Table of Contents

Introduction

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

Upon completion of **Basics of Motor Control Centers**, you should be able to:

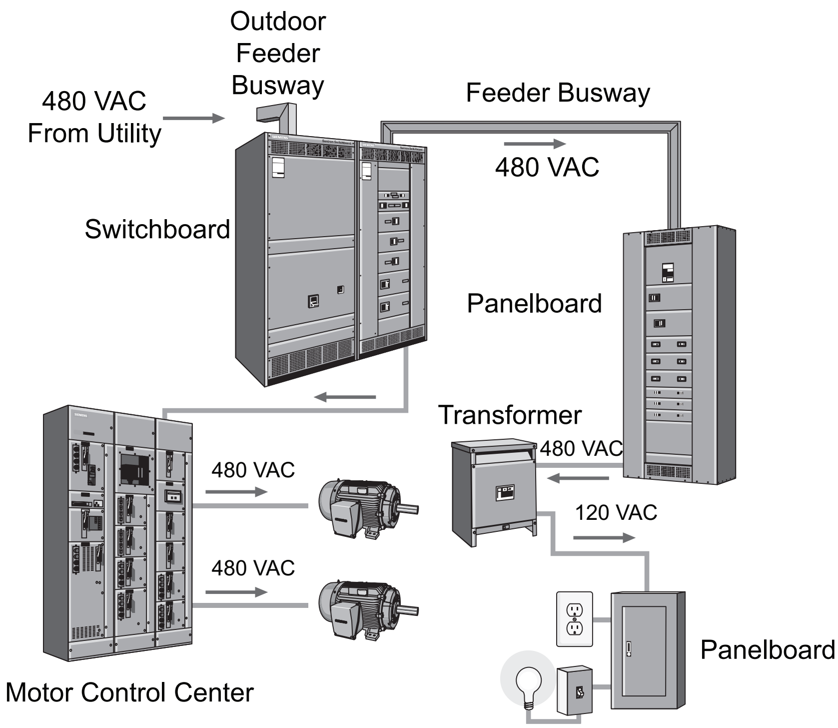
- Explain the role of motor control centers in a distribution system
- Define a motor control center according to NEMA and UL
- Explain the need for circuit protection
- Identify various components of a motor control center
- Explain the difference between the various classifications and types of motor control center wiring
- Explain features of the TIASTAR motor control centers

This knowledge will help you better understand customer applications. In addition, you will be better prepared to describe motor control products to customers. You should complete **Basics of Electricity** and **Basics of Control Components** before attempting **Basics of Motor Control Centers**.

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

Motor Control

Power distribution systems used in large commercial and industrial applications can be complex. Power may be distributed through switchgear, switchboards, transformers, and panelboards. Power distributed throughout a commercial or industrial application is used for a variety of applications such as heating, cooling, lighting, and motor-driven machinery.

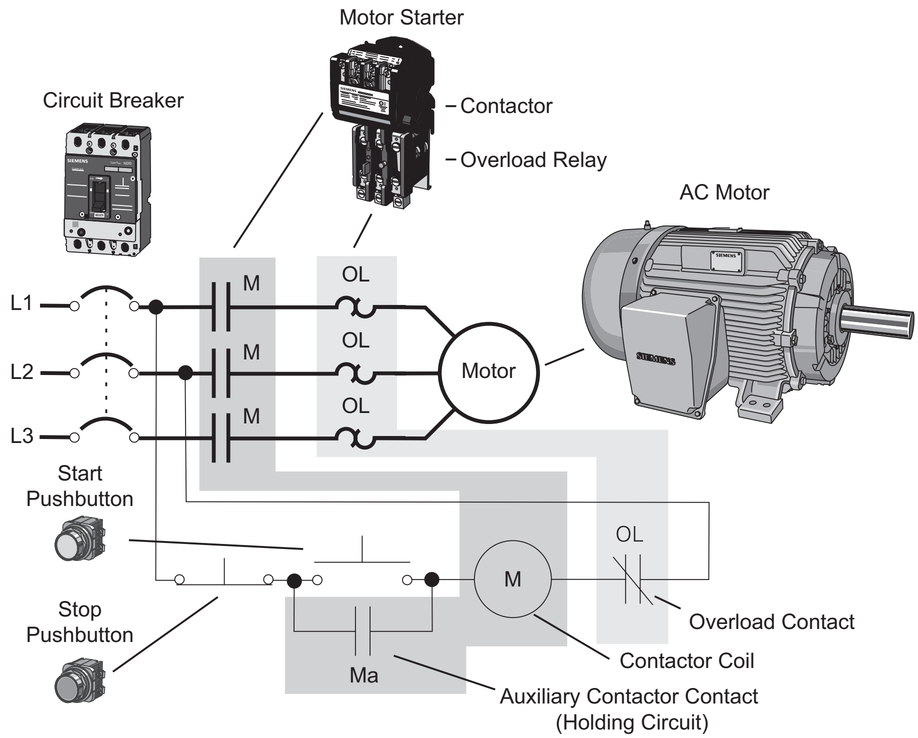


Basic Motor Control

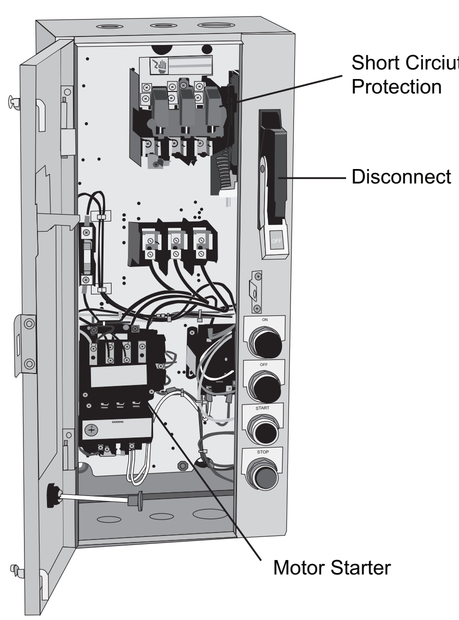
Wherever motors are used, they must be controlled. In **Basics of Control Components** you learned how various control products are used to control the operation of motors. The most basic type of AC motor control, for example, involves turning the motor on and off. This is often accomplished using a motor starter made up of a contactor and an overload relay.

The contactor's contacts are closed to start the motor and opened to stop the motor. This is accomplished electromechanically using start and stop pushbuttons or other pilot devices wired to control the contactor.

The overload relay protects the motor by disconnecting power to the motor when an overload condition exists. Although the overload relay provides protection from overloads, it does not provide short-circuit protection for the wiring supplying power to the motor. For this reason, a circuit breaker or fuses are also used.



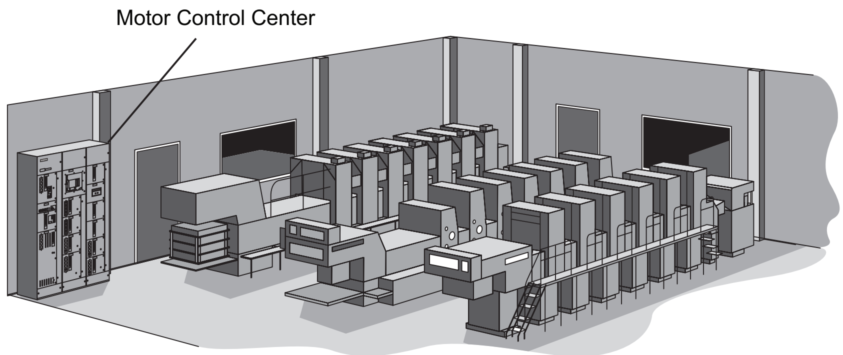
Typically one motor starter controls one motor. When only a few geographically dispersed AC motors are used, the circuit protection and control components may be located in a panel near the motor.



Motor Control Centers

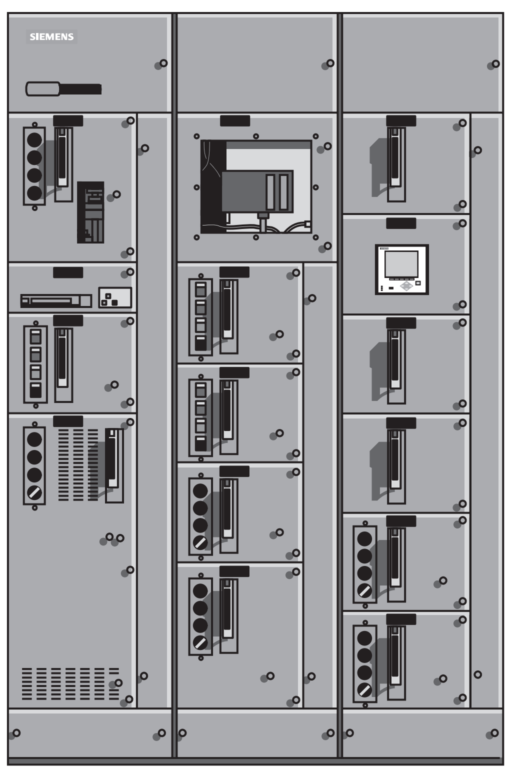
In many commercial and industrial applications, quite a few electric motors are required, and it is often desirable to control some or all of the motors from a central location. The apparatus designed for this function is the **motor control center (MCC)**.

Motor control centers are simply physical groupings of combination starters in one assembly. A combination starter is a single enclosure containing the motor starter, fuses or circuit breaker, and a device for disconnecting power. Other devices associated with the motor, such as pushbuttons and indicator lights may also be included.



Siemens TIASTAR Motor Control Centers

TIASTAR™ (pronounced tie-star) is the trade name for Siemens motor control centers. TIASTAR motor control centers offer a number of innovative features as described throughout this course.



TIASTAR

Advantages of Siemens TIASTAR MCCs

Some of the advantages of using TIASTAR motor control centers are:

- Faster and easier installation and wiring
- Centralized motor control
- Generally less total space is required
- Neat, attractive appearance
- Simplicity in adding special components such as service entrance switches, load centers, and transformers
- Ease of future modifications, such as increasing the size of the starters, adding additional starters, or adding additional vertical sections.

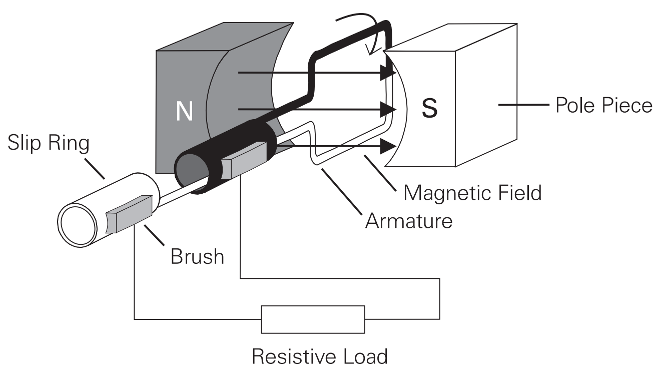
TIA

The **TIA** portion of the TIASTAR name stands for Totally Integrated Automation. TIA is more than a concept. It is a strategy developed by Siemens that emphasizes the seamless integration of automation, networking, drive, and control products. The TIA strategy has been the cornerstone of development for a wide variety of Siemens products.

TIA is important not just because it simplifies the engineering, startup, and maintenance of systems developed using Siemens products, but also because it lowers the life-cycle costs for systems incorporating these products. Additionally, by reducing engineering and startup of systems, TIA helps Siemens customers reduce time to market and improve overall financial performance.

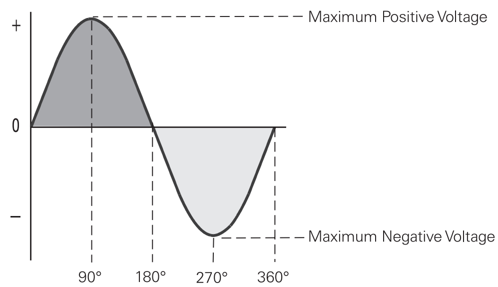
Power Supplies

The major source of electrical power used by motor control centers is an AC generator located at a power generating facility. AC generators operate on the theory of electromagnetic induction. This simply means that when conductors are moved through a magnetic field, a voltage is induced into the conductors. A basic generator consists of a magnetic field, an armature, slip rings, brushes, and some type of resistive load. An armature is any number of conductive wires (conductors) wound in loops which rotate through the magnetic field. For simplicity, one loop is shown.



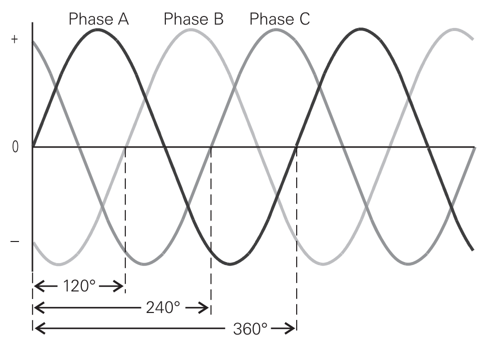
If the rotation of the AC generator were tracked through a complete revolution of 360°, it could be seen that during the first quarter of a revolution voltage would increase until it reached a maximum positive value at 90°. Voltage would decrease during the second quarter of revolution until it reached zero at 180°. During the third quarter of a revolution voltage would increase in the opposite direction until it reached a maximum negative value at 270°. During the last quarter of a revolution voltage would decrease until it reached zero at 360°. This is one complete cycle or one complete alternation between positive and negative.

If the armature of the simple AC generator shown here rotates 3600 times per minute (3600 RPM), the generator produces 60 cycles of voltage per second, or 60 hertz (Hz). In practice, AC generators typically have two or three pairs of electromagnetic poles, allowing the generation of 60 Hz voltage at a slower rotational speed.

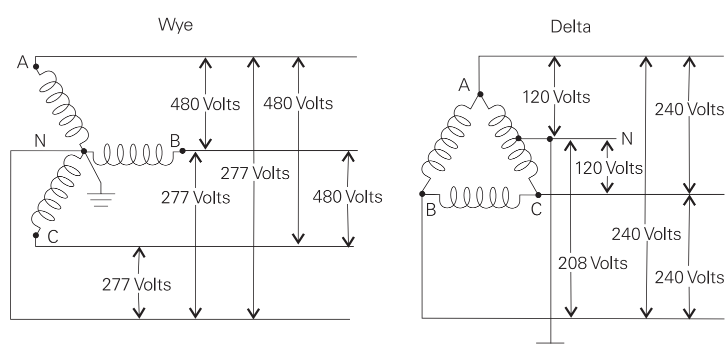


Three-Phase Voltage

In most large commercial and industrial motor applications, **three-phase voltage** is used. In a three-phase system, the generator produces three voltages. Each voltage phase rises and falls at the same frequency (60 Hz in the U.S., 50 Hz in many other countries); however, the phases are offset by 120° from each other.



The motor control center receives this power through complex distribution systems which include power distribution lines, transformers, substations, and switchboards. Transformers used with three-phase power require three interconnected coils in both the primary and the secondary. These transformers can be connected in either a wye or a delta configuration. The type of transformer and the actual voltage depend on the requirements and capability of the power company and the needs of the customer. The following illustration shows examples of the secondary windings of wye- and delta-connected transformers.

