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Introduction

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

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

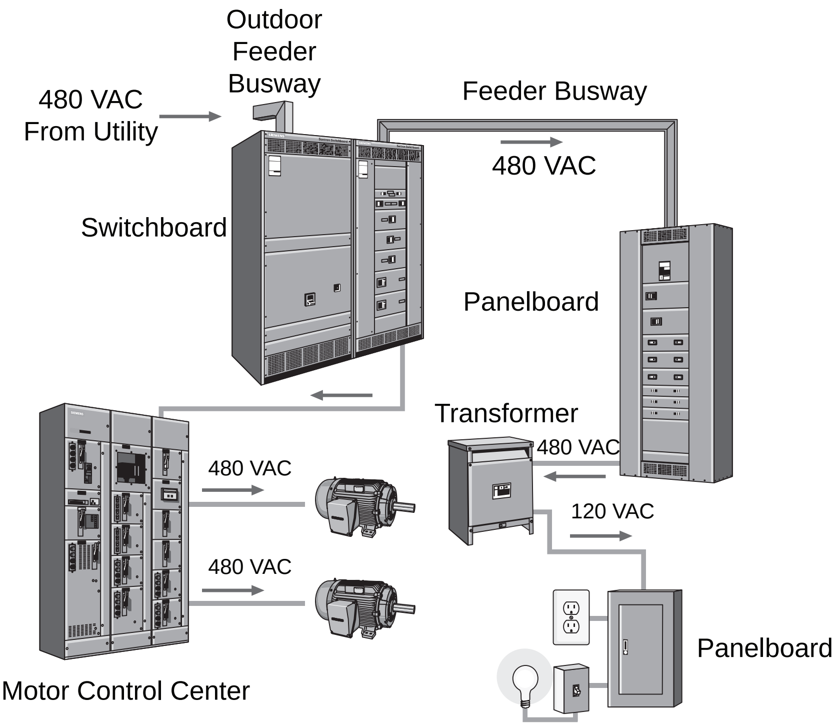
- Explain the role of motor control centers (MCCs) in a distribution system
- Define an MCC according to NEMA and UL
- Explain the need for circuit protection
- Identify various components of a MCC
- Explain the difference between the various classifications and types of motor control center wiring
- Describe key features of the tiastar MCCs
- Describe key features of tiastar arc resistant MCCs
- Explain the term smart MCC
- Identify key advantages of smart MCCs
- Describe key features of tiastar smart MCCs

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**.

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

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. Unlike other types of power distribution equipment, which are used with a variety of load types, motor control centers primarily control the distribution of power to electric motors.

