination motor control units to the vertical bus but does not provide interconnecting wiring between combination motor control units, different vertical units, or remotely connected devices. Diagrams of the individual units only are supplied.

Class I, Type A Wiring

Type A wiring is only available on Class I motor control centers. The motor control center manufacturer connects the combination motor control unit to the vertical bus via the stabs on the back of the unit. Power is applied to the circuit breaker from the vertical bus. The circuit breaker is factory wired to the motor starter. The customer connects the motor leads and control wiring to the motor starter. There is no interconnecting wiring between combination motor control units.

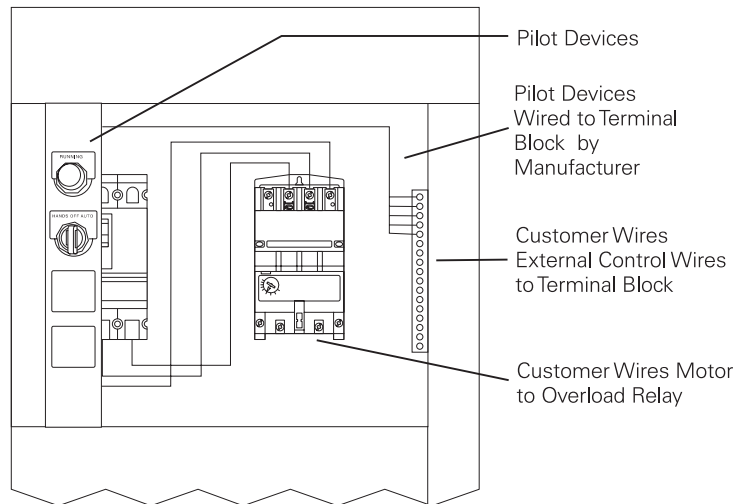


Vertical Section

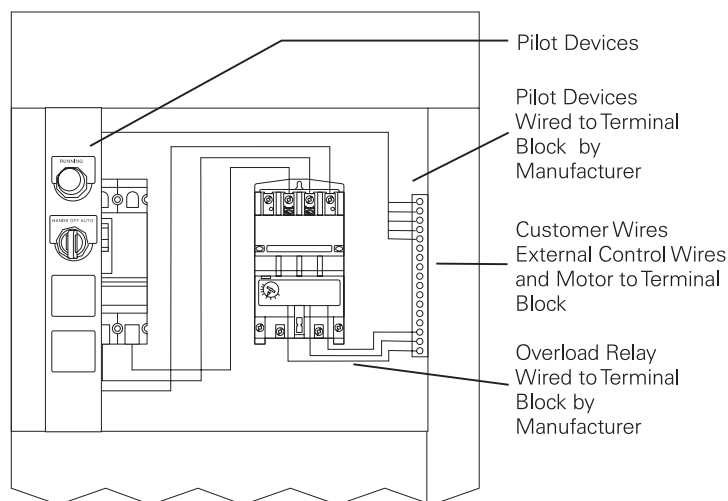
Class I, Type B Wiring

Typically pilot devices, such as indicator lights, pushbuttons, and selector switches, are used with Class I, Type B wiring. Type B wiring is divided into two designations: B-d (-d for connection of load wires directly on starter or contactor terminals) and B-t (-t for connection of load wires to unit mounted load terminal blocks).

When Type B-d wiring is specified, terminal blocks are furnished near the wireway for control circuit connections. Motor leads are connected directly to the overload relay terminals.

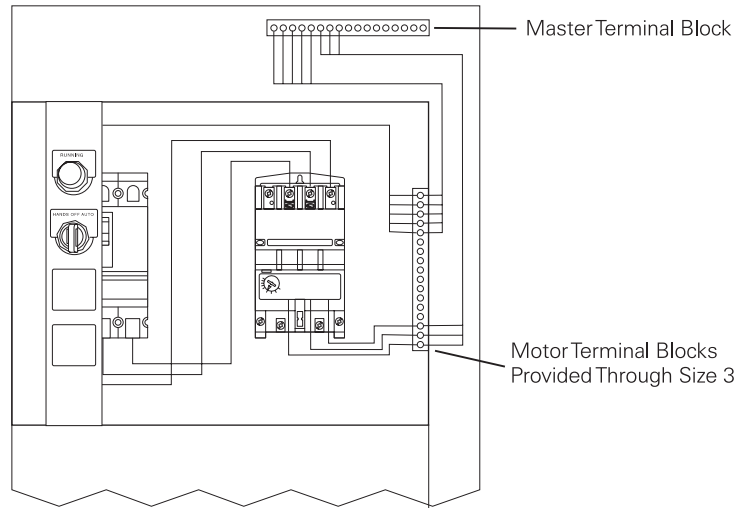


When Type B-t wiring is specified, terminal blocks are furnished near the wireway for control circuit connections and for motor starter leads. Type B-t wiring can be used on starters up to size 3.



Class I, Type C Wiring

With Type C wiring, a master terminal block is provided in either the top or bottom horizontal wiring gutter. The manufacturer of the motor control center brings the control wires from each control unit to the master terminal block. The installer is then able to make his wiring connections at the master terminal block. With Type C wiring, load wiring for combination motor control units smaller than size 3 (50 HP) are connected to the master terminal block. Load wiring for combination motor control units larger than size 3 are connected directly to unit device terminals..