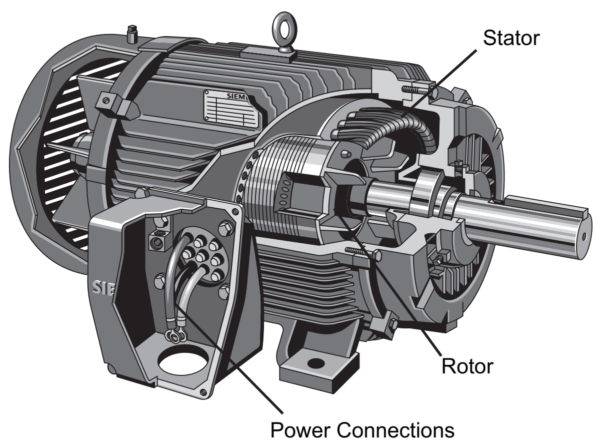


A - B	480 volts
B - C	480 volts
C - A	480 volts
A - N	277 volts
B - N	277 volts
C - N	277 volts

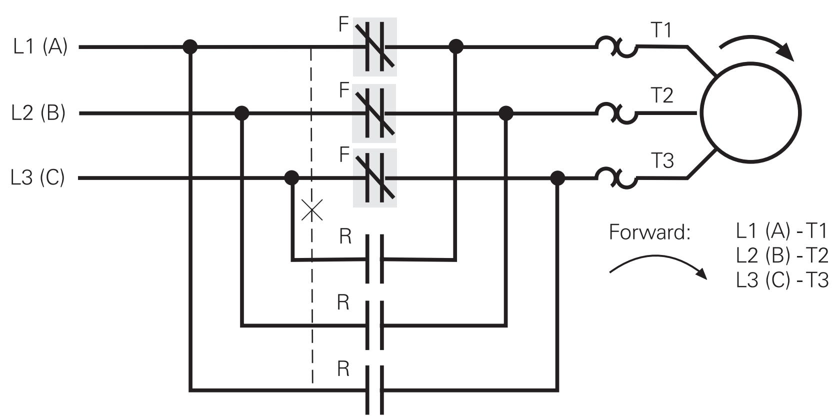
A - B	240 volts
B - C	240 volts
C - A	240 volts
A - N	120 volts
B - N	208 volts
C - N	120 volts

Motor Rotation

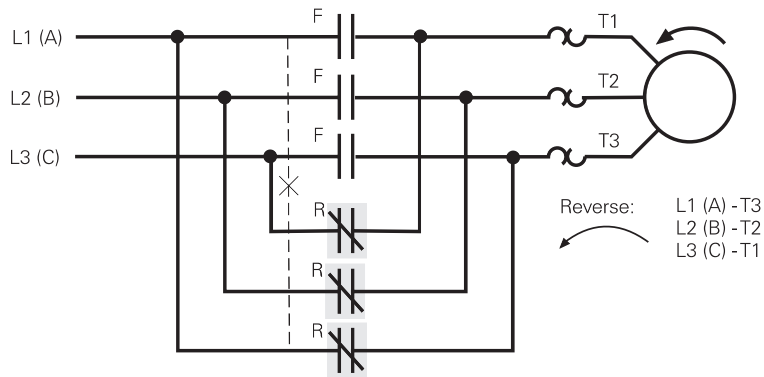
Three-phase voltage is used throughout large commercial and industrial facilities to run AC motors. An AC motor is made up of a stationary member, called a stator, and a rotating member, called a rotor. Three-phase AC power is applied to the stator through the power connections.



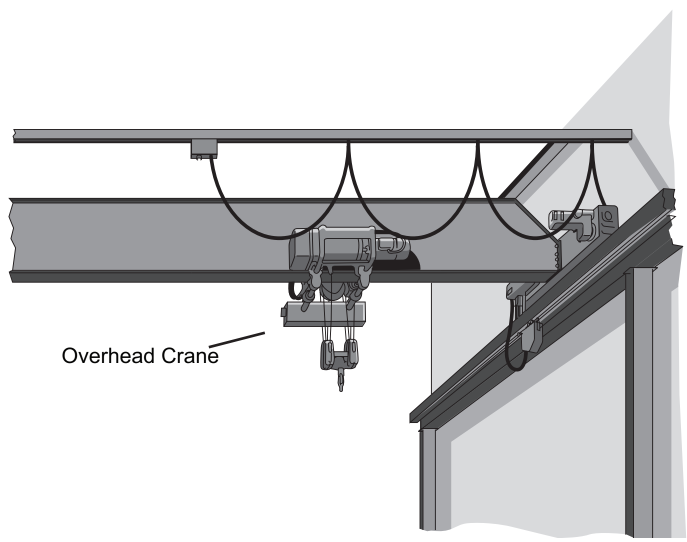
The direction a three-phase AC motor rotor turns depends on the phase sequence of the incoming power supply. In the following example, L1 (A) is connected to motor lead T1, L2 (B) is connected to motor lead T2, and L3 (C) is connected to motor lead T3. When power is applied through the "F" contacts, the motor turns in a clockwise, or forward direction.



However, if any two of the three power supply leads are reversed, the motor runs in the opposite direction. In this example, when the F contacts open and the R contacts close, L1 (A) is connected to motor lead T3, L2 (B) is connected to motor lead T2, and L3 (C) is connected to motor lead T1. (L1 and L3 have been reversed.) As a result, the motor runs in the counterclockwise, or reverse direction.



Many applications are designed for forward and reverse operation. An overhead crane, for example, might use the forward direction to raise the crane and reverse direction to lower the crane.



Review 1

1. Which of the following is a advantage of using a TIASTAR motor control center?

   a. Faster and easier installation and wiring
   b. Simplicity in adding special components
   c. Ease of future modifications
   d. All the above

2. The TIA portion of the TIASTAR name stands for ______.

3. In most large commercial and industrial motor applications, ________-phase voltage is used.

4. Motor rotation of a three-phase AC induction motor can be reversed by reversing any ________ of the three power supply leads.

Design Standards

Although several organizations are involved in establishing standards for the design, construction, and application of motor control centers, the primary standards discussed in this book were established by UL, NEMA, and NFPA. The following organizations have established standards which may be applied to motor control centers. It is beyond the scope of this course to cover every standard; however, reference will be made throughout the course to important standards with which Siemens motor control centers comply.

UL

Underwriters Laboratories (UL) is a private company that is nationally recognized as an independent testing laboratory. UL tests products for safety and products that pass UL tests can carry a UL mark. Siemens motor control centers are designed to UL 845 standards.

NEMA

The **National Electrical Manufacturers Association (NEMA)** is an organization that, among other things, develops standards for electrical equipment.

NFPA

The **National Fire Protection Association (NFPA)** is a nonprofit organization which publishes the *National Electrical Code®* (*NEC®*). The intent of the *NEC®* is to describe safe electrical practices.

ANSI

The **American National Standards Institute (ANSI)** is a nongovernmental organization that facilitates the development of standards by establishing a consensus among qualified groups.

IEEE

The **Institute of Electrical and Electronic Engineers (IEEE)** is an organization open to individual membership and provides a variety of services for its members. It also develops numerous standards for electrical and electronic equipment and practices.

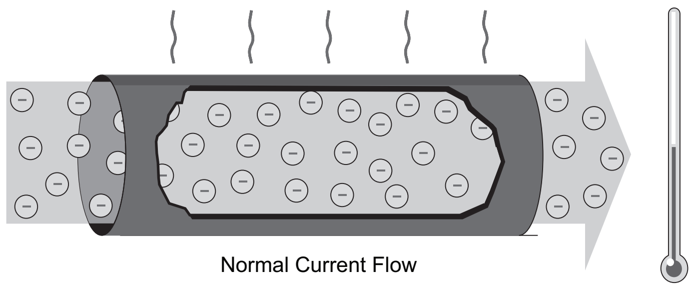
IEC

The **International Electrotechnical Commission (IEC)** is an organization based in Geneva, Switzerland with over 50 member nations. IEC writes standards for electrical and electronic equipment practices.

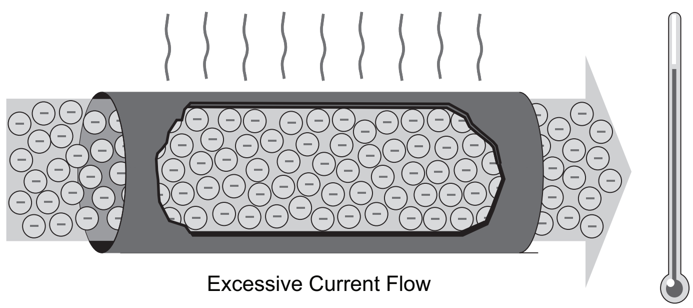
Need for Circuit Protection

Current and Temperature

Current flow in a conductor always generates heat. The greater the current flow in any one size conductor, the hotter the conductor. Excess heat is damaging to electrical components and conductor insulation. For that reason, conductors have a rated, continuous current-carrying capacity or **ampacity**. Overcurrent protection devices, such as fuses, are used to protect conductors from excessive current flow.



Normal Current Flow

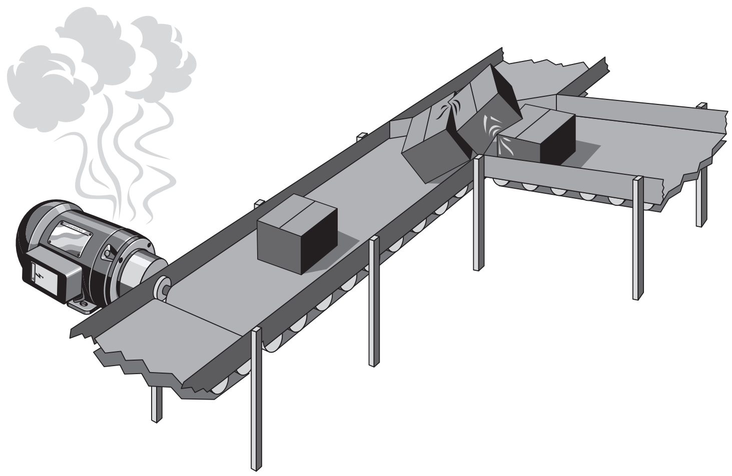


Excessive Current Flow

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

Overloads

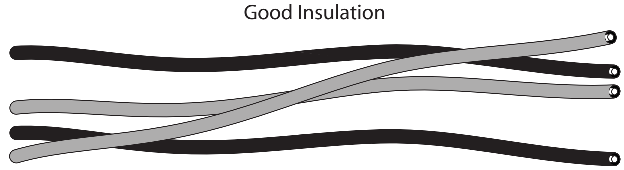
An **overload** occurs when too many devices are operated on a single circuit or when electrical equipment is made to work harder than its rated design. For example, a motor rated for 10 amperes may draw 20, 30, or more amperes in an overload condition. In the following illustration, a package has become jammed on a conveyor, causing the motor to work harder and draw more current. Because the motor is drawing more current, it heats up. Damage will occur to the motor in a short time if the problem is not corrected or if the circuit is not shut down by an overcurrent protection device.



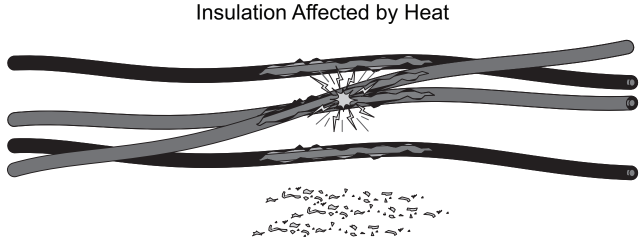
Conductor Insulation

Motors, of course, are not the only devices that require circuit protection for an overload condition. Every circuit requires some form of protection against overcurrent. Heat is one of the major causes of insulation failure of any electrical component. High levels of heat to insulated wire can cause the insulation to breakdown, melt, or flake off, exposing conductors.

Good Insulation

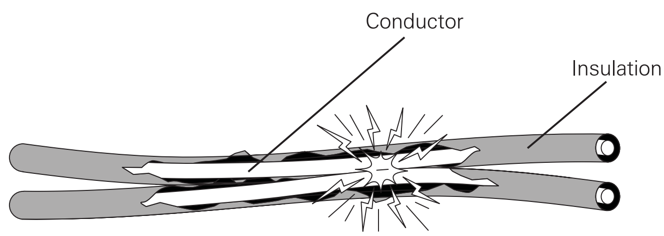


Insulation Affected by Heat



Short Circuits

When two bare conductors touch, a **short circuit** occurs. When a short circuit occurs, resistance drops to almost zero. Short circuit current can be thousands of times higher than normal operating current.



Ohm's Law demonstrates the relationship of current, voltage, and resistance. For example, a 240 volt motor with 24 Ω (ohms) of resistance would normally draw 10 amperes of current.

$$I = \frac{E}{R}$$

$$I = \frac{240}{24}$$

$$I = 10 \text{ amperes}$$

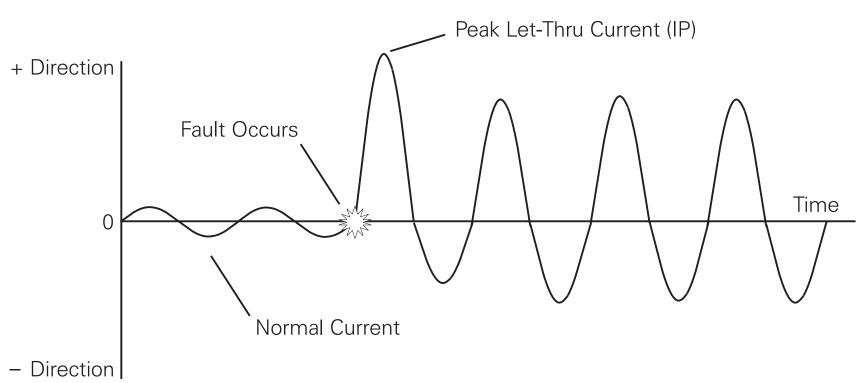
When a short circuit develops, resistance drops. If resistance drops to 24 milliohms, current will be 10,000 amperes.

$$I = \frac{240}{0.024}$$

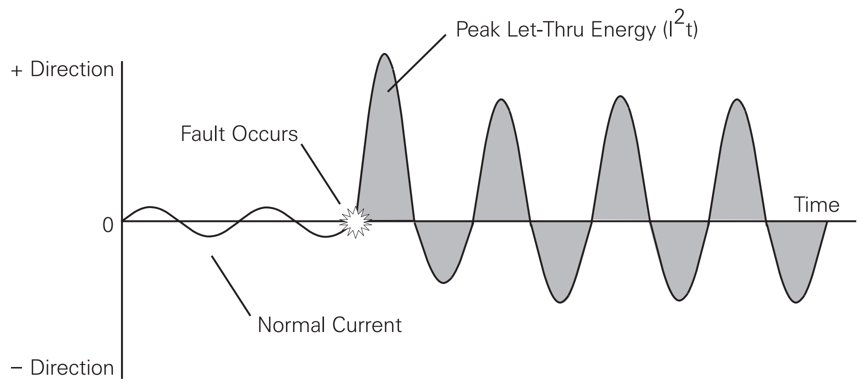
$$I = 10{,}000 \text{ amperes}$$

Short-Circuit Current on Unprotected Electrical Circuits

When a short circuit occurs, current will continue to flow in an unprotected electrical circuit. The peak short-circuit current of the first cycle is the greatest and is referred to as **peak let-thru current (I_P)**. The force of this current can cause damage to wires, switches, and other electrical components of a circuit.

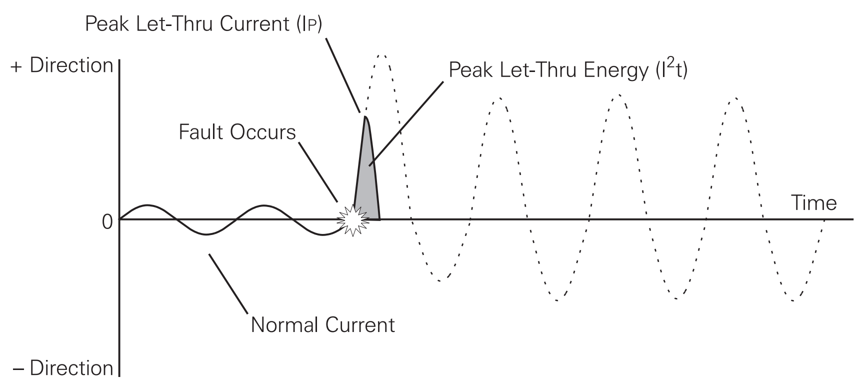


Associated with the peak let-thru current is **peak let-thru energy (I^2t)**. For an unprotected circuit, this energy is often capable of dramatic destruction of equipment and is a serious safety concern.