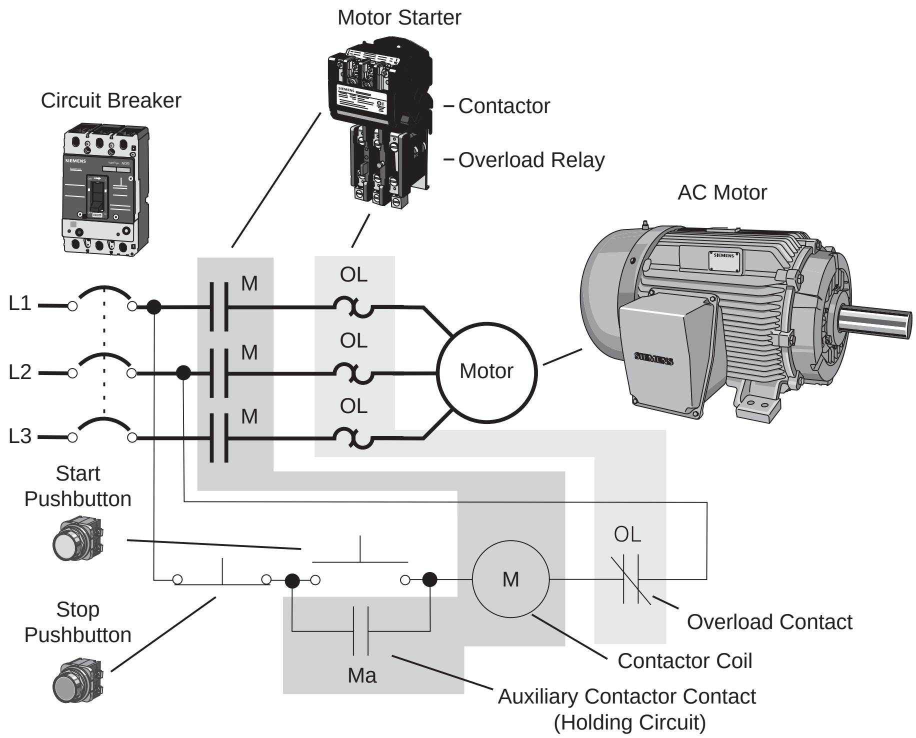


Basic Motor Control

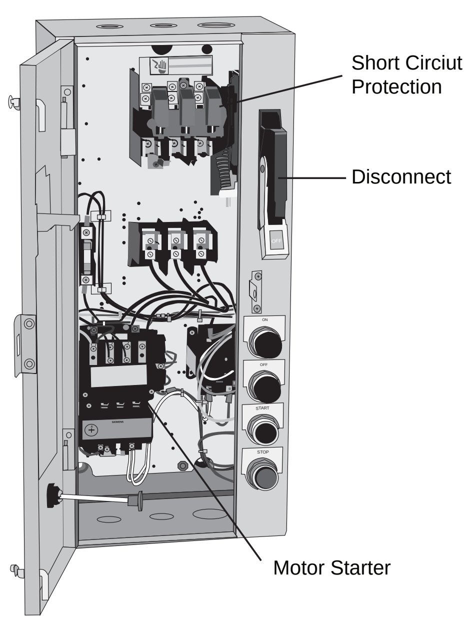
Wherever motors are used, they must be controlled. In **Basics of Control Components** you learned how various control products are used to control the operation of motors. For example, the most basic type of AC motor control, involves turning the motor on and off. This is often accomplished using a 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 done electromechanically and often requires using start and stop pushbuttons and other 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.



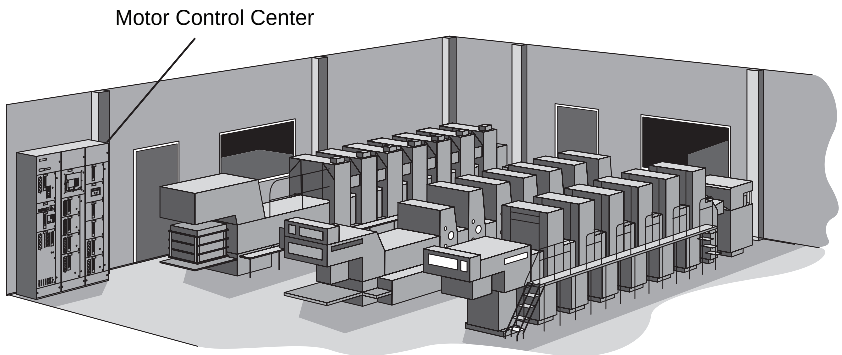
Typically one motor starter controls one motor. When only a few geographically dispersed AC motors are used, the circuit protection and control components may be in an enclosure mounted close to the motor.



Motor Control Centers

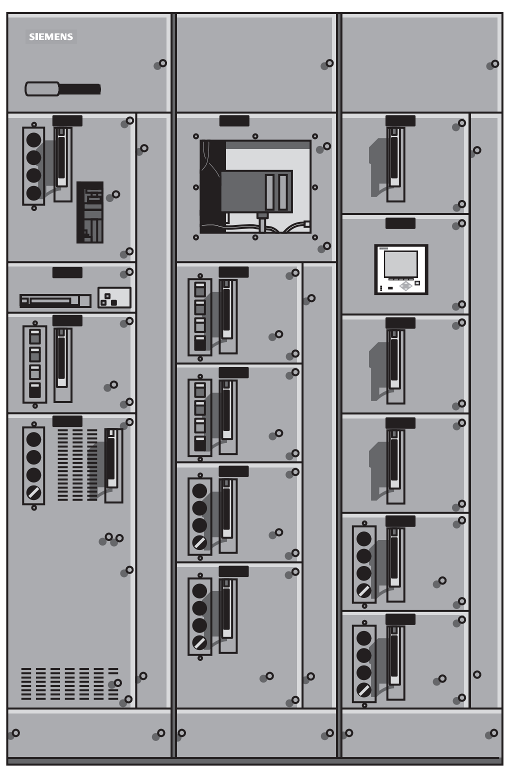
In many commercial and industrial applications, quite a few electric motors are required, and it is often desirable to control some or all of the motors from a central location. The apparatus designed for this function is the **motor control center (MCC)**.