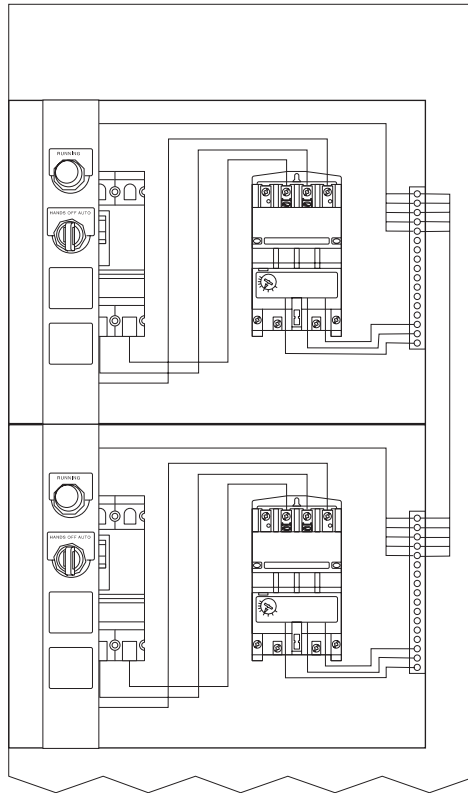


Class II

Class II consists of a grouping of combination motor control units with interwiring and interlocking between the starters to form a complete control system. Wiring diagrams, including the interwiring, is furnished. Class II is generally specified when a group of motors requires sequencing, interlocking, or interconnecting.

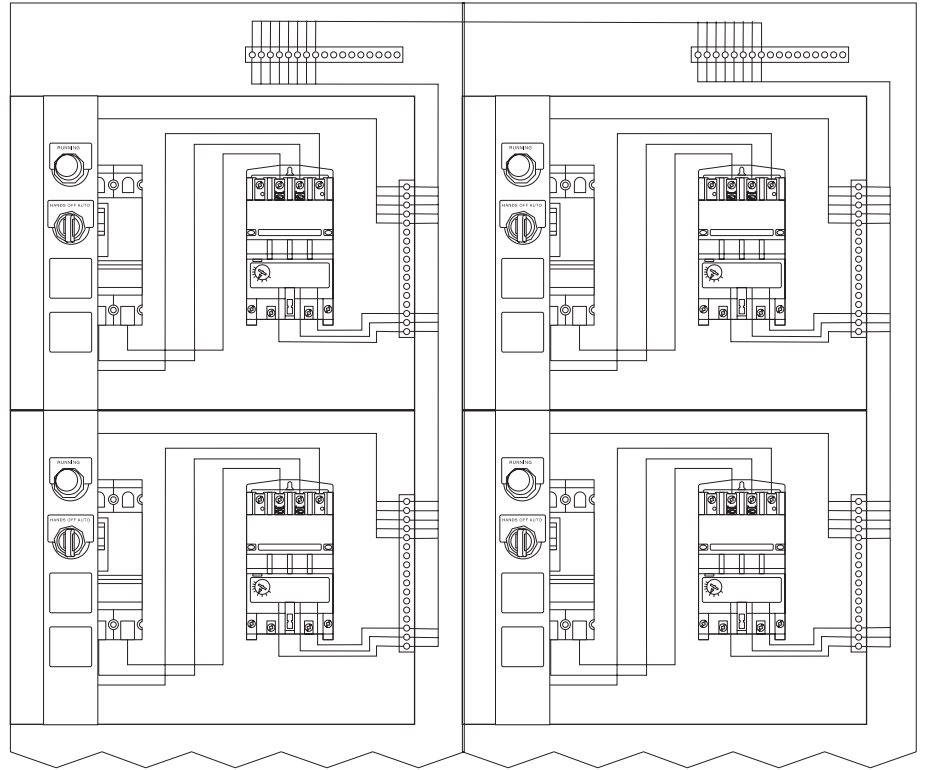
Class II, Type B

Class II, Type B wiring is similar to Class I, Type B wiring. Terminal blocks are furnished near the wireway. In addition, Class II, Type B wiring includes interconnecting wiring between motor starters.



Class II, Type C

Class II, Type C wiring is similar to Class I, Type C wiring. In addition, Class II, Type C wiring includes interconnecting wiring between motor starters and vertical sections.



Reference Chart

The following chart provides a handy reference when determining the class and type of wiring used in motor control centers.

Description	Class I Types				Class II Types		
	A	B-d	B-t	C	B-d	B-t	C
Terminals Required For all Control Connections For Starter Load Connections Sizes 1 through 3 ^①		✓	✓	✓	✓	✓	✓
Terminals Mounted On Control Unit In Master Terminal Compartment ^②		✓	✓	✓	✓	✓	✓
Interwiring Between Units in the same MCC					✓	✓	✓
Diagram Connection for each Starter or Control Unit Elementary and Interconnection of Complete MCC	✓	✓	✓	✓	✓	✓	✓
Other Drawings Overall Dimensions of MCC Location of Terminals in Master Terminal Compartment	✓	✓	✓	✓	✓	✓	✓ ^③

① No load terminals furnished for starters sizes 3½ through 6, main or branch circuit breaker or fusible switches, distribution transformers or lighting panelboards.

② Located at top or bottom of each section and wired to the various parts.

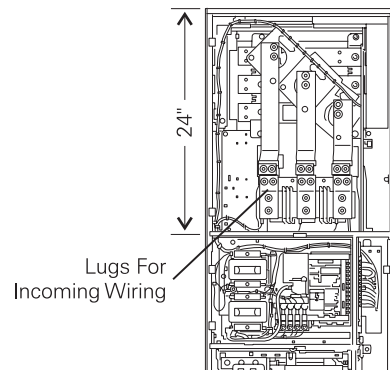
③ Included on motor control center interconnection diagram.

Cable Entry

There are several ways incoming power can be terminated in a motor control center. Cable can be routed directly to the incoming power lugs, to main breakers or disconnects, or to a terminal block in a vertical section. In addition, incoming power cables can enter and exit the motor control center from the top or bottom depending on the application.

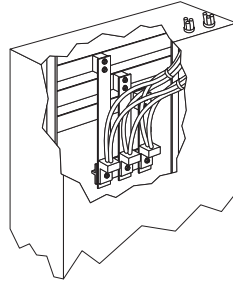
Main Lugs

When using main lugs the amount of vertical space required varies with the amperage rating. When the main lugs are located on the top, as in the following illustration, the vertical space is taken at the top. A motor control center can also have the lugs located at the bottom of the MCC. In the following illustration, for example, main lugs rated for 600 amps are located on the top of the MCC. In this example 24" of vertical space is required.