Short-Circuit Current on Protected Electrical Circuits

Fortunately, if a circuit has a properly applied overcurrent protection device, the device will open the circuit quickly when if a short circuit occurs, limiting peak let-thru current (I_P) and energy (I^2t).



Circuit protection would be unnecessary if overloads and short circuits could be eliminated. Unfortunately, overloads and short circuits do occur.

NEC® Article 240

Article 240 of the *NEC®* covers overcurrent protection. You are encouraged to become familiar with this material. Article 240.1 states that:

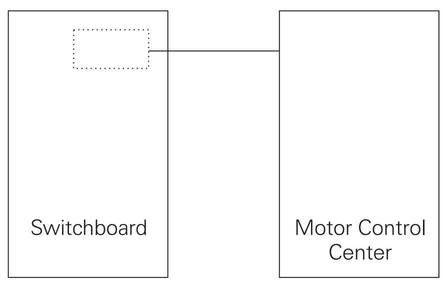
Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation.

NEC® Article 430.94

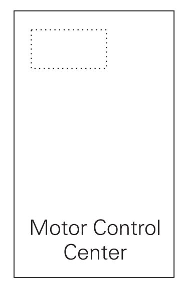
The *National Electrical Code®* requires overcurrent protection for motor control centers. *NEC®* Article 430.94 states:

Motor control centers shall be provided with overcurrent protection in accordance with Parts I, II, and IX of Article 240. The ampere rating or setting of the overcurrent protective device shall not exceed the rating of the common power bus. This protection shall be provided by (1) an overcurrent protective device located ahead of the motor control center or (2) a main overcurrent protective device located within the motor control center.

There are two ways Article 430.94 can be met. An overcurrent protection device can be installed ahead of the motor control center. A switchboard, for example, located upstream of the motor control center may contain the overcurrent protection device for the motor control center. The second way to meet this requirement is to install a main overcurrent protection device within the motor control center.



Overcurrent-Protection Device Ahead of MCC



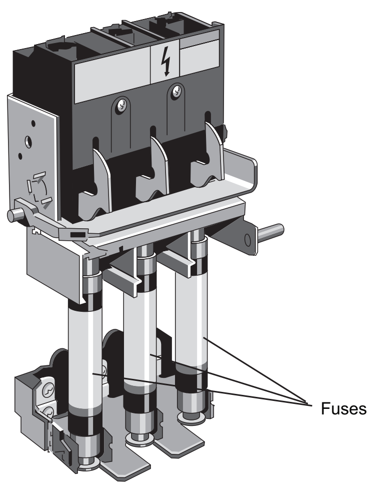
Main Overcurrent-Protection Device Located in MCC

Overcurrent Protection Devices

An **overcurrent protection device** must be able to recognize the difference between an overcurrent and short circuit and respond in the proper way. Slight overcurrents can be allowed to continue for some period of time; but as the current magnitude increases, the protection device must open faster. Short circuits must be interrupted instantly.

Fusible Disconnect Switch

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

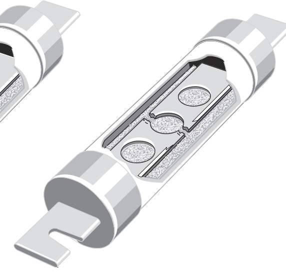


Fusible Disconnect Switch

Fuse

A **fuse** is a one-shot device. The heat produced by overcurrent causes the current carrying element to melt open, disconnecting the load from the source voltage.

Fuse During Fault



Fuse After Fault

Non-time-Delay Fuses

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

Time-Delay Fuses

Time-delay fuses provide overload and short-circuit protection. Time-delay fuses usually allow several times the rated current to flow for a short time to allow a motor to start.

Fuse Classes

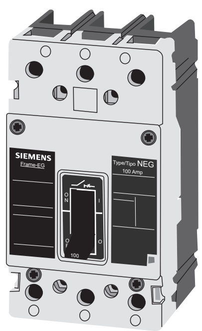
Fuses are grouped into classes based on their operating and construction characteristics. Each class has an **interrupting rating (IR)** in amperes which is the amount of fault current this class of fuses is capable of interrupting without destroying the fuse casing. Fuses are also rated according to the maximum continuous current and maximum voltage they can handle. Underwriters Laboratories (UL) establishes and standardizes basic performance and physical specifications to develop its safety-test procedures. These standards have resulted in distinct classes of low-voltage fuses rated at 600 volts or less. The following chart lists the **fuse class** and its ratings.

Class	Voltage Rating	Ampere Rating	Interrupting Rating (Amps)	Sub Classes	UL Standard
R	250, 600	0-600	200,000	RK1 and RK5	UL 248 12
J	600	0-600	200,000		UL 248 B
L	600	601-6000	200,000		UL 248 10
CC	600	0-30	200,000		UL 248 4

Circuit Breakers

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

Circuit breakers provide a manual means of energizing and de-energizing a circuit. In addition, circuit breakers provide automatic overcurrent protection of a circuit. One key advantage of a circuit breaker is that it allows a circuit to be reactivated quickly after a short circuit or overload is cleared by simply resetting the breaker.



Circuit Breaker

Ampere Rating

Like fuses, every circuit breaker has ampere, voltage, and interrupting ratings. The **ampere rating** is the maximum continuous current a circuit breaker can carry without exceeding its rating. In general, the circuit breaker ampere rating should not exceed the conductor ampere rating. For example, if the conductor is rated for 20 amps, the circuit breaker rating should not exceed 20 amps. Siemens breakers are rated on the basis of using 60° C or 75° C conductors. This means that even if a conductor with a higher temperature rating were used, the ampacity of the conductor must be figured on its 60° C or 75° C rating.

Voltage Rating

The **voltage rating** of the circuit breaker must be at least equal to the supply voltage. The voltage rating of a circuit breaker can be higher than the supply voltage, but never lower. For example, a 480 VAC circuit breaker could be used on a 240 VAC circuit. A 240 VAC circuit breaker could <u>not</u> be used on a 480 VAC circuit.

The voltage rating is a function of the circuit breaker's ability to suppress the internal arc that occurs when the circuit breaker's contacts open.

Fault-Current Interrupting Rating

Circuit breakers are also rated according to the level of fault current they can interrupt. When applying a circuit breaker, one must be selected to sustain the largest potential short-circuit current which can occur in the selected application. Siemens circuit breakers have **interrupting ratings** from 10,000 to 200,000 amps.

Review 2

1. ________ is a private company that is nationally recognized as an independent testing laboratory.

2. An ________ occurs when too many devices are operated on a single circuit or when electrical equipment is made to work harder than its rated design.

3. Time-delay fuses provide overload and ________ protection.

4. Class R fuses have an interrupting rating of ________ amps.

5. The ________ rating of a circuit breaker must be at least equal to the supply voltage.

NEMA Definition

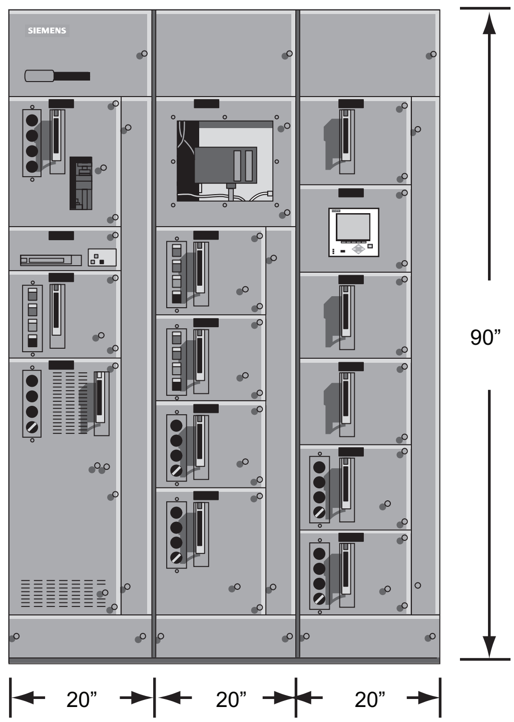
NEMA defines a motor control center in ICS-18-2001 as being *a floor-mounted assembly of one or more enclosed vertical sections having a horizontal common power bus and principally containing combination motor control units. These units are mounted one above the other in the vertical sections. The sections normally incorporate vertical buses connected to the common power bus, thus extending the common power supply to the individual units. Power may also be supplied to the individual units by bus bar connections, by stab connection, or by suitable wiring.*

According to the NEMA definition, motor control centers:

- Are floor-mounted assemblies
- Have one or more enclosed vertical sections
- Have a common horizontal power bus
- May incorporate vertical buses connected to the common bus
- Principally contain combination motor control units

Vertical Sections

The motor control center is made up of a steel structure to contain the combination motor control units, wireways, internal wiring, and bus bars. From the NEMA definition it can be seen that a motor control center is a floor-mounted assembly made up of enclosed **vertical sections**. One vertical section may stand alone as a complete motor control center, or several sections may be bolted and bussed together. Vertical sections are generally 20" wide by 90" high, but structures less than 90" are available.



Three Vertical Sections

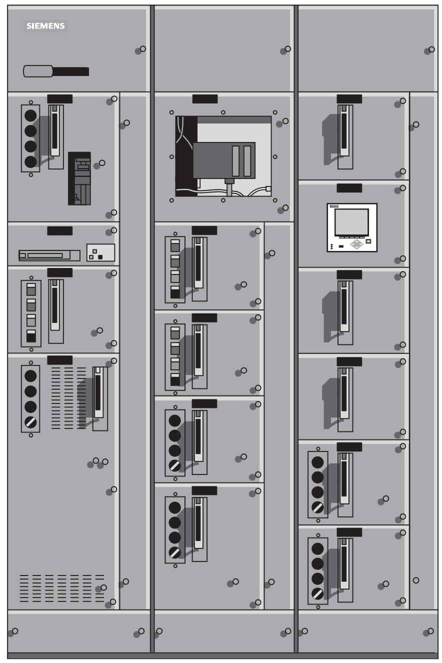
Enclosure Types

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 types** available for TIASTAR 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. This is the standard enclosure type for TIASTAR motor control centers, but TIASTAR motor control centers can also be provided with the other NEMA enclosure types listed in the following paragraphs.



Type 1 Gasket Front

Type 1 gasketed front, general purpose, indoor enclosures have the same use as Type 1 enclosures except some additional gasketing is used.

Type 2, Drip-Proof, Indoor

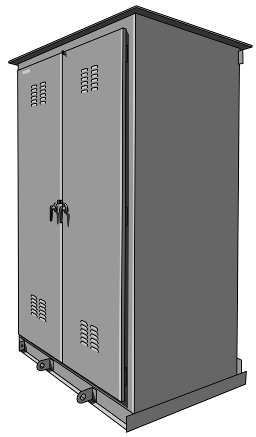
Type 2, drip-proof, indoor enclosures are intended to protect equipment from falling noncorrosive liquids and dirt. The enclosure prevents the entrance of dripping liquid at a higher level than the lowest live part within the enclosure. This design is a Type 1 gasketed front, or Type 12, with a drip 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. All openings in Type 12 enclosures are gasketed. 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. These features allow Type 12 enclosures to provide a greater degree of protection than Type 1 enclosures.

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.

IEC Enclosure Types

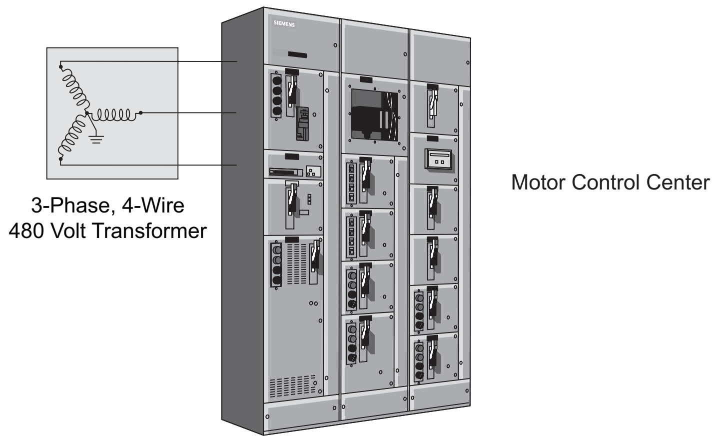
The International Electrotechnical Commission (IEC) is another organization that defines the degree of protection provided by enclosures. NEMA is primarily associated with equipment used in North America. IEC is associated with equipment sold in many countries including the United States.

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. Although TIASTAR motor control centers are provided in the NEMA enclosure types listed in the preceding paragraphs, the following chart provides an approximate conversion between NEMA and IEC designations.

NEMA	IEC
1	IP10
2	IP11
3R	IP14
12	IP52

MCC Voltage Rating

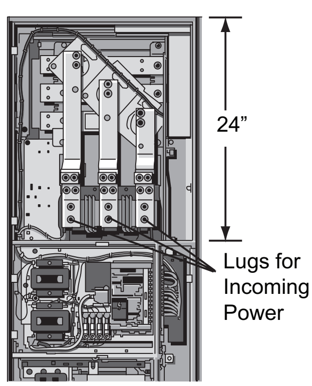
In addition to the various ratings of individual components used in motor control centers, motor control centers also have an overall rating of 600 volts. This is the maximum voltage that can be applied to a motor control center. A motor control center can be connected to a lower voltage, however, and a three-phase, 480 VAC supply voltage is common.



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. Also, incoming power cables can enter and exit the motor control center from the top or bottom depending on the application. Finally, incoming power can be provided using busway.

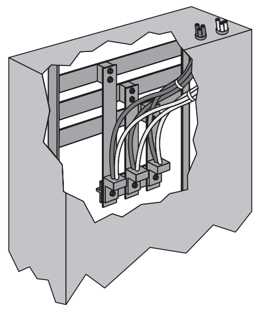
Main Lugs

When using **main lugs,** the amount of vertical space required varies with the amperage rating and the bus bracing. 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.



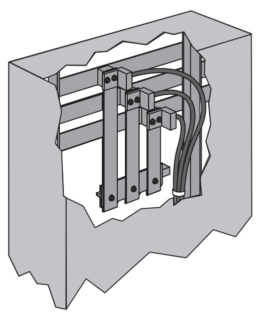
Main Lugs on Top, Top Entry

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



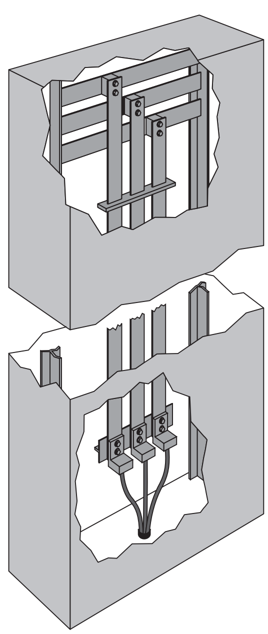
Main Lugs on Top, Bottom Entry

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



Main Lugs on Bottom, Bottom Entry

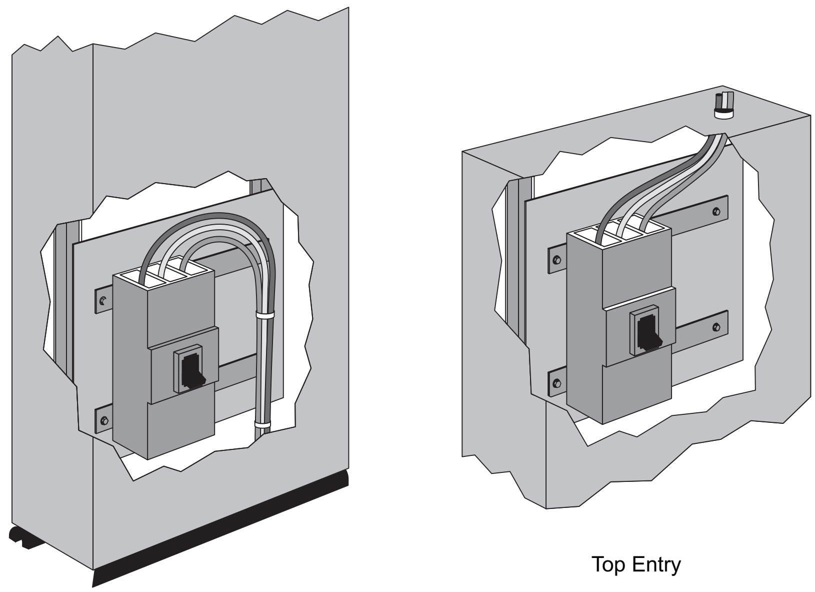
Lugs can also be supplied on the bottom of the vertical bus for bottom cable entry.