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 Motor Control Center

Advantages of Siemens tiastar MCCs

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

- Ruggedness and reliability
- Reduced time needed for installation and startup
- Space saving design
- Excellent component selection
- Simplicity in adding special components
- Ease of future modifications.

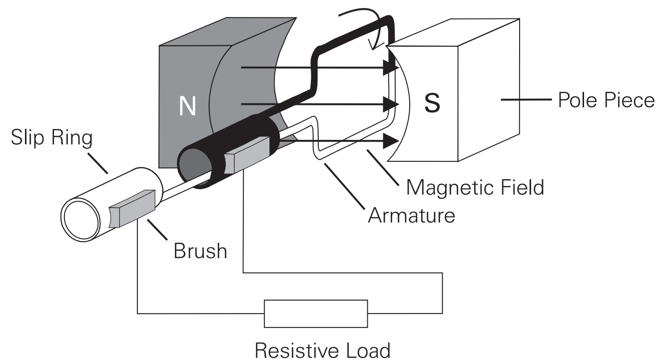
TIA

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 is the cornerstone of development for a wide variety of Siemens products.

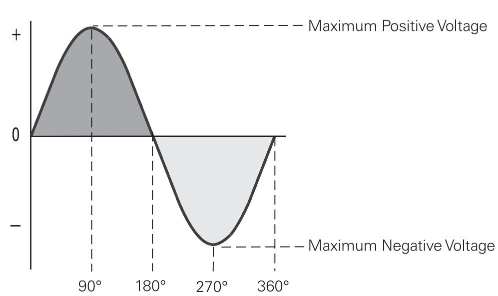
TIA is important not just because it simplifies the engineering, startup, and maintenance of systems developed using Siemens products, but also because it lowers the life-cycle costs for systems incorporating these products. Additionally, by reducing the engineering and startup time and expense for systems, 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.



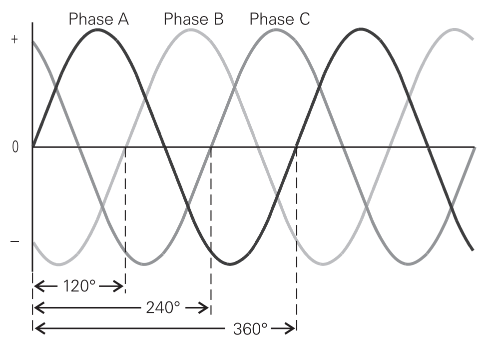
If the rotation of the AC generator were tracked through a complete revolution of 360°, it could be seen that during the first quarter of a revolution voltage would increase until it reached a maximum positive value at 90°. Voltage would decrease during the second quarter of revolution until it reached 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.



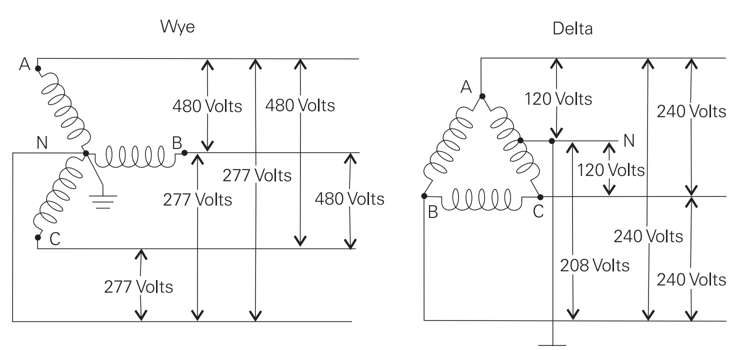
If the armature of the simple two-pole AC generator shown here rotates 3600 times per minute (3600 RPM), the generator produces 60 cycles of voltage per second, or 60 hertz (Hz). If the generator had four poles, it would generate the needed 60 Hz with a rotational speed of 1800 RPM.