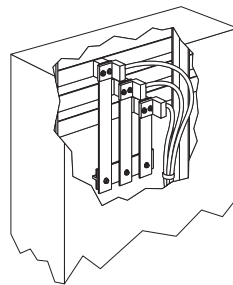
**Main Lugs on Top,
Top Entry**

In the arrangement illustrated below incoming power cables enter through the top of a vertical section and are connected to main lugs.



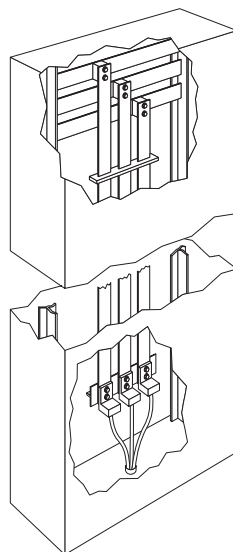
**Main Lugs on Top,
Bottom Entry**

Incoming cables can also enter from the bottom and connect to main lugs located in the top section.



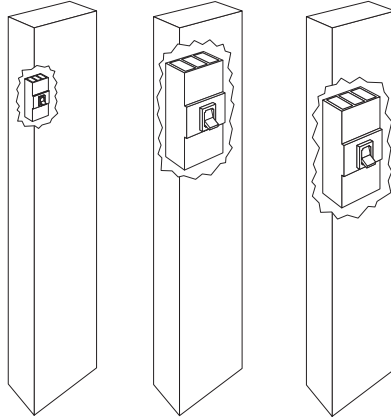
**Main Lugs on Bottom,
Bottom Cable Entry**

Lugs can also be supplied on the bottom of the vertical bus for bottom cable entry.

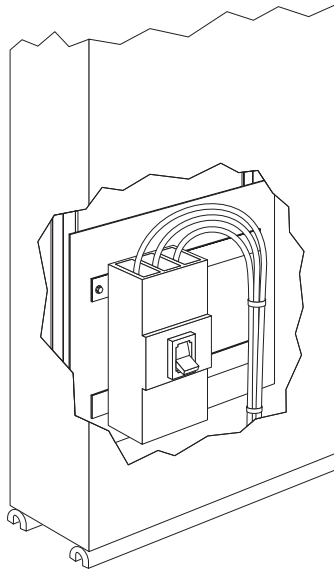


Disconnect Device

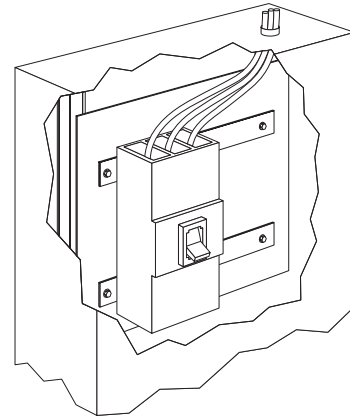
When a main disconnect device, such as a circuit breaker or fusible disconnect, is used, the disconnect is mounted in its own unit. The amount of space required depends on the disconnect used. The space can vary from 12" to 72"



In the following illustration a main circuit breaker is used. Cable entry can be from the top or bottom of the vertical section.



Bottom Entry

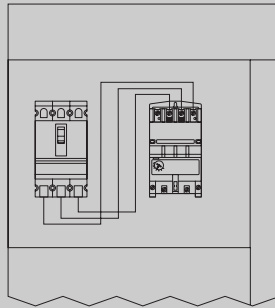


Top Entry

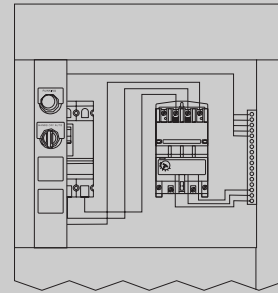
Review 5

1. The maximum current rating for a horizontal bus on Siemens motor control center is _____ amps.
2. The maximum bus bracing available for a Siemens motor control center is _____ AIC.
3. The IEC equivalent of a NEMA Type 3R enclosure is _____ .
4. Identify the following types of Class I wiring:

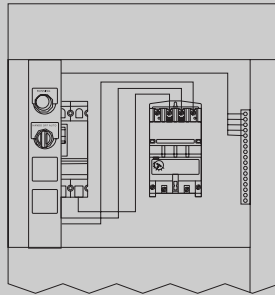
a. _____



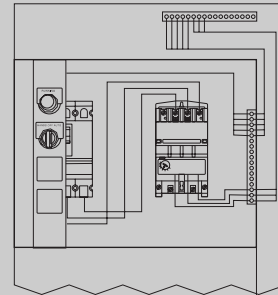
b. _____



c. _____

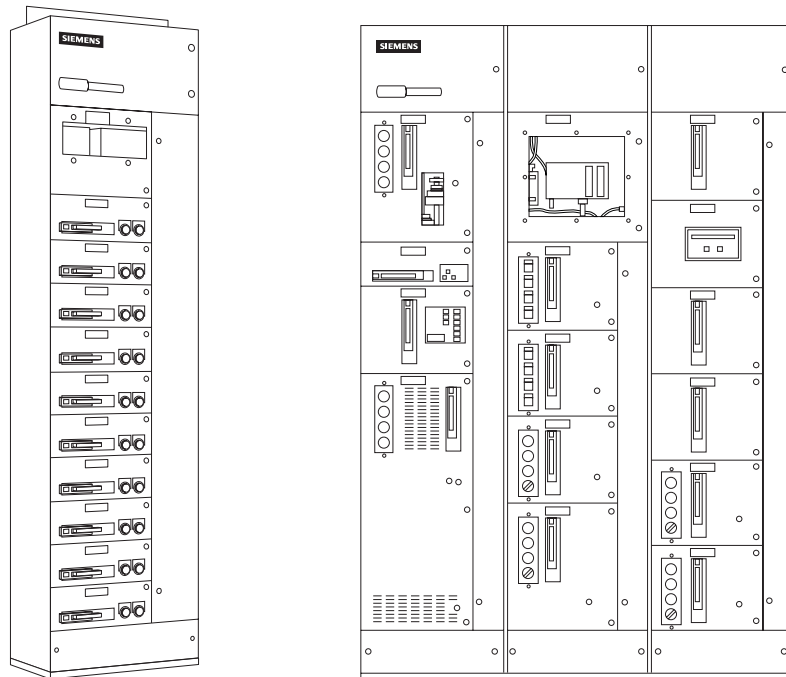


d. _____



TIASTAR

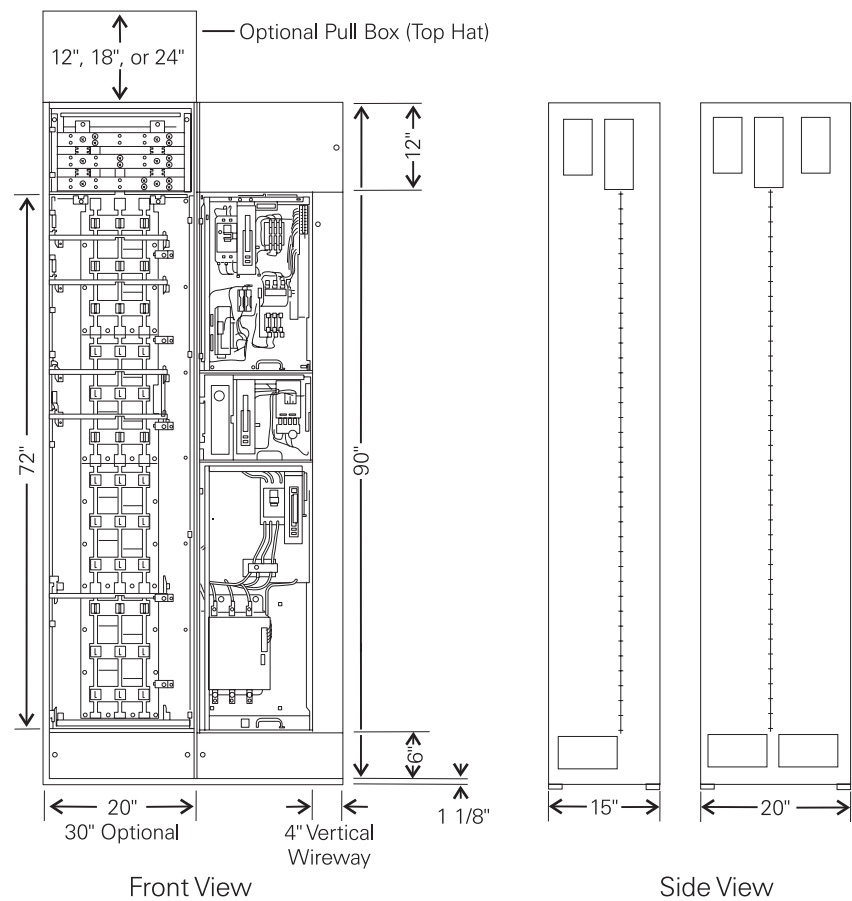
TIASTAR™ is trade name of the motor control centers that Siemens manufactures. Several mechanisms and features have been designed into TIASTAR. Many of these features will be discussed in this section.



Dimensions

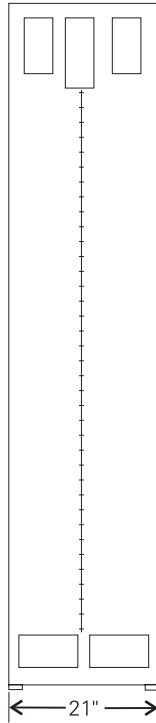
The nominal height of TIASTAR is 90" high. The overall height is 91 1/8" including a standard 1 1/8" base channel. There are 72" of vertical space available for combination motor control units, with 12" at the top and 6" at the bottom for wiring. The horizontal power bus is located in the 12" of top space making it easier to service. Each vertical unit will hold up to six 12" units (6 x 12 = 72). An optional pull box (top hat) can be supplied when extra wire-bending space is required. Pull boxes can be 12", 18", or 24" high.

Vertical structures are 20" wide. A 30" wide unit is available for special units, such as large AC drives or transformers that require more space. The vertical wireway is 4" wide on 20" wide sections. An optional 8"-wide wireway is available on 20" wide sections. Vertical units can be 15" or 20" deep.

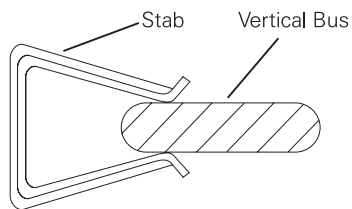


Back-to-Back Mounting

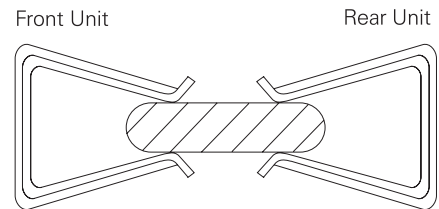
A feature of TIASTAR motor control centers is the ability to mount combination motor control units back to back. This permits mounting 12 combination motor control units in 72" of vertical space. TIASTAR vertical units designed for back-to-back mounting are 21" deep.



Back-to-back combination motor control units use the same stab-on connection as front mounted units.