Main 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.

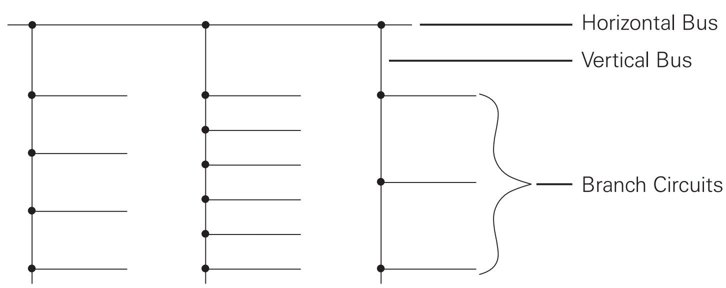


Top Entry

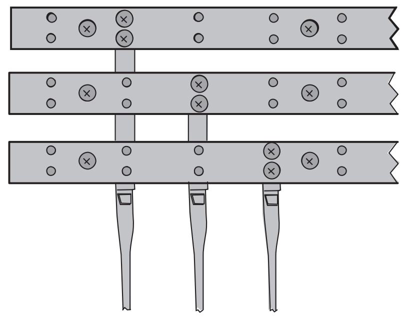
Bottom Entry

Horizontal and Vertical Bus

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



In power circuits, such as motor control centers, a bus is made of a heavy-duty metal bar. These bus bars provide power to each of the combination motor control units. The **vertical bus** is connected to a corresponding **horizontal bus** and is isolated from the other bus bars.



Temperature Rise

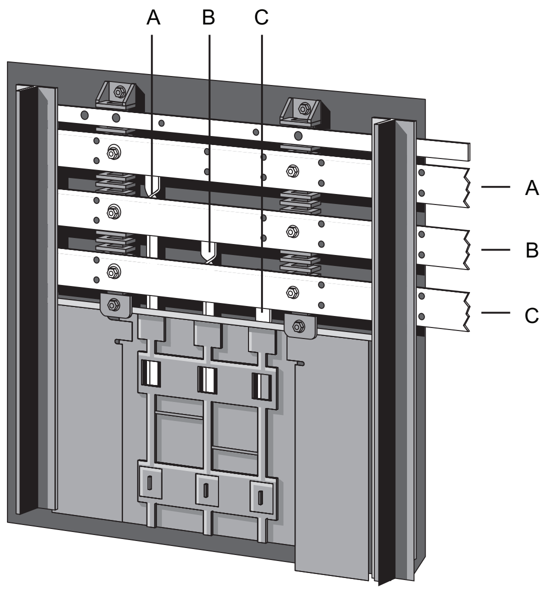
The bus bars are the major current carrying component of the motor control center. Before a motor control center is operated, bus bars are at the temperature of the surrounding air. This is known as the ambient temperature. Temperature rises in the motor control center bus bars during operation. The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

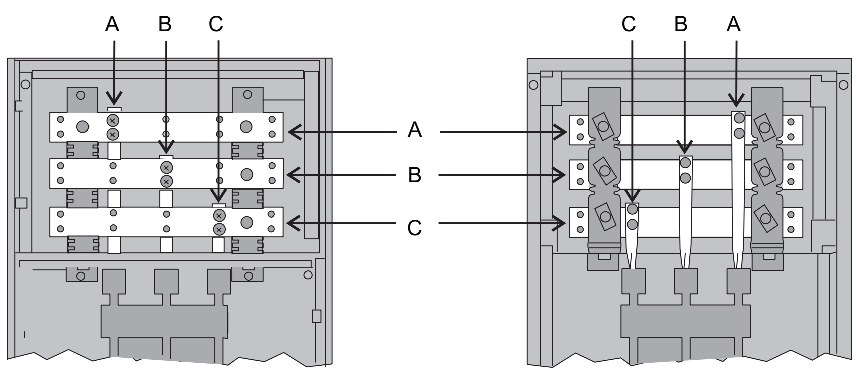
NEMA Phase Arrangement

NEMA requires bus bars to have phases in sequence so that an installer can have the same fixed phase arrangement at each termination point in any motor control center. The following diagram illustrates accepted **NEMA phase arrangements**. It is possible to have a non-NEMA phase sequence; however, this would have to be clearly marked.



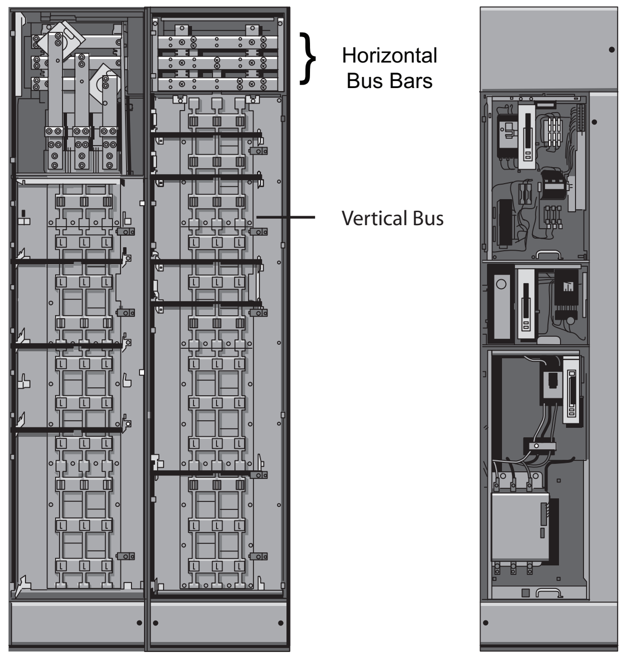
Back to Back Structures

It should be noted that the NEMA phase arrangement illustrated in the previous drawing is viewed from the front. The vertical bus bars appear to be in reverse order when viewed from the rear. Some motor control centers can have devices installed on the front and rear of the motor control center.



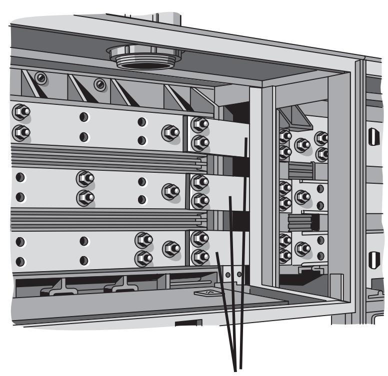
Shipping Splits

When a motor control center is made up of more than one vertical section, the sections are assembled together with a common top- and bottom-frame assembly. For shipping, this assembly can consist of a maximum of four 20" wide vertical sections (80" maximum). Several assemblies can be bolted and bussed together at the installation site to form a complete lineup.



Shipping Split #1 Shipping Split #2

When there are more than four sections or the customer specifies a split between two vertical sections, a splice kit, must be installed to join the horizontal bus bars.



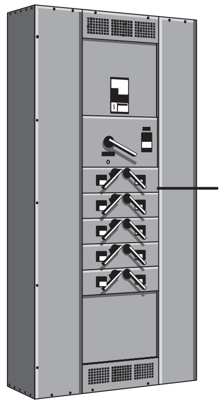
Splice Plates

Combination Motor Control Units

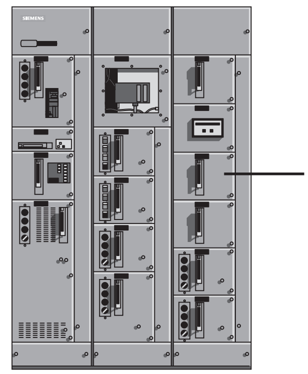
Motor control centers are distinguished from other distribution devices, such as panelboards and switchboards, in that motor control centers principally contain **combination motor control units**. In contrast, panelboards and switchboards principally contain branch circuit-protection devices such as circuit breakers and fusible switches.

Underwriter's Laboratory

UL 845 does allow the use of auxiliary devices and panelboards in a motor control center, provided they do not make up a major portion of the motor control center. Often, lighting transformers, panelboards, and other distribution devices are incorporated in motor control centers.



Panelboard



Motor Control Center

Review 3

1. NEMA Type ___ 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.

2. Motor control centers have an overall voltage rating of ________ volts.

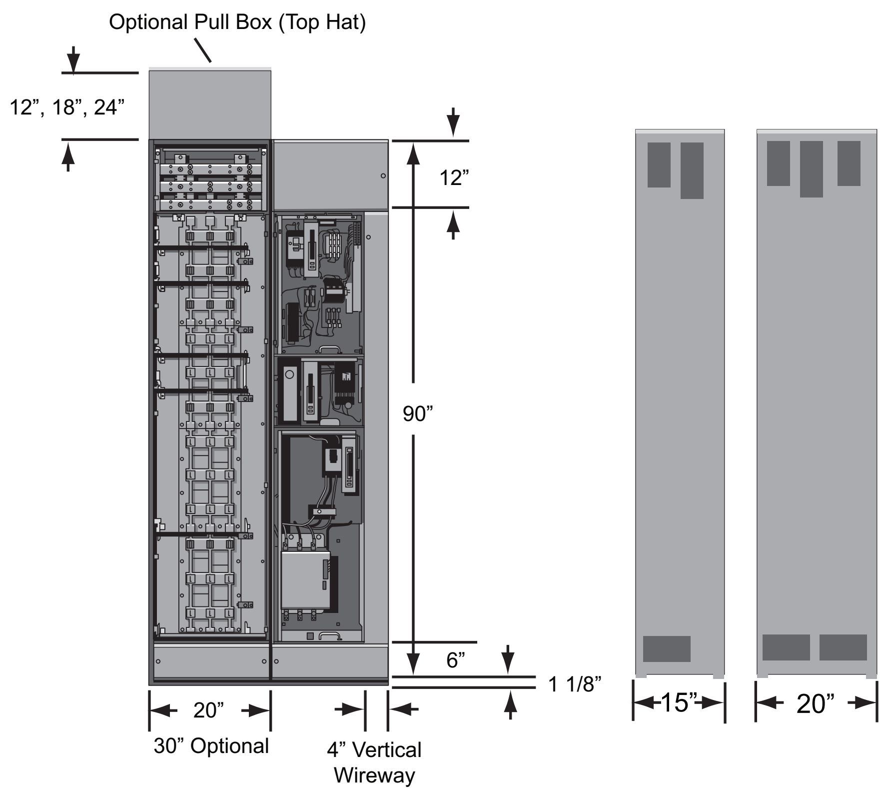
3. ________ provide power to each of the combination motor control units in a motor control center. .

4. NEMA requires bus bars to have ________ in sequence so that an installer has same fixed ________ arrangement at each termination point in a motor control center.

Dimensions

The nominal height of a TIASTAR motor control center is 90″. 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 behind the wireway in the top 12″ of the structure making it easier to service. Each vertical structure 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 normally 20″ wide, but a 30″ wide structure is available for special equipment, such as large AC drives or transformers, that requires more space. The vertical wireway is 4″ wide on 20″ wide sections, but an optional 8″-wide wireway is available. Front-mounted vertical units can be 15″ or 20″ deep.

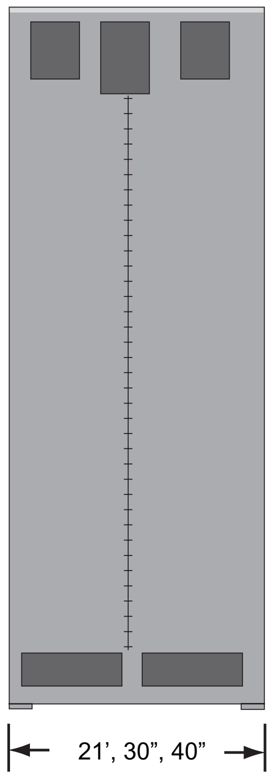


Front View

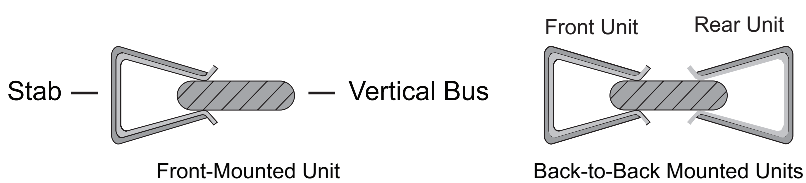
Side View

Back-to-Back Mounting

TIASTAR sections designed for back-to-back mounting are 30″ or 40″ deep and include two vertical and horizontal buses. This allows for correct bus phasing on the front and rear. Siemens also provides a 21″-deep, back-to-back design with common horizontal and vertical buses for applications where available floor space is limited.



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



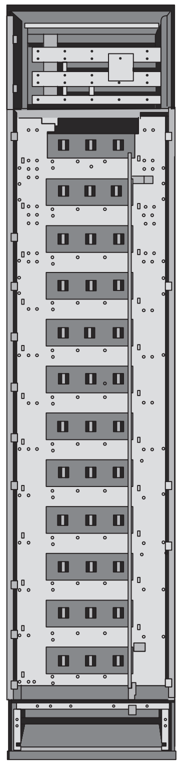
Stab-on Connections

Basic Construction

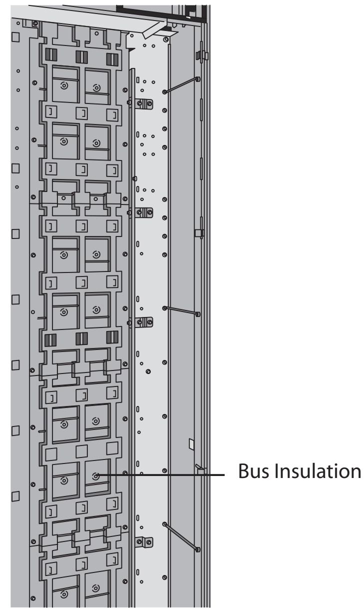
TIASTAR motor control centers offer two vertical bus designs. Front only structures with 42K or 65K ampere bus bracing are supplied with an insulated vertical bus design standard. The vertical bus bars are not physically isolated phase-to-phase.

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



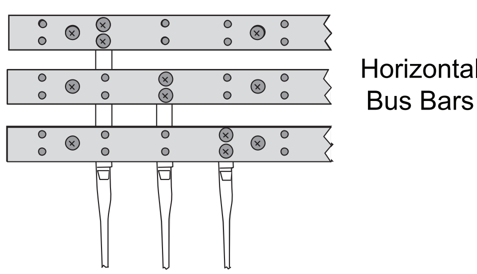
Section with
Insulated Vertical Bus



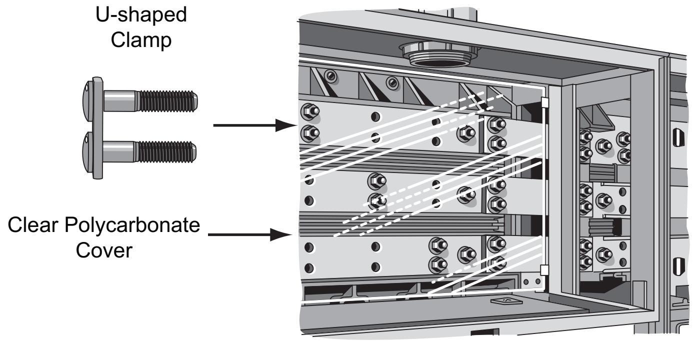
Section with Optional
Isolated, Insulated Vertical Bus

Horizontal Bus

The **horizontal bus** on TIASTAR motor control centers are made of tin or optional silver plated copper. They are available with 600, 800, 1200, 1600, 2000 and 2500 ampere current ratings.