Three-Phase Voltage

In most large commercial and industrial motor applications, **three-phase power** 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.



Motor control centers receive this power through complex distribution systems which include power distribution lines and related equipment. 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 transformers. Keep in mind that these are only examples and other transformer secondary voltages are possible.

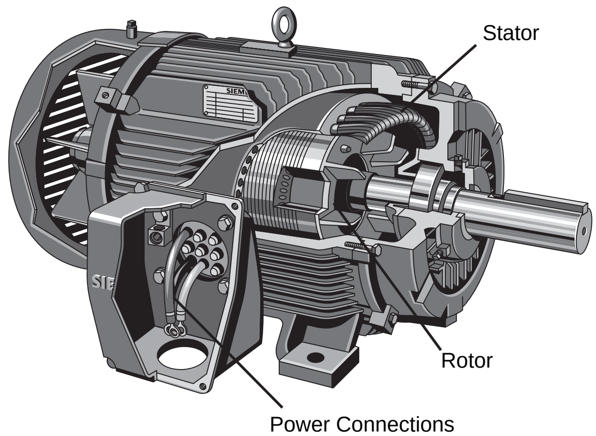


A - B	480 volts
B - C	480 volts
C - A	480 volts
A - N	277 volts
B - N	277 volts
C - N	277 volts

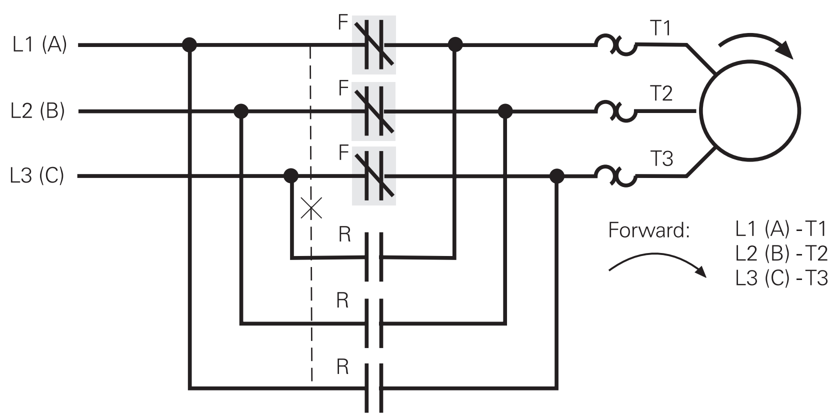
A - B	240 volts
B - C	240 volts
C - A	240 volts
A - N	120 volts
B - N	208 volts
C - N	120 volts

Motor Rotation

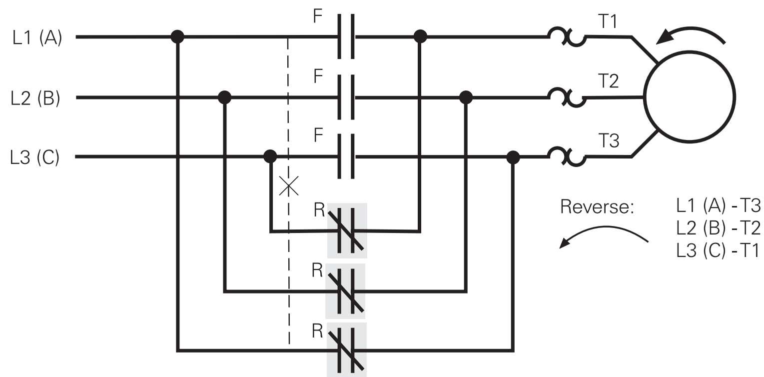
Three-phase voltage is used throughout large commercial and industrial facilities to run AC motors. An AC motor is made up of a stationary member, called a stator, and a rotating member, called a rotor. Three-phase AC power is applied to the stator through the power connections.