Front Mounted Unit Only



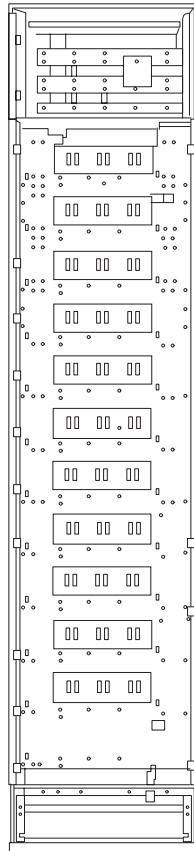
Back-to-Back Mounted Units

Basic Construction

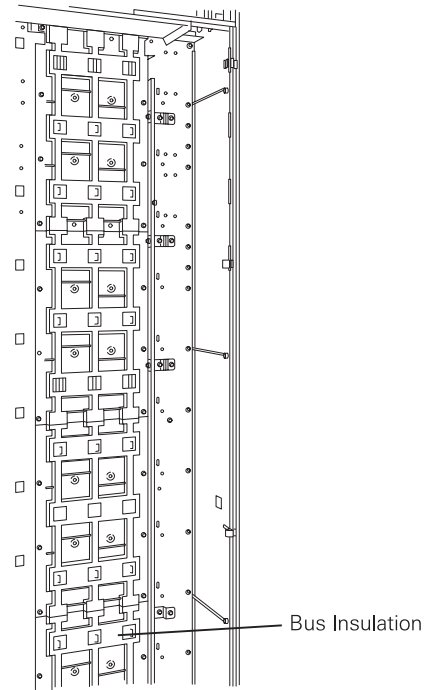
TIASTAR motor control centers offer two vertical bus designs. Front only structures with 42K or 65K bus bracing are supplied with an insulated vertical bus design standard. The vertical bus bars are not physically isolated phase-to-phase.

An optional isolated and insulated vertical bus assembly is available for front only 42K and 65K bus bracing. The isolated and insulated vertical bus design is standard for 100K bus bracing and all back-to-back structures.

Combination motor control units can be interchanged and are easily rearranged on either bus assembly. The unit support brackets can be repositioned to accommodate various size units.



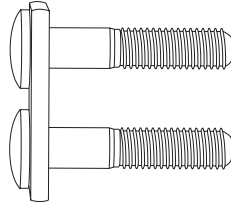
Standard Insulated Vertical Bus



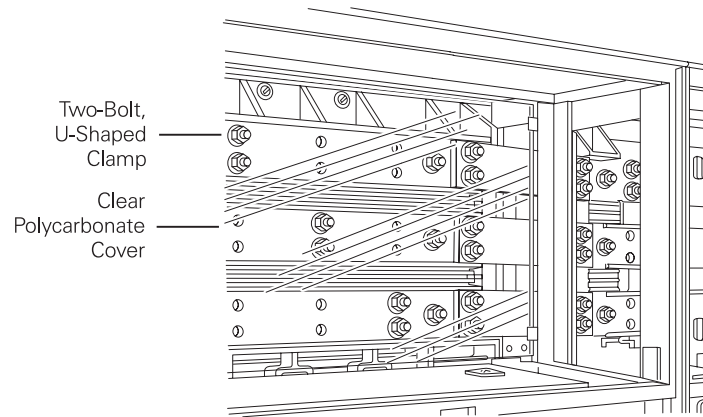
Optional Isolated and Insulated Vertical Bus

Horizontal Bus

The horizontal bus is connected to the vertical bus with a two-bolt, U-shaped clamp utilizing spring washers to maintain torque. This allows the bolts to be tightened from the front.

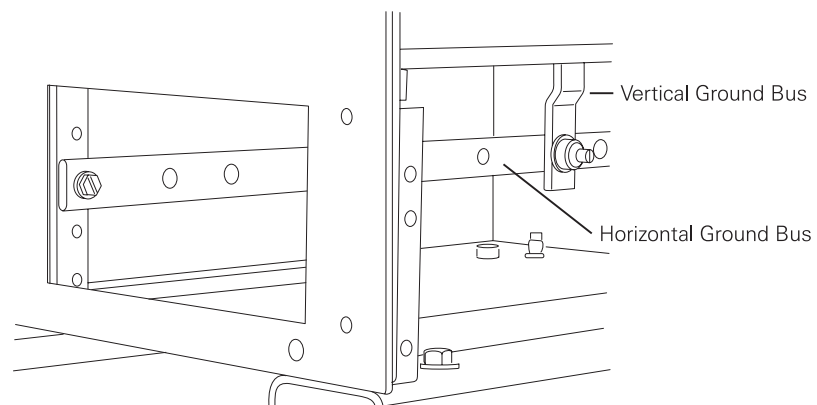


Horizontal bus bars are shielded by a clear polycarbonate cover for safety and easy visibility for inspection.



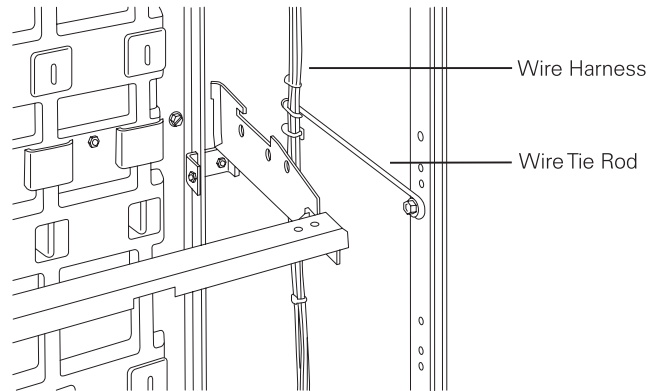
Ground Bus

A horizontal ground bus is mounted in the bottom 6" of space. The horizontal ground bus is standard. An optional vertical ground bus can be connected to the horizontal bus. When a combination motor control unit is inserted into the MCC the vertical ground bus is the first item engaged. Likewise, when the unit is removed the vertical ground bus is the last thing to be disengaged.