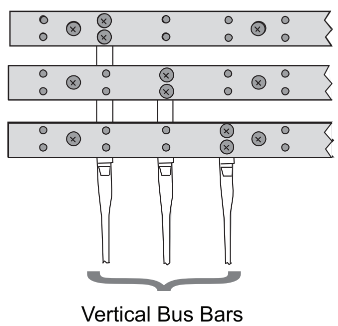


The horizontal bus is connected to the vertical bus with a two-bolt, U-shaped clamp utilizing spring washers to maintain torque. This allows the bolts to be tightened from the front. Horizontal bus bars are shielded by a clear polycarbonate cover for safety and easy visibility for inspection.



Vertical Bus

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

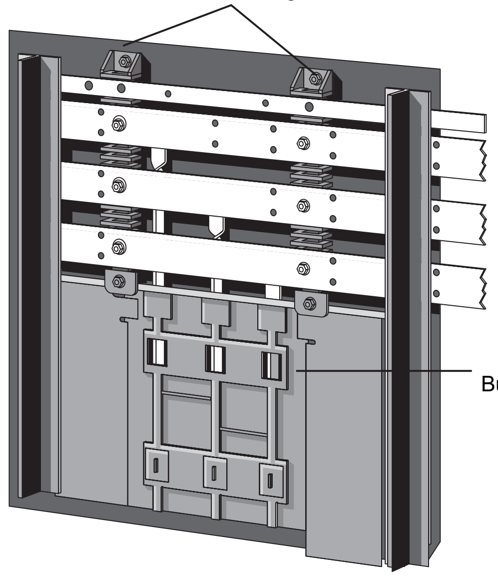


Bus Bracing

The *NEC*® discusses bus bars used in motor control centers in Article 430.97(A), which states that *busbars shall be protected from physical damage and be held firmly in place*.

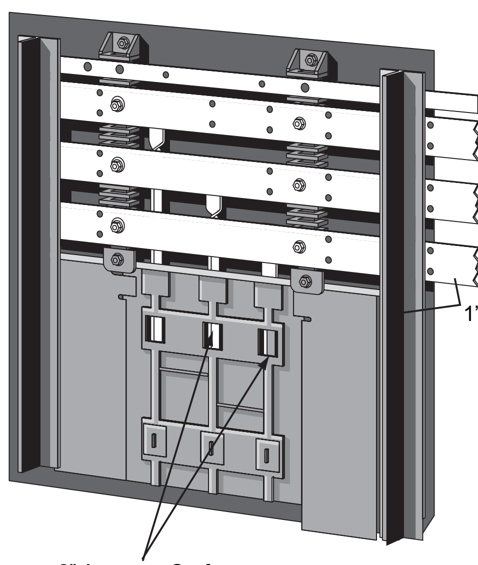
Motor control centers must be capable of withstanding the largest potential short-circuit current which can occur in the selected application. The amount of short-circuit current available depends on the amount of power available to a facility. Short-circuit current can be thousands of times higher than normal current.

Bus bars must be braced to withstand this potential current. The bus bars used in Siemens TIASTAR motor control centers are braced for 42,000 ampere interrupting rating with optional bracing available to 100,000 amperes.



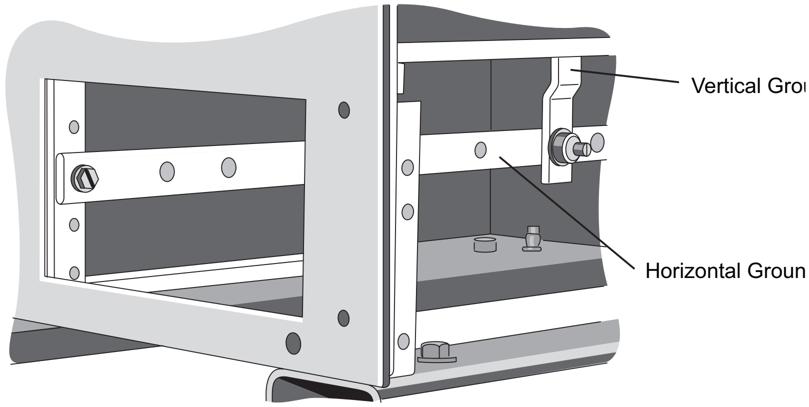
Bus Spacing

In addition, *NEC®* Table 430.97 requires 1″ of clearance between a live bus and ground, 1″ of clearance between phases through air, and 2″ of clearance across a surface for nominal voltages over 250 volts, but not over 600 volts. These spacings are used throughout the horizontal and vertical bus in the TIASTAR motor control centers.



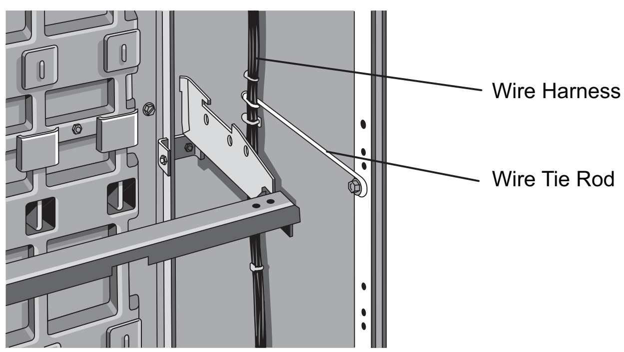
Ground Bus

A horizontal **ground bus** is typically mounted in the bottom 6” of the structure. 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.



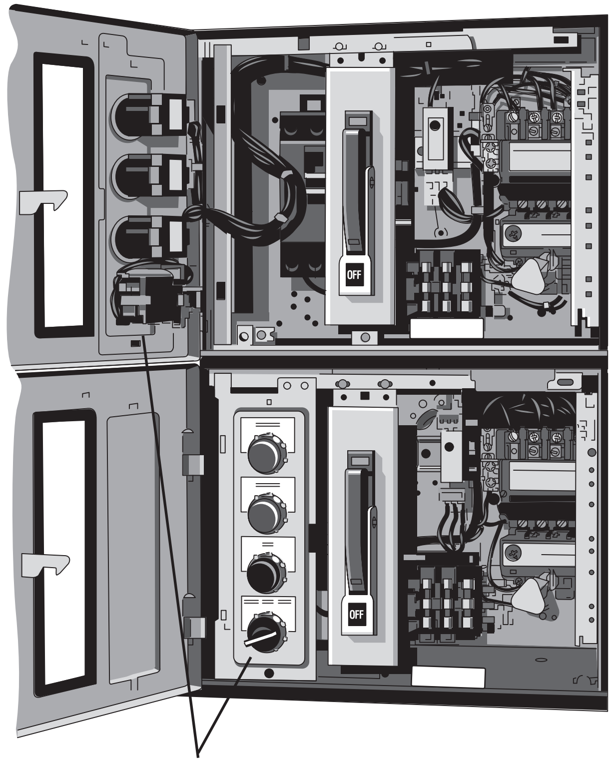
Wire Tie Rods

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



Pilot Devices

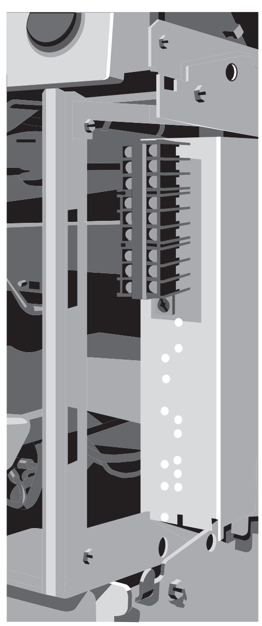
Pilot devices are mounted on a panel that attaches to the unit door with two captive screws. The pilot-device panel can be removed from the door and attached to the combination motor control unit for service or unit removal. There is room for four 22 mm or 30 mm pilot devices on the panel.



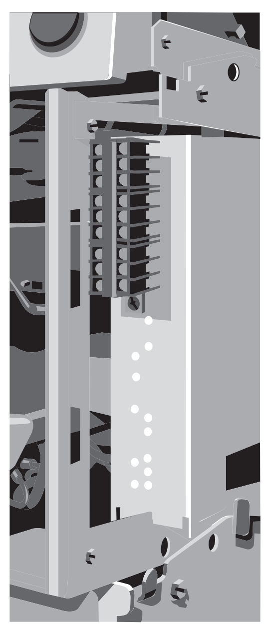
Pilot Devices Panels

Terminal Blocks

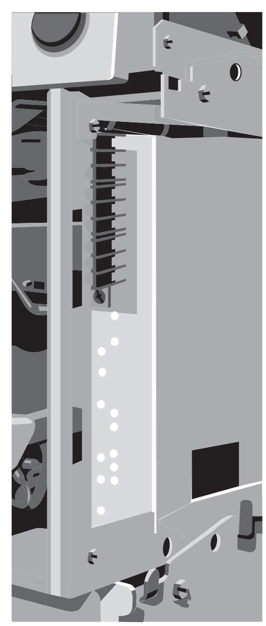
Terminal blocks are supplied with Type B and C wiring. The terminal blocks are mounted up front on a swing-out side panel. The panel is notched so that the terminal block can be placed inside the unit, in a center position, or in the vertical wireway. This secures the terminals inside the unit when access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



Terminal Block
in Vertical Wireway



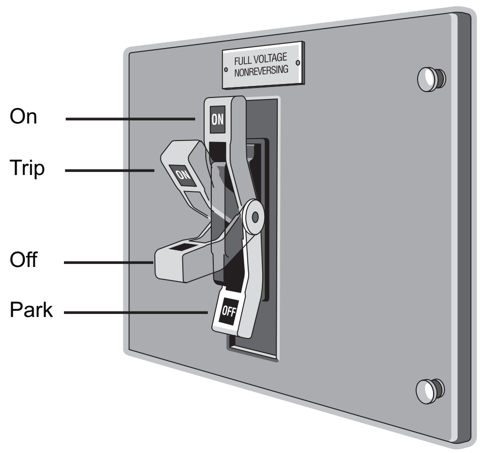
Terminal Block
in Center Position



Terminal Block
in Control Unit

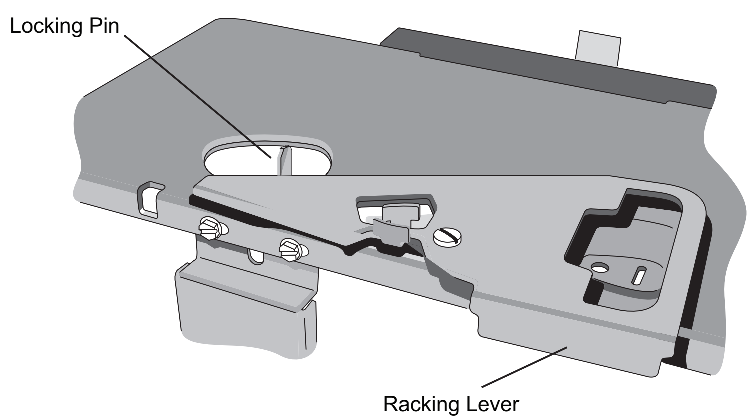
Disconnect Operating Handle

The **disconnect operating handle** has four positions. When the handle is placed in the "PARK" position, the unit door can be opened without the handle interfering. The "ON," "OFF," and"TRIP" position are clearly indicated by color, position, and label. The "TRIP" position applies only to circuit breaker equipped units.



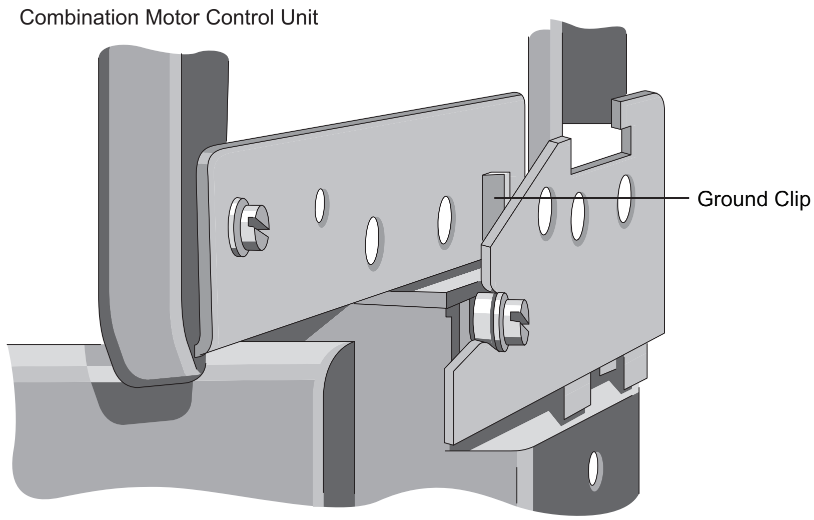
Racking Lever

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.



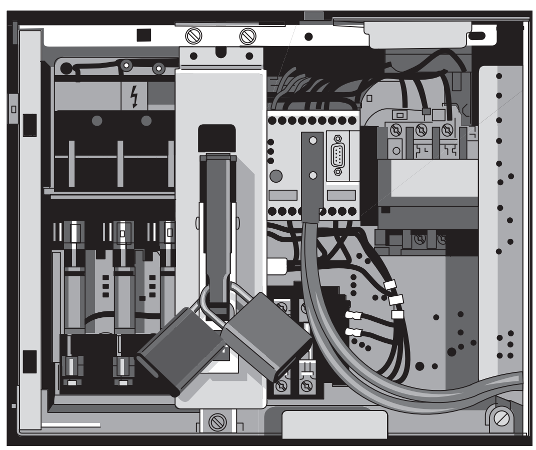
Ground Clip

A copper **ground 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.



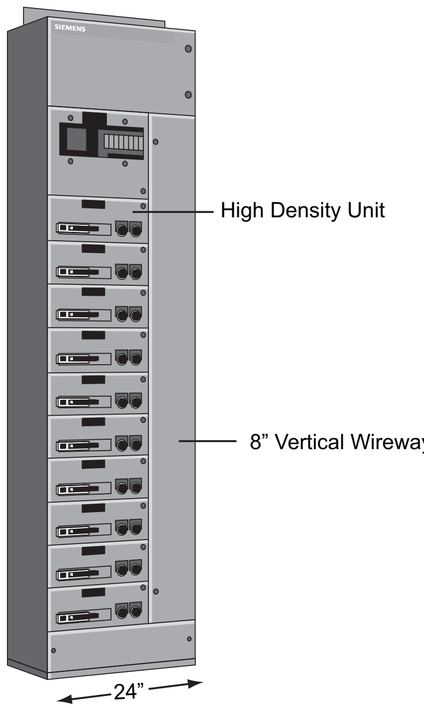
Locking

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



High Density Units

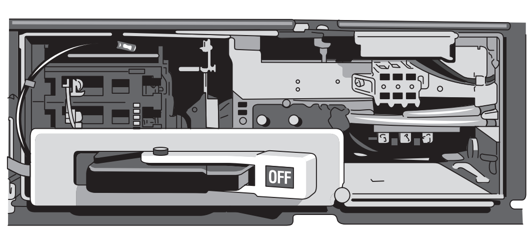
TIASTAR motor control centers are also available with **high density units**. High density units are 6" tall. A maximum of 12 high density units can be installed in 72" of vertical space. High density combination motor control units are available in NEMA size 0 (5 HP) and size 1 (10 HP). High density feeder circuit breaker units are available through 100 amps. 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. High density units can only be provided with 22 mm pilot devices.