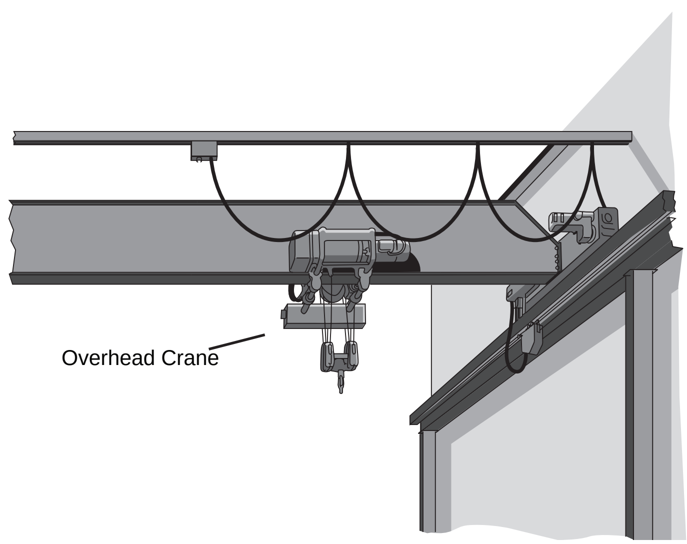
The direction a three-phase AC motor rotor turns depends on the phase sequence of the incoming power supply. In the following example, L1 (A) is connected to motor lead T1, L2 (B) is connected to motor lead T2, and L3 (C) is connected to motor lead T3. When power is applied through the "F" contacts,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



However, if any two of the three power supply leads are reversed, the motor runs in the opposite direction. In the following 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 (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. Ruggedness and reliability
   b. Reduced time needed for installation and startup
   c. Space saving design
   d. All the above

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

3. In most large commercial and industrial motor applications, ________-phase power 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.

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.

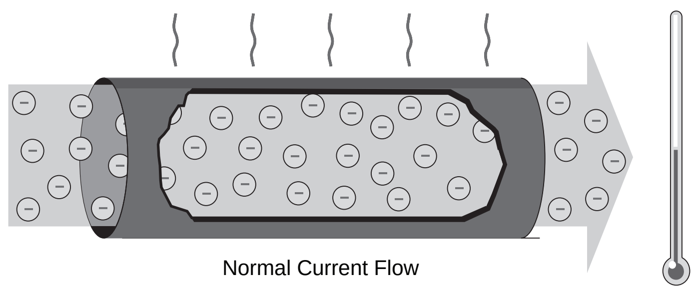
Need for Circuit Protection

Some of the components described in this course are designed to protect circuits and/or motors from overcurrents. In order to understand these components, you must have a clear understanding of what an overcurrent condition is and why overcurrent protection is needed.

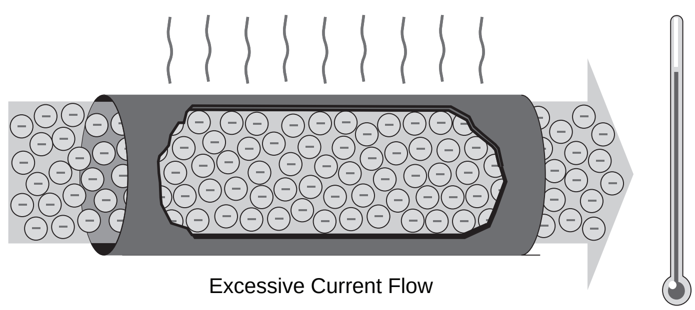
Current and Temperature

To begin with, current flow always generates heat. The amount of heat generated is proportional to both the amount of current flow and the resistance of the conductive path. Keep in mind that conductors can be damaged by excess heat. For that reason, each conductor has a continuous current rating, also called its **ampacity**.

Excessive current is referred to as **overcurrent**. An overcurrent may result from a short circuit, overload, or ground fault. The first two types of overcurrent conditions are pertinent to this discussion.