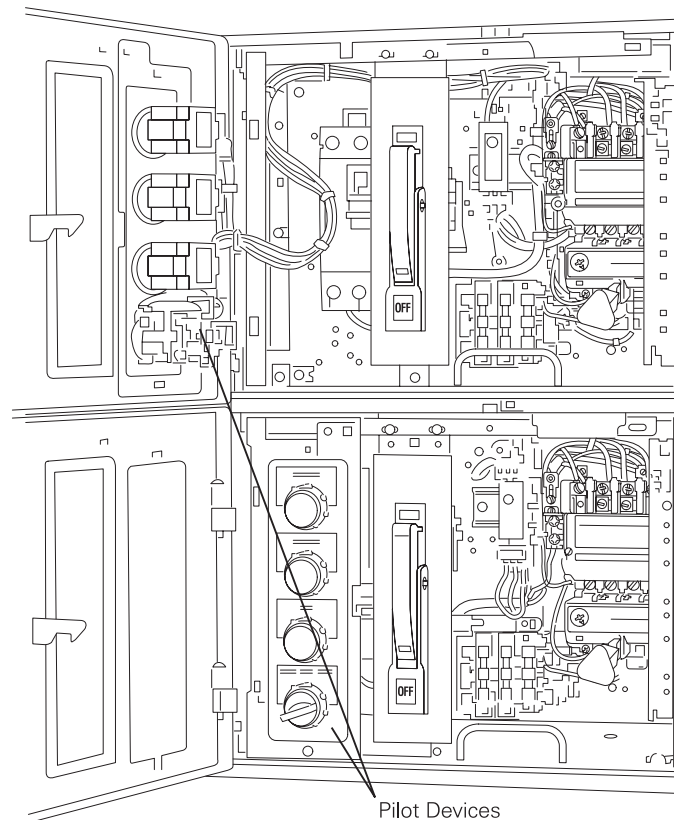
Wire Tie Rods

Round wire tie rods are located in each vertical wireway to hold wire harnesses in place.



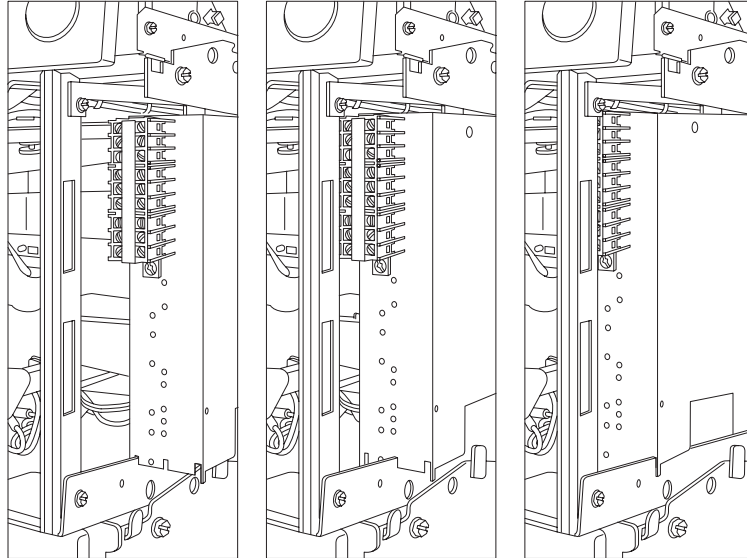
Pilot Devices

Pilot devices are mounted on a panel which latches onto the unit door with a simple tab-and-notch mechanism. The pilot-device panel can be removed from the door and attached to the combination motor control unit for service or unit removal. There is room for four 30mm pilot devices on the panel.



Terminal Blocks

Terminal blocks are supplied with Type B and C wiring. The terminal blocks are mounted up front on a swing-out side panel. The panel is notched so that the terminal block can be placed inside the unit, in a center position, or in the vertical wireway. This secures the terminals inside the unit when access is not required, or allows access from the vertical wireway. Pull-apart terminals are available as an option.



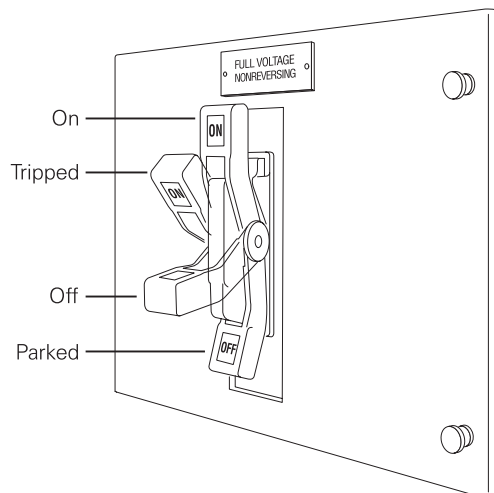
Terminal Block
in Vertical Wireway

Terminal Block
in Center Position

Terminal Block
in Control Unit

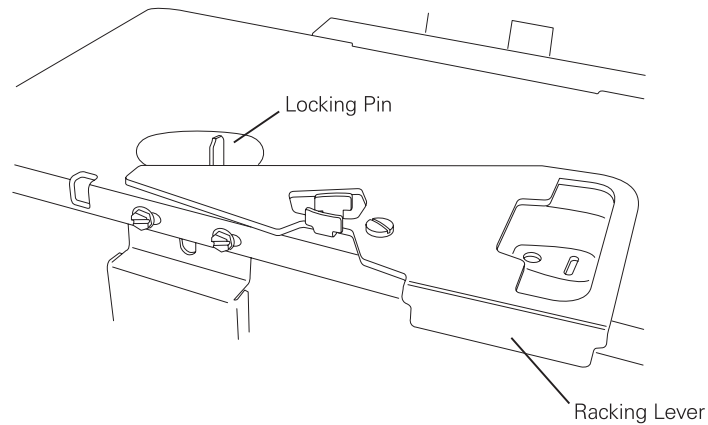
Operating Handle

The disconnect operating handle has four positions. When placed in the "PARK" position the unit door can be opened without the handle interfering. The "TRIPPED" position is clearly indicated.