Combination Units

High density units have many of the same features as the full size units, but 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.



Review 4

1. Mounting TIASTAR motor control centers back to back allows for ___ combination motor control units to be mounted in 72″ of vertical space.

2. TIASTAR motor control centers are available with horizontal bus current ratings of 600 to ______ amperes.

3. TIASTAR motor control centers are available with vertical bus ratings of 300 and ____ amperes.

4. The operating handle for a combination motor control unit in a TIASTAR motor control center has four positions: ON, ________, OFF, and ________.

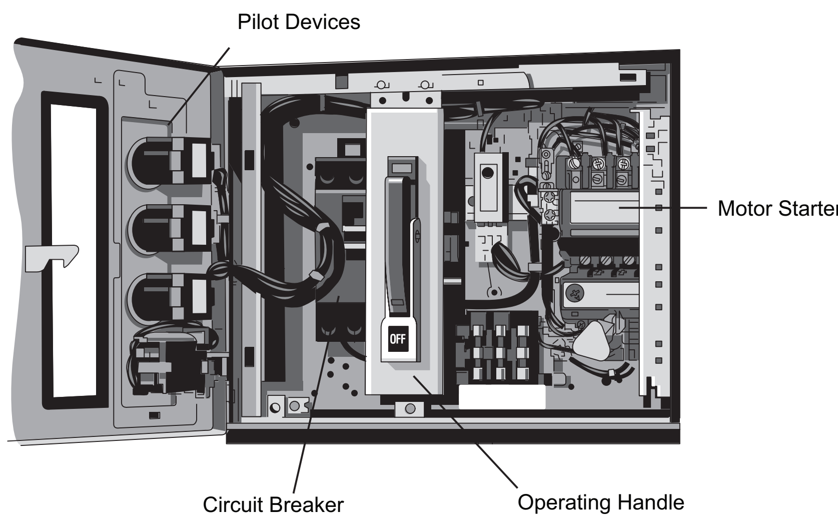
5. TIASTAR motor control centers can accommodate a maximum of ___ high density units in 72″ of vertical space.

Combination Motor Control Units

Motor control centers principally contain **combination motor control units**. A combination motor control unit takes all the elements required to control an AC motor and combines them into one unit.

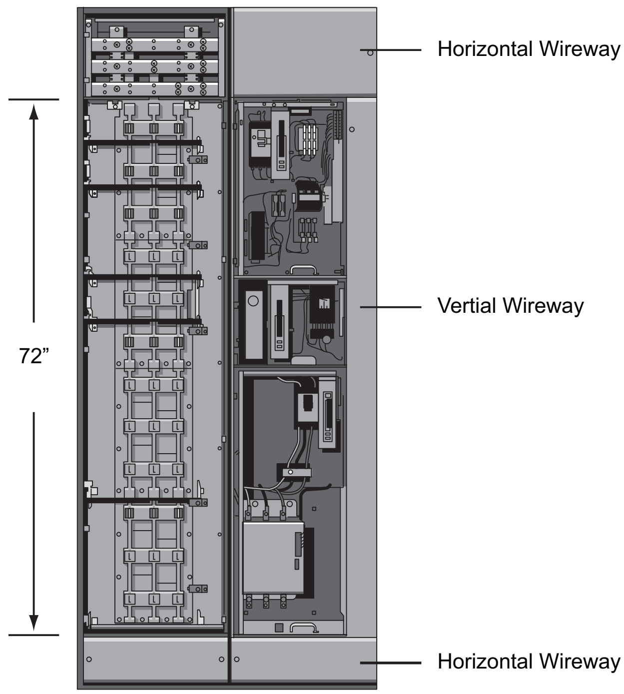
The combination motor control unit in the following example uses a molded case circuit breaker to provide circuit disconnecting means and branch-circuit overcurrent protection. The circuit breaker is opened and closed using the operating handle located on the front of the unit.

The magnetic motor starter is used to start and stop an AC motor and provide overcurrent protection for the motor. Pilot devices, located on the door, serve to provide an operator means to start and stop the motor as well as provide visual indication of the motor's status.



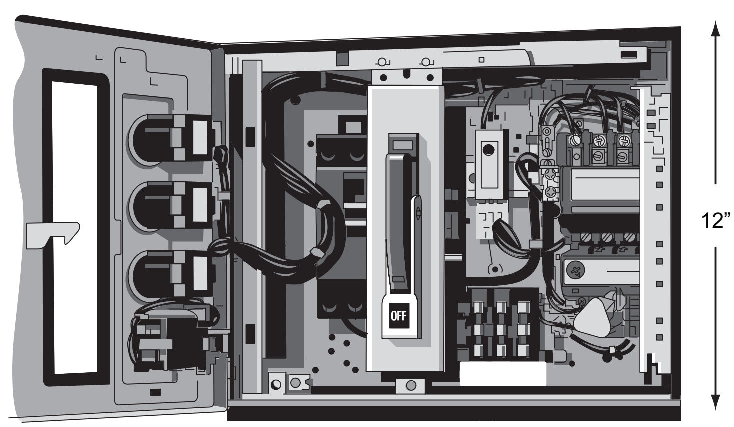
Vertical Space

Most vertical sections provide 72" of **vertical space** for the combination motor control units. As many sections as needed will be assembled together to contain all of the required combination motor control units and other equipment. Wireways run horizontally across the top and bottom of all of the sections. A vertical wireway is provided in each vertical section.



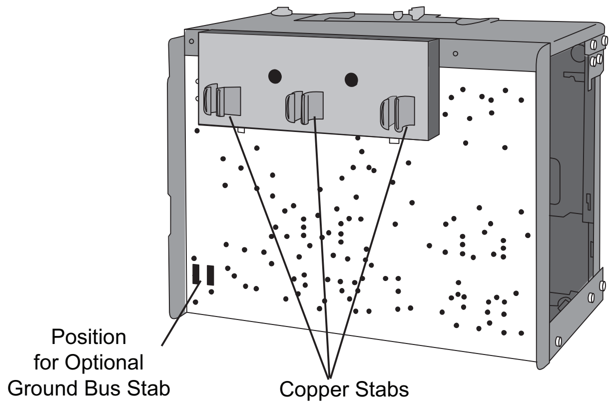
Dimensions

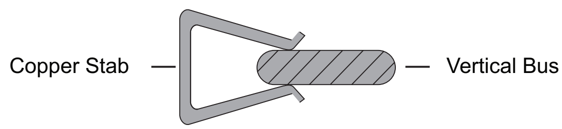
Combination motor control units are designed to fit into modular compartments. Typically, the minimum height of a combination motor control unit is 12", increasing in 6" increments (12", 18", 24", 30", up to 72") as needed. Six combination motor control units that are 12" high will fit in 72" of vertical space.



Installation and Removal

To simplify installation and removal, combination motor control units are provided with self-aligning copper stabs on the back of the control unit. An optional ground bus stab is used when a vertical ground bus is supplied. A fixed mounting is used when the unit is physically too large for stabs or rated for greater than 250 amperes.

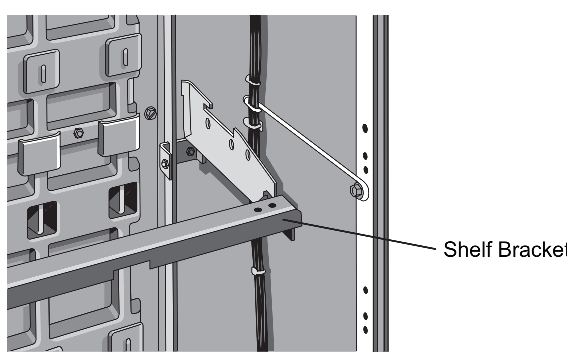




These stabs engage the vertical bus bars, making the electrical connection to the control unit. Siemens incorporates a flat vertical bus bar to ensure positive connection between the stab and the bus bar.

Shelf Brackets

Combination motor control units are supported in the motor control center on **shelf brackets**. The brackets can be easily moved to accommodate different size units. The shelf bracket guides the combination motor control unit to assure positive engagement with the vertical bus and provides the standard grounding means for the combination motor control unit.



Wiring Classes and Types

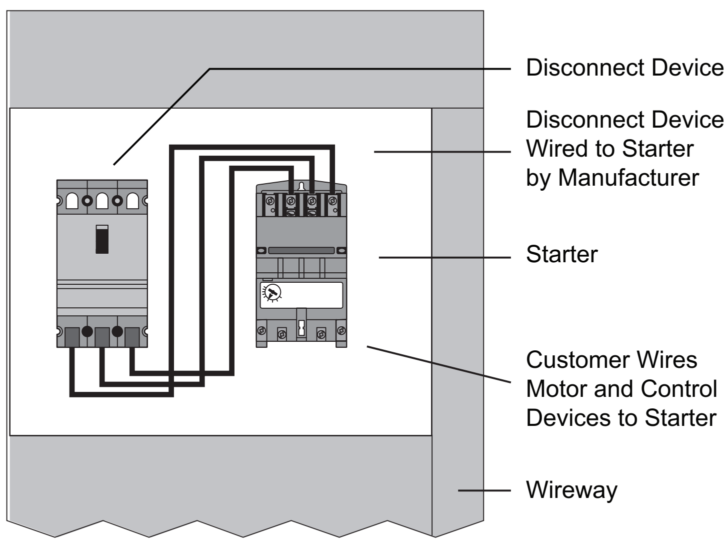
NEMA has established two classification standards (**Class I and Class II**) and three types of wiring (**A, B, and C**) used in the construction of motor control centers. The class and type used in a motor control center are specified by the customer.

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 components. There is no interconnecting wiring between combination motor control units.

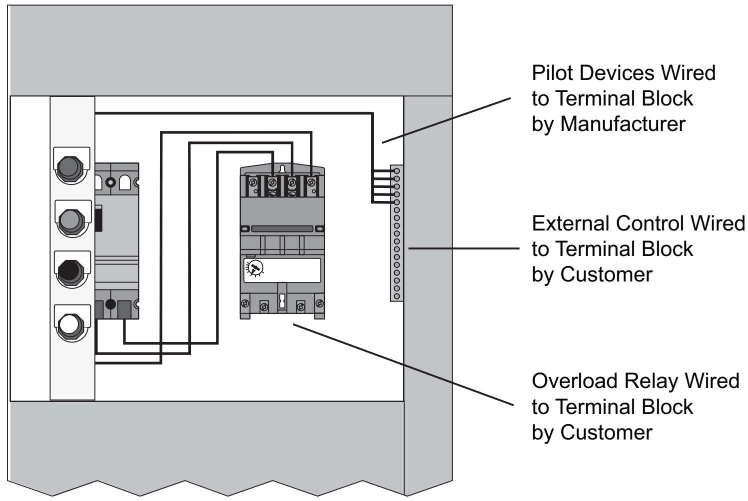


Vertical Section

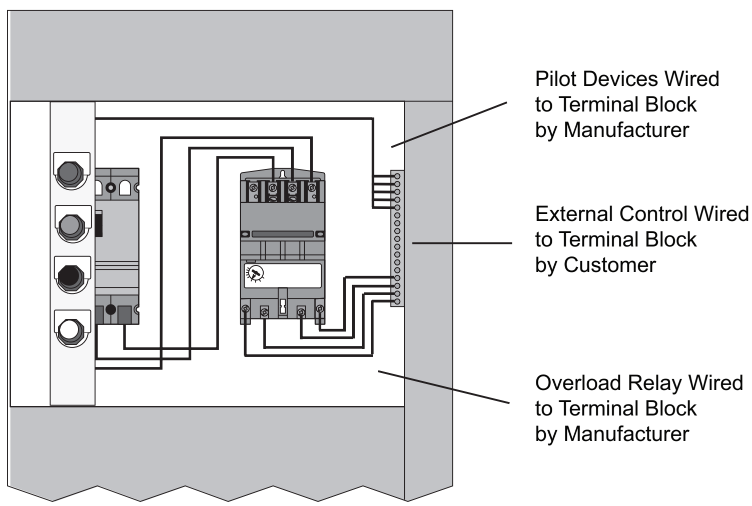
Class I, Type B Wiring

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.

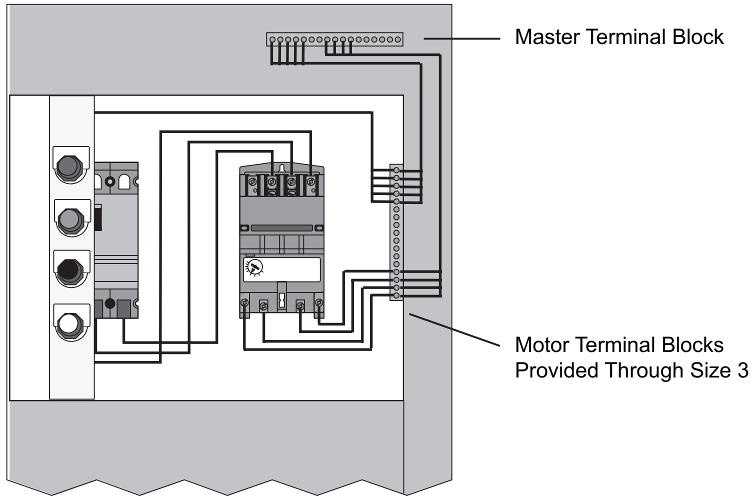


When Type B-t wiring is specified, terminal blocks are furnished near the wireway for control circuit connections and for motor starter leads. Type B-t wiring can be used on starters up to size 3.



Class I, Type C

With **Type C** wiring, a master terminal block is typically 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 is connected directly to unit device terminals.

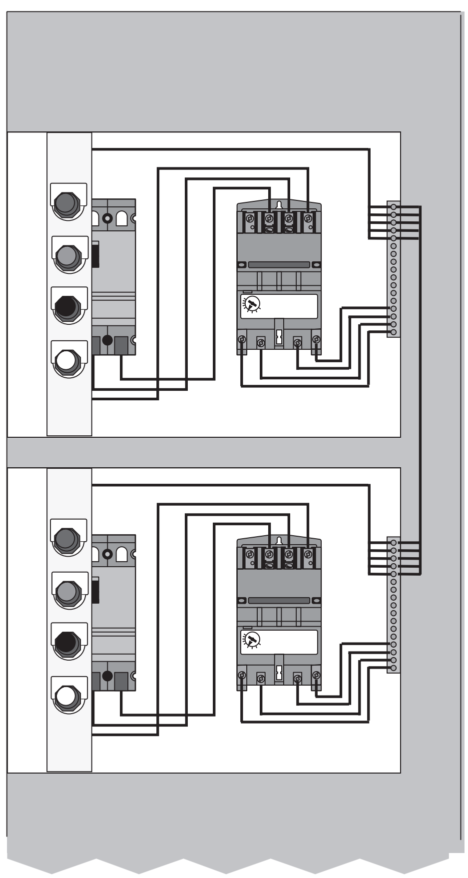


Class II

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.