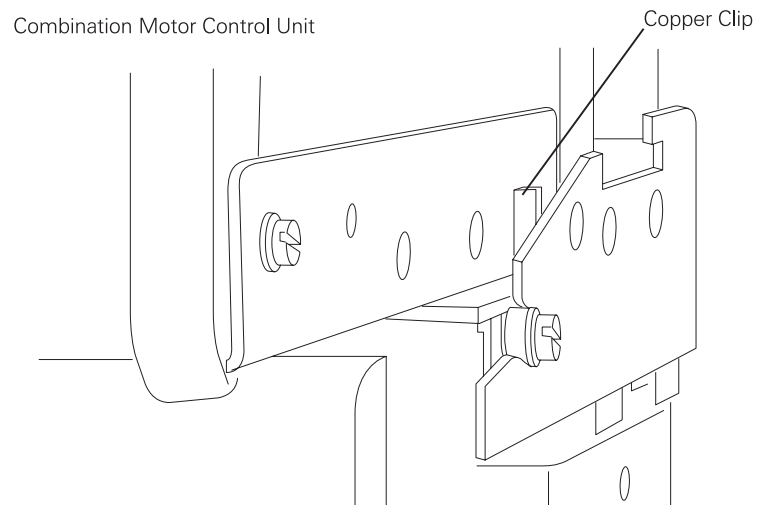
Racking Lever

A racking lever located on each combination motor control unit is used to remove or install the unit. When the operator handle is in the "ON" position, a locking pin blocks the racking lever closed. When the operator handle is switched to the "OFF" position, the locking pin disengages the racking lever. The combination motor control unit can be pulled to a test position. The operator handle is placed in "PARK" to completely remove the combination motor control unit. The unit is designed so that it cannot be inserted or removed with the operator handle in the "ON" position. In the test position the unit can be padlocked in place.



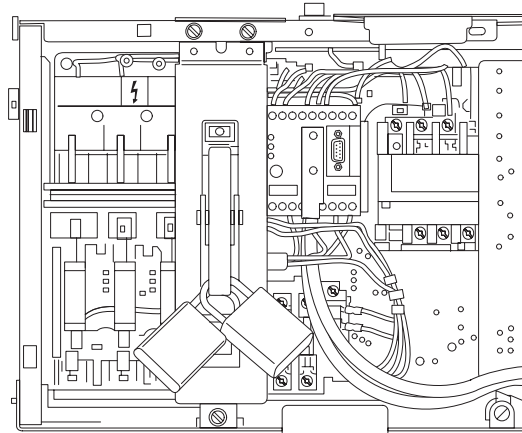
Ground Clip

A copper clip on the side of the combination motor control unit engages the unit support bracket, grounding the unit to the motor control center at all times. An optional vertical bus stab is mounted on the unit when a vertical ground bus is used.



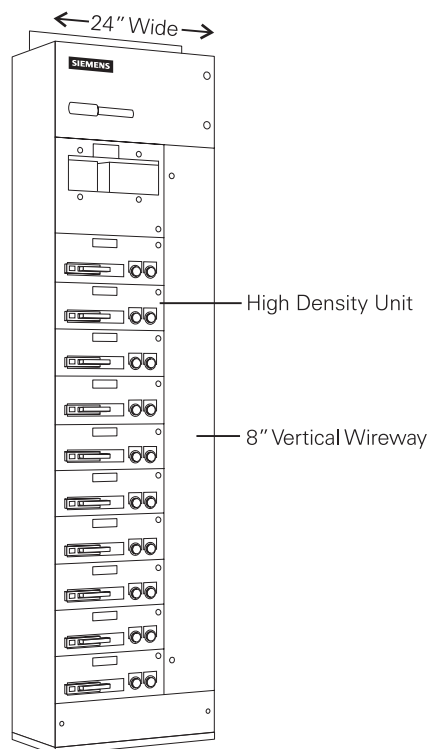
Locking

The disconnect operating handle can be locked in the "OFF" position with up to three padlocks.



High Density Units

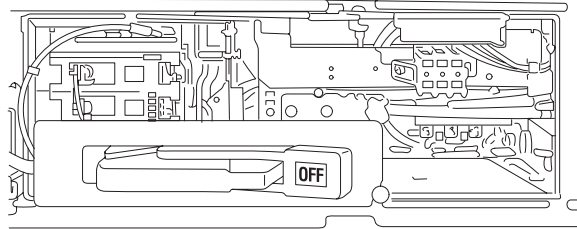
TI STAR is also available with high density units. High density units are 6" tall. A maximum of 12 high density units can be installed in 72" of vertical space. High density combination motor control units are available in NEMA size 0 (5 HP) and size 1 (10 HP). To compliment the high density unit, a 24" wide structure is available with an oversized (8" wide) vertical wireway. While the 24" wide structure allows for the increased quantity of wires typical of high density applications, they are not required when high density units are used.



Combination Units

High density units have many of the same features as the full size units. The disconnect operating handle is mounted sideways. When Type B or C wiring is specified, a swing-out terminal block is supplied.

The motor starter is located behind the terminal block. The circuit breaker is located behind the operator handle. A unique "swing out" feature permits components to swing out of the unit for easy inspection or maintenance.



Information Needed to Order MCCs

When ordering a motor control center several questions need to be answered. The following information will be useful.

- Voltage, frequency, number of phases, and available fault current of power supply
- Incoming power requirements (main circuit breaker, main fusible switch, main lugs only, or splicing to existing MCC)
- Amp rating of the horizontal bus and finish material (tin or silver)
- Voltage rating and source of control power
- Size, type (aluminum or copper), number per phase and location of incoming cables or busway and outgoing cables
- Enclosure
 - Type, finish
 - Accessibility (front, rear, or both)
 - Clearance for door swing
 - Restrictions on height, width, and depth
- Horsepower rating and motor design of motors to be controlled
- Ampacity of feeder tap units and unit disconnect devices
- Type of disconnect for units: thermal-magnetic, instantaneous trip, or fusible
- Ground bus requirements
- Types of starting method of combination motor-control units, such as FVNR, FVR, 2S1W, 2S2W, PW, or RVAT
- Type of control circuit for units

- Service entrance requirements
- Vertical bus requirements (finish, isolated/insulated, amp rating)
- Class and Type of wiring
- Additional equipment requirements (transformers, panelboards, transfer switches, PLCs, etc.)
- Preferred layout of units
- Special features, codes, or restrictions
- Customer specifications
- Drawing requirements

Review 6

1. The maximum height of an optional pull box for the TIASTAR is _____ inches.
2. A maximum of _____ high density units can be mounted in 72" of vertical space.
3. High Density units are available in NEMA size _____ and NEMA size _____ .
4. The horizontal power bus is located in the 12" of _____ space.
5. Isolated and insulated vertical bus design is standard for _____K bus bracing and all back-to-back structures.
6. Vertical space for the TIASTAR motor control center is _____ inches.
7. The horizontal ground bus for TIASTAR motor control centers is typically located in the _____ 6" of space.
8. TIASTAR back-to-back structures are _____ inches deep.

Review Answers

Review 1

1) d; 2) TIASTAR; 3) 3; 4) 2.

Review 2

1) Underwriters Laboratories; 2) National Fire Protection Association; 3) 200,000; 4) 430-94.

Review 3

1) B; 2) 80; 3) B; 4) A; 5) B.

Review 4

1) 10; 2) 3; 3) 200; 4) f; 5) SIRIUS and SIKOSTART.

Review 5

1) 2000; 2) 100,000; 3) IP14; 4) a=A, b=B-t, c=B-d, d=C

Review 6

1) 24; 2) 12; 3) 0 and 1; 4) top; 5) 100; 6) 72; 7) bottom; 8) 21.

Final Exam

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

Questions

1. _____ is the trade name for a Siemens motor control center.
 - a. SIKOSTART
 - b. INNOVA PLUS
 - c. SAMMS
 - d. TIASTAR

2. Article _____ of the *National Electrical Code*® requires overcurrent protection for MCCs.
 - a. 430.94
 - b. 240
 - c. ICS-1-322
 - d. 430.97

3. Which of the following is not a part of the NEMA definition for motor control centers?
 - a. Principally contains branch circuit protection
 - b. Floor-mounted assemblies
 - c. Common horizontal bus
 - d. One or more vertical sections

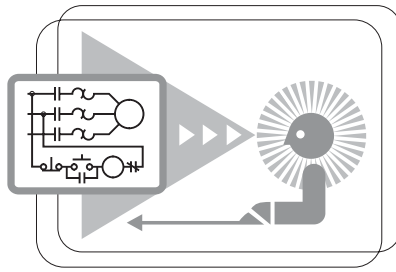
4. The standard height of a vertical section is _____ inches.
 - a. 72
 - b. 40
 - c. 90
 - d. 20

5. The maximum shipping width of a motor control center assembly is _____ inches.
- a. 60"
 - b. 80"
 - c. 90"
 - d. 120"
6. According to *NEC*® Article 430.97, there should be a minimum distance of _____ inch(es) of clearance between a live bus and ground.
- a. 1
 - b. 2
 - c. 3
 - d. 4
7. A Class 20 overload relay will trip within _____ seconds when motor current is 600%.
- a. 3
 - b. 10
 - c. 20
 - d. 30
8. _____ is a motor protection device that is designed to work with PROFIBUS-DP.
- a. INNOVA PLUS
 - b. SENSITRIP III
 - c. FVNR
 - d. SIMOCODE-DP
9. A NEMA size 3 controller is rated for _____ HP at 480 volts.
- a. 3
 - b. 25
 - c. 50
 - d. 100
10. Motor control centers are rated for _____ volts.
- a. 480
 - b. 600
 - c. 1000
 - d. 1200

11. Up to _____ 30 mm pilot devices can be mounted on the combination motor control unit door of a Siemens TIASTAR motor control center.
- 2
 - 4
 - 6
 - 8
12. Siemens motor control centers are manufactured with a maximum temperature rise of _____ over 40°C ambient.
- 25°C
 - 50°C
 - 65°C
 - 75°C
13. Type B-t wiring can be used on starters up to size _____ .
- 3
 - 5
 - 6
 - 7
14. No terminal blocks are supplied on Class I, Type _____ wiring.
- A
 - B-t
 - B-d
 - C
15. Type _____ wiring is not available on Class II motor control centers.
- all types are available on Class II
 - A
 - B
 - C
16. The primary standards for MCCs are established by _____ .
- ANSI, IEEE, IEC
 - ANSI, NEC, IEC
 - UL, IEEE, NEMA
 - UL, NEMA, *NEC*®

17. TIASTAR high density units take up _____ inches of vertical space.
- a. 18
 - b. 12
 - c. 6
 - d. 4
18. Most Siemens plug-in combination motor control units use _____ for quick bus connect and disconnect.
- a. pull-apart terminal blocks
 - b. two-bolt, U-shaped clamp
 - c. shelf-brackets
 - d. stab clips
19. To remove a combination motor control unit from a System/89 MCC, the operating handle is placed in _____ .
- a. On
 - b. Off
 - c. Park
 - d. Tripped
20. _____ will allow the use of branch circuit protective units in a motor control center provided their use does not make up a major portion of the motor control center.
- a. NEMA (ICS-2-322)
 - b. *NEC*® (430.97)
 - c. *NEC*® (430.94)
 - d. UL (845)

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