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 ①		✓	✓	✓	✓	✓	✓
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

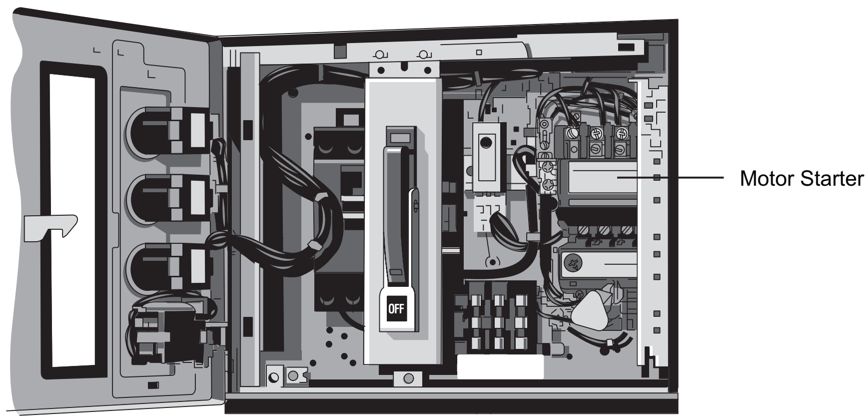
① No load terminals furnished for starters sizes 3½ through 6, main or branch circuit breaker or fusible switches, distribution transformers or lighting panelboards.

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

③ Included on motor control center interconnection diagram.

Motor Starters

The **motor starter** is the heart of the combination motor control unit. The most common type of starter is the full-voltage starter which consists of a contactor and an overload relay. The contactor portion of a motor starter provides the means to remotely start and stop a motor. The overload relay protects the motor from overload conditions.



Starter Ratings

Starter contactors are rated according to size and type of load they handle. The International Electrotechnical Commission (IEC) and NEMA rate contactors and motor starters. IEC is associated with equipment sold in many countries including the United States. NEMA is primarily associated with equipment used in North America. Contactors and starters used in TIASTAR motor control centers are NEMA rated. NEMA specifies sizes from size 00 to size 9, which cover the horsepower range from 2 HP to 1,600 HP at 460 volts.

Size of Controller	Horsepower at 460 V / 60 Hz
00	2
0	5
1	10
2	25
3	50
4	100
5	200
6	400
7	600
8	900
9	1600

Types of Starters

While full-voltage starters are the most common type of starter, other types of starters are also available. The following types of starters are available for use in TIASTAR motor control centers:

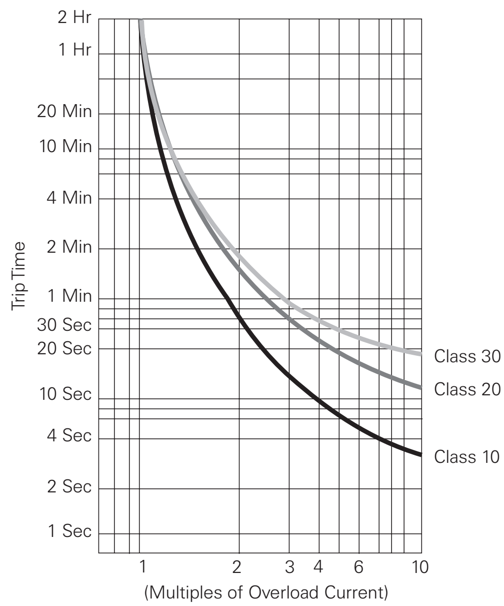
FVNR	Full-Voltage Non-Reversing
FVR	Full-Voltage Reversing
2S1W	Two-Speed One Winding Reconnectable Consequent Pole Unit
2S2W	Two-Speed Two Winding
PW	Full-Voltage Part Winding
RVAT	Reduced-Voltage Auto-Transformer (Closed Transition)
YD	Wye Delta (Open or Closed Transition)
RVSS	Reduced-Voltage Solid State (Soft Starter)
VFD	Variable Frequency Drive

Full-Voltage Starters

Full-voltage starters are sometimes referred to as across-the-line starters because they start an induction motor by applying the full line voltage to the motor's stator windings when the contacts of the motor starter's contactor close. The current that flows through these contacts also flows through the motor starter's overload relay which is designed to protect the motor by removing power in the event of an overload condition.

Overload Relay Trip Classes

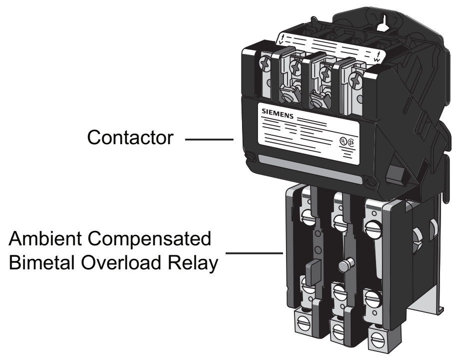
Overload relays are rated by a **trip class**, which defines the length of time it will take for the relay to trip in an overload condition. The most common trip classes are Class 10, Class 20 and Class 30. Class 10 overload relay, for example, has to trip the motor off line in 10 seconds or less at 600% of the full load amps. This is usually sufficient time for the motor to reach full speed. Many industrial loads, particularly high inertia loads, require Class 30. Siemens offers overload relays in all three classes.



Starters used in TIASTAR motor control centers can be equipped with ambient-compensated bimetal overload relays or solid-state overload relays.

Class 14 NEMA Starters

Class 14 NEMA starters are available in NEMA sizes 00 through 4. In addition to whole sizes, this range includes 1¾, 2½, and 3½ sizes, and are available up to 100 HP. These starters are available with Class 10 or 20 ambient-compensated bimetal overload relays.

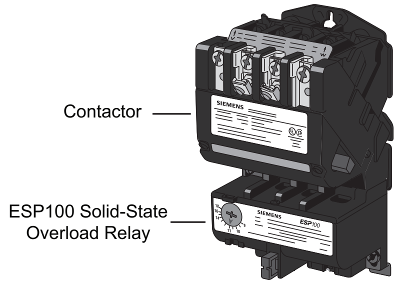


Class 14 ESP100 Starters

Class 14 ESP100 starters use the same contactors as Class 14 NEMA starters equipped with bimetal overload relays (for NEMA sizes 00 through 4), but are supplied with a Class 10, 20, or 30 ESP100 solid-state overload relay. In addition, these starters are available with contactors up to and including NEMA size 8.

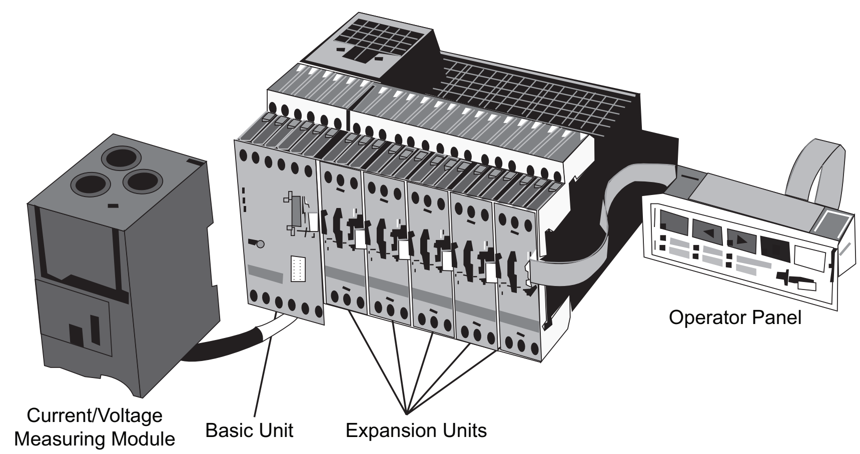
A single ESP100 overload relay replaces at least six size ranges of heaters. Instead of installing heaters the full load amperes (FLA) of the motor is set with a dial.

The ESP100 overload relay protects three-phase motors with full-load ampere (FLA) ratings of 0.25 through 1220 amperes, and single-phase motors with FLA ratings of 0.75 through 16 amperes. All ESP100 overload relays have an adjustable overload ampere range. In addition, the ESP100 also protects the motor by tripping within three seconds if any of the three power phases is lost.



SIMOCODE pro

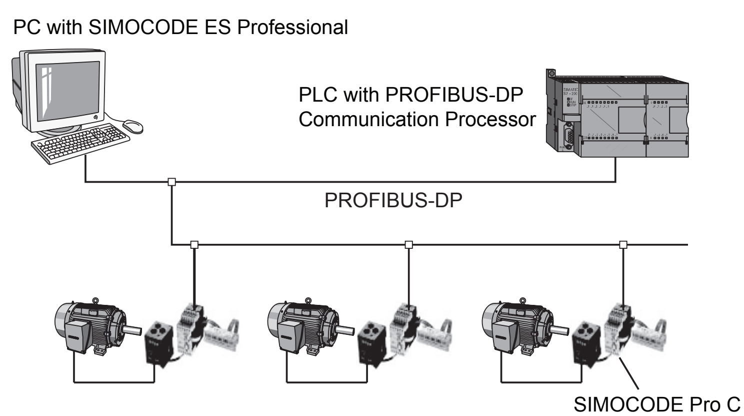
TIASTAR motor control centers may also be equipped with **SIMOCODE pro** systems. SIMOCODE pro is a flexible, modular motor management system that provides multifunctional, solid-state protection for constant speed motors. SIMOCODE pro implements all motor protection and control functions; provides for tracking of operational, diagnostic, and statistical data; and communicates with the automation system via PROFIBUS DP. SIMOCODE pro C includes a Basic Unit, a Current Measuring Module, and an Operator Panel. SIMOCODE pro V includes a Basic Unit, a Current/Voltage Measuring Module, and Operator Panel, but can accommodate up to five expansion modules. Expansion modules are available for digital inputs, analog inputs, ground fault detection, and temperature sensing.



SIMOCODE pro V

PROFIBUS DP

In any complex process, the need for rapid communication is critical. **PROFIBUS DP** is an open communication system based upon international standards developed through industry associations. PROFIBUS DP allows multiple field devices, including SIMOCODE pro Basic Units, to communicate with a PLC or computer.

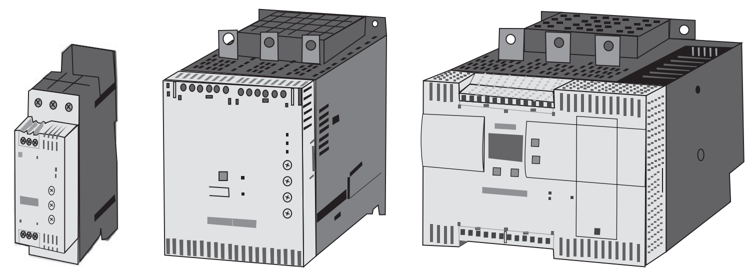


SIRIUS 3R Soft Starters

Solid-state, reduced-voltage controllers or **soft starters** limit motor starting current and torque by ramping up the voltage applied to the motor during the selectable starting time.

Soft starters accomplish this by gradually increasing the portion of the power supply cycle applied to the motor windings, a process sometimes referred to as phase control. Soft starters also allow this phase control process to be applied in reverse when the motor is being stopped. This controlled starting and stopping significantly reduces stress on connected devices and minimizes line voltage fluctuations.

The **SIRIUS 3R** modular system of components incorporates a broad range of soft starters that includes SIRIUS 3RW30/31 and 3RW40 soft starters for standard applications, and SIRIUS 3RW44 soft starters for high feature applications.



3RW30/31 3RW40 3RW44

SIRIUS 3RW30/31 soft starters have an especially compact design that saves space and easily integrates with other SIRIUS 3R components. SIRIUS 3RW30/31 soft starters are available for supply voltages up to 575 VAC and for operating current up to 100 amperes at 40º C. Potentiometers on the front of the unit provide settings for starting time, starting voltage, and stopping time.

SIRIUS 3RW40 soft starters have all the advantages of 3RW30/31 soft starters, but have more features and are available for operating current up to 432 amperes at 40º C. Potentiometers on the front of the unit provide settings for current limit, starting voltage, and starting and stopping times of the voltage ramp.

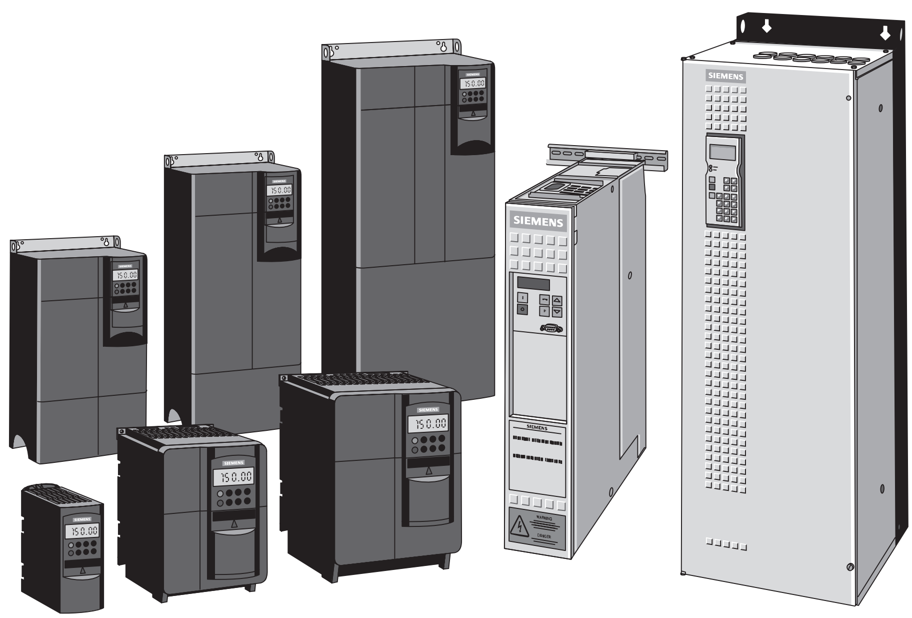
SIRIUS 3RW44 soft starters make soft starting and stopping attractive for difficult starting applications and combine a high degree of functionality, simplified operational settings, and extensive diagnostics. SIRIUS 3RW44 soft starters are available for operating current up to 1214 amperes at 40º C and can be equipped with a Profibus DP communication option.

Variable Frequency Drives

An AC drive is an electronic device that, in addition to controlling speed, may control other quantities, but that depends upon the capabilities of the drive and the needs of the application. Because the type of motor being controlled is often an AC induction motor and the speed of this motor is dependent upon the frequency of the AC power applied, an AC drive is often referred to as a **variable frequency drive**, or **VFD** for short.

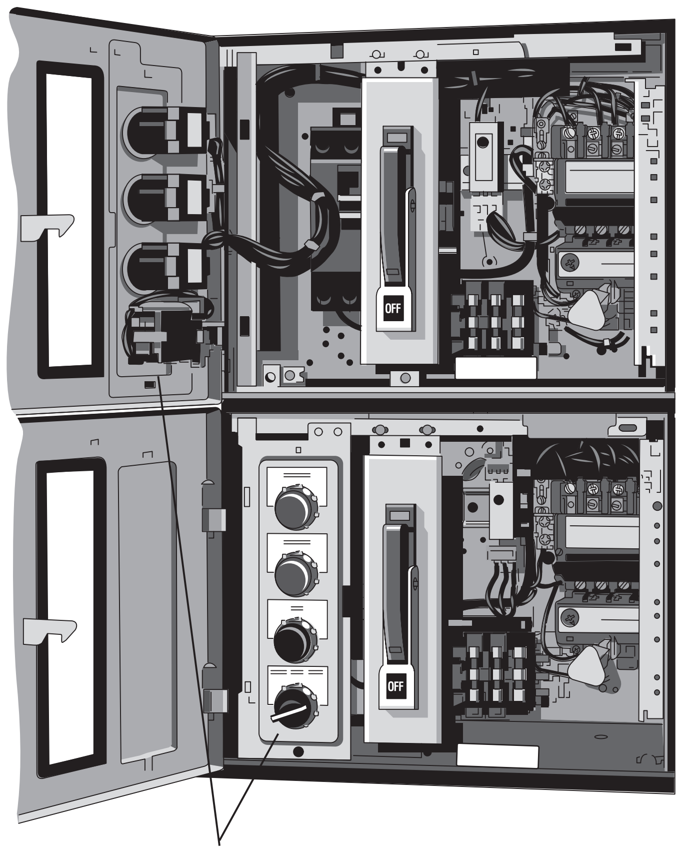
Siemens offers a broad range of AC drives to meet widely varying application requirements. TIASTAR motor control centers can accommodate an increasing selection of AC drives including:

- Siemens MICROMASTER 4 AC drives up through 150 HP at 480 VAC for constant torque applications or up through 200 HP at 480 VAC for variable torque applications.
- Siemens SED2 AC drives for heating, ventilation, and air conditioning (HVAC) applications.
- Siemens MASTERDRIVE 6SE70 AC drives up through 250 HP at 480 VAC for constant torque applications or up through 300 HP at 480 VAC for variable torque applications.



Pilot Devices

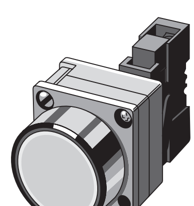
A variety of **pilot devices** can be used on Siemens motor control centers. Pilot devices include pushbuttons, selector switches, and pilot lights.



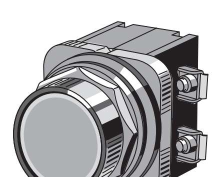
Pilot Devices Panels

Pushbuttons

A **pushbutton** is a control device used to manually open and close a set of contacts. Pushbuttons are available in a flush mount, extended mount, with a mushroom head, illuminated, or non-illuminated. Pushbuttons come with either normally open, normally closed, or a combination contact block.



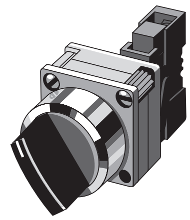
22 mm SIGNUM
3SB3 Pushbutton



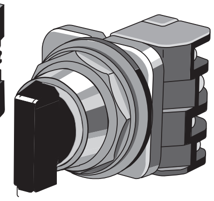
30 mm Class 52
Pushbutton

Selector Switches

Selector switches are also used to manually open and close contacts. Selector switches can be maintained, spring return, or key operated. Selector switches are available in 2-, 3-, and 4-position types.



22 mm SIGNUM
3SB3 Selector Switch

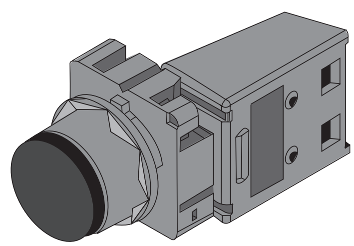


30 mm Class 52
Selector Switch

Pilot Lights

Pilot lights provide visual information of the circuit's operating condition. Pilot lights are normally used for ON/OFF indication, caution, changing conditions, and alarm signaling. Pilot lights are available with a variety of lens colors, such as red, green, amber, blue, white, or clear.

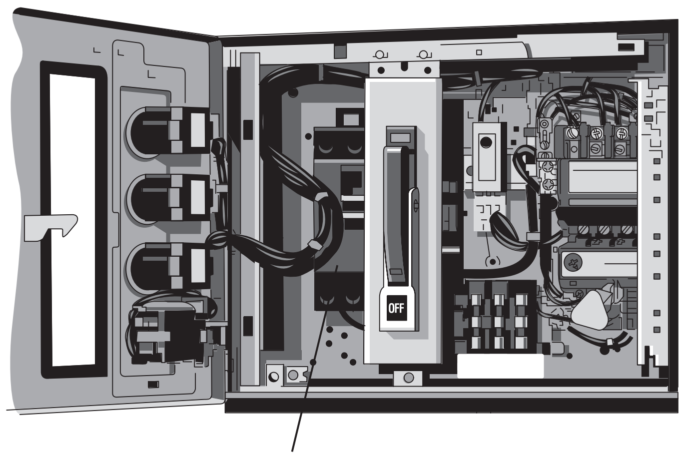
22 mm SIGNUM
3SB3 Indicator Light



30 mm Class 52
Indicator Light

Circuit Breakers

Circuit breakers are typically used as disconnect devices in combination motor control units. Circuit breakers provide a manual means of energizing and de-energizing a circuit. In addition, circuit breakers provide automatic overcurrent protection of a circuit.



Circuit Breaker

There are three types of circuit breakers that are typically used in motor control centers. **Instantaneous trip-only circuit breakers**, also referred to as **magnetic-only** or **Type ETI circuit breakers**, provide short circuit protection, but do not provide overload protection. Type ETI circuit breakers are commonly used in combination motor control units where a motor starter, such as a Siemens Class 14 motor starter, provides overload protection.

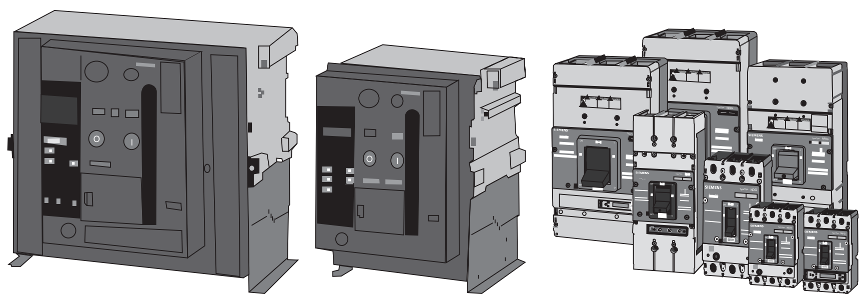
ETI trip ranges are selected to meet maximum settings per *NEC®* table 430.52 and Article 430.52(C)(3). Refer to the *National Electical Code®* for additional information.

Thermal-magnetic circuit breakers have both overload and instantaneous trip features. When an overload condition exists, the excess current generates heat, which is detected in the circuit breaker. After a short period of time, depending on the rating of the breaker and the amount of the overload, the breaker trips, disconnecting the load from the voltage source. If a short circuit occurs, the breaker responds instantaneously to the fault current and disconnects the circuit.

A thermal-magnetic circuit breaker may be used as a main disconnect for the motor control center or as part of feeder tap unit. In addition, some motor control centers have equipment, such as a panelboard, that incorporates thermal-magnetic circuit breakers.

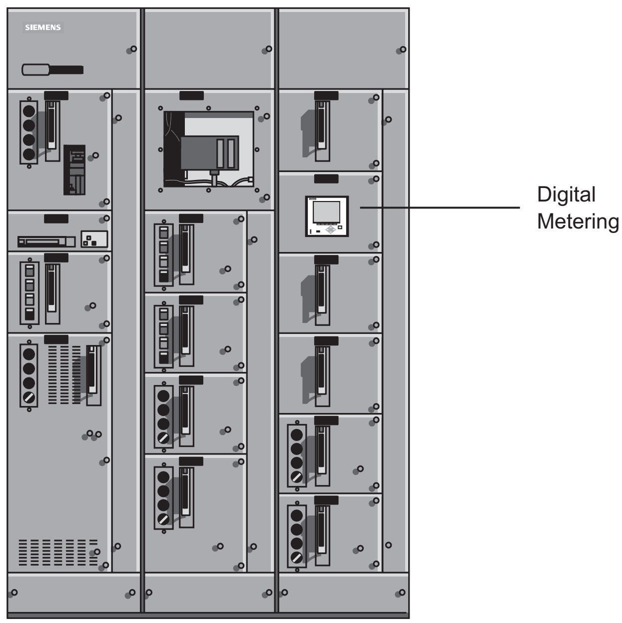
Solid state circuit breakers are another type of circuit breaker available for motor control center main, feeder, or other applications. This type of circuit breaker features a solid-state trip unit with multiple adjustments to optimize circuit breaker trip performance. In addition, solid-state circuit breakers often can incorporate optional communication features. For example, Siemens WL circuit breakers offer integrated communications over PROFIBUS to provide real-time data on breaker status and power utilization.

Siemens offers a broad range of circuit breakers and accessories including circuit breakers in all three of the categories mentioned.



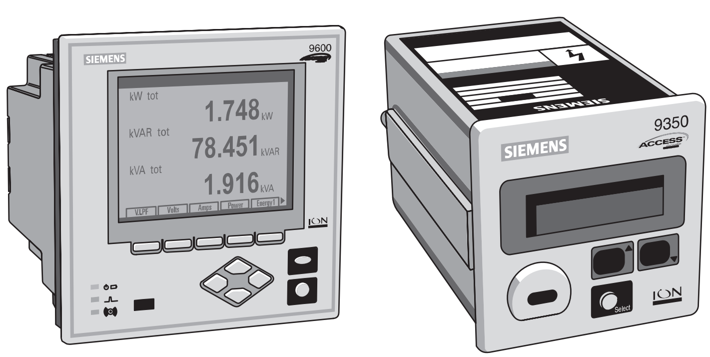
Other Types of Devices in MCCs

In addition to devices used to directly control or protect motors and related equipment, TIASTAR motor control centers can incorporate a variety of other devices such as power meters, programmable logic controllers (PLCs), power distribution equipment, etc.



Digital Metering

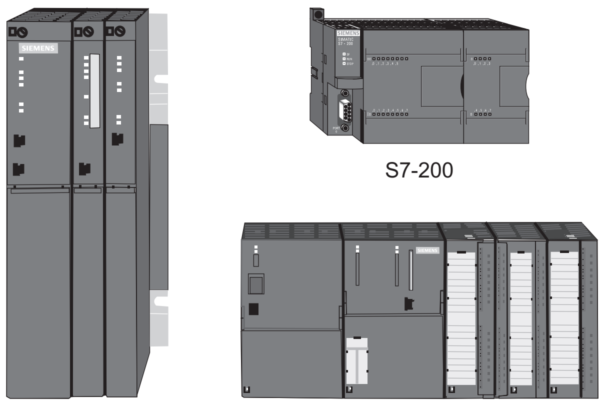
Power meters can be included in TIASTAR motor control centers to measure real-time RMS values of phase currents, phase and line voltages, power usage, power factor, KW, frequency, and peak demand. Siemens offers a variety of **digital meters** that can replace multiple analog meters and can communicate with other devices as part of the Siemens ACCESS™ system.



PLCs

Programmable logic controlers (PLCs) are widely used for machine and process control. TIASTAR motor control centers can accommodate selected models of PLCs, such as Siemens SIMATIC S7-200, S7-300, and S7-400.

A PLC system incorporates modules or points which are connected to switches and sensors. Information from these inputs is used by the PLCs central processing unit (CPU) to determine the status of output devices which are connected to the PLC via output modules or points. Devices controlled by PLCs can include motor starters, contactors, solenoids, AC drives, etc. In addition, many PLCs are also equipped to accept signals from analog sensors and can generate analog outputs.



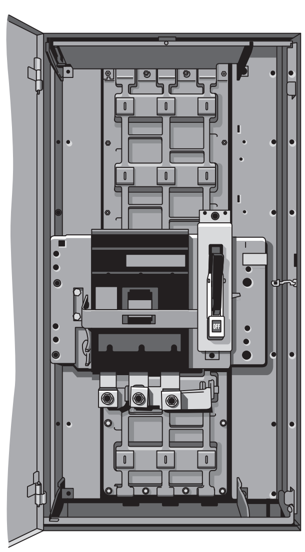
S7-200

S7-400 S7-300

Other Devices

TIASTAR motor control centers can also incorporate a variety of other devices such as relay panels, panelboards, and feeder-tap units.

A feeder-tap unit, such as the one shown in the following illustration, is typically used to supply power to non-motor loads located downstream of the motor control center.



UL Marks

A TIASTAR motor control center typically has a **UL mark** for the structure and bus, and each control unit also caries a UL mark. Some TIASTAR MCCs may contain special sections or units that have not been UL tested and therefore may not be able to carry the UL mark. Some municipalities may not allow devices that do not carry the UL mark.

Review 5

1. A Class _____ overload relay will trip within 10 seconds at 600% of full load amperes.

2. The ESP100 solid-state overload relay trips within ___ seconds of loss of any of the three power-supply phases.

3. A NEMA size 5 controller is rated for ________ HP.

4. Which of the following devices can be used in a TIASTAR motor control center?

   a. SIMOCODE pro system
   b. SIRIUS 3R soft starter
   c. Class 14 ESP100 starter
   d. SIMATIC S7 PLC
   e. MICROMASTER, SED2, or MASTERDRIVE 6SE70 drive
   f. all of the above

5. A TIASTAR motor control center can incorporate a other devices such as ________ unit to supply power to non-motor loads located downstream of the motor control center.

TIASTAR Ordering Information

The following information will be essential when ordering a TIASTAR motor control center.

- 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)
- Ampere 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, RVAT, RVSS, VFD, or YD

- 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
- Detailed quotation

Review Answers

Review 1 1) d; 2) Totally Integrated Automation; 3) three; 4) two.

Review 2 1) Underwriters Laboratories; 2) overload; 3) short-circuit 4) 200,000; 5) voltage.

Review 3 1) 1; 2) 600; 3) Bus bars; 4) phases, phase.

Review 4 1) 12; 2) 2500; 3) 600; 4) Trip, Park; 5) 12.

Review 5 1) 10; 2) 3; 3) 200; 4) f; 5) feeder-tap.

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. SIRIUS
   b. SIMATIC
   c. MICROMASTER
   d. TIASTAR

2. Article ________ of the *National Electrical Code®* requires overcurrent protection for MCCs.

   a. 430.94
   b. 450.5
   c. 427.6
   d. 501.12

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 nominal height of a TIASTAR motor control center vertical section is ________ inches, not including the 1 1/8 inch standard base channel.

   a. 72
   b. 40
   c. 90
   d. 20

5. The maximum shipping width of a TIASTAR 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 modular motor management system available in C and V versions.

   a. SIRIUS 3RW40
   b. SED2
   c. ESP100
   d. SIMOCODE pro

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 TIASTAR motor control center.

    a. 2
    b. 4
    c. 6
    d. 8

12. TIASTAR motor control centers are manufactured with a maximum temperature rise of ________ over 40°C ambient temperature.

    a. 25°C
    b. 50°C
    c. 65°C
    d. 75°C

13. Type B-t wiring can be used on starters up to size ________.

    a. 3
    b. 5
    c. 6
    d. 7

14. No terminal blocks are supplied on Class I, Type ________ wiring.

    a. A
    b. B-t
    c. B-d
    d. C

15. ________ motor control center wiring is generally specified when a group of motors requires sequencing, interlocking, or interconnecting.

    a. Class I, Type B-t
    b. Class II
    c. Class I, Type B-d
    d. Class I, Type C

16. Standards for motor control centers are provided by which of the following organizations?

a. NFPA
b. NEMA
c. UL
d. All the above

17. TIASTAR high density units take up ________ inches of vertical space.

a. 4
b. 12
c. 6
d. 18

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

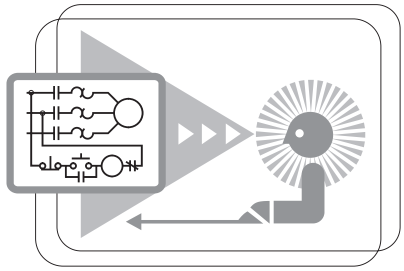
19. The operating handle of a TIASTAR combination motor control unit is place in the ________ position to remove the unit from the motor control center.

a. On
b. Off
c. Park
d. Tripped

20. The TIA portion of the TIASTAR name stands for ________.

a. Telecommunication Industry Association
b. True Industrial Automation
c. Total Information Available
d. Totally Integrated Automation

quickSTEP Online Courses



quickSTEP online courses are available at http://www.sea.siemens.com/step.

The quickSTEP training site is divided into three sections: Courses, Downloads, and a Glossary. Online courses include reviews, a final exam, the ability to print a certificate of completion, and the opportunity to register in the Sales & Distributor training database to maintain a record of your accomplishments.

From this site the complete text of all STEP courses can be downloaded in PDF format. These files contain the most recent changes and updates to the STEP courses.

A unique feature of the quickSTEP site is our pictorial glossary. The pictorial glossary can be accessed from anywhere within a quickSTEP course. This enables the student to look up an unfamiliar word without leaving the current work area.