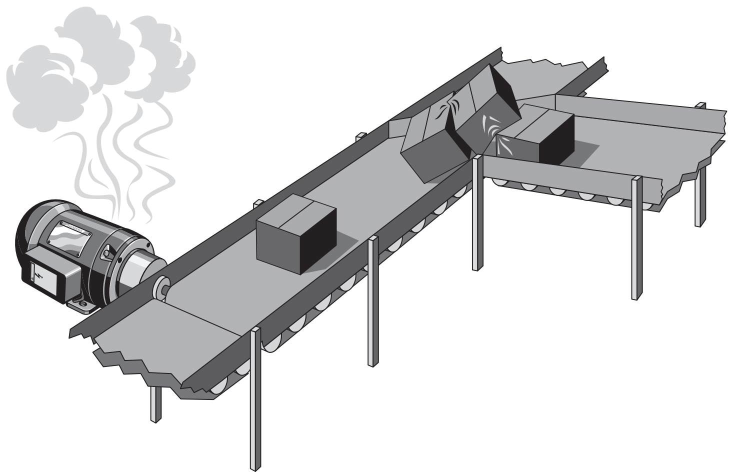
Normal Current Flow



Excessive Current Flow

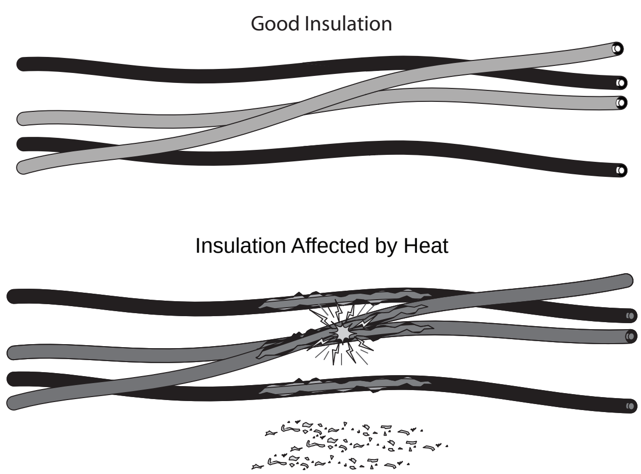
Overloads

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 capabilities. 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.



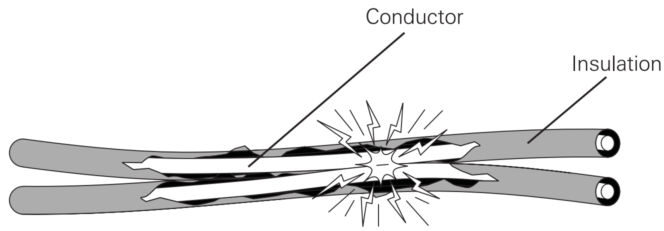
Conductor Insulation

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.



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.

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

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

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

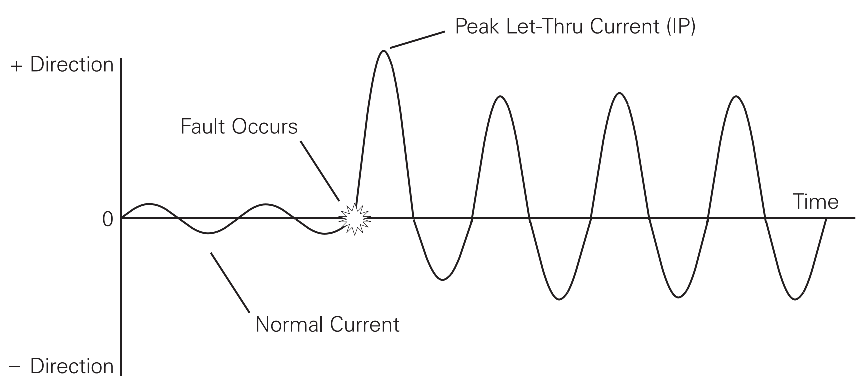
When a short circuit develops, resistance drops. If resistance drops to 24 milliohms, current will be 10,000 amperes.

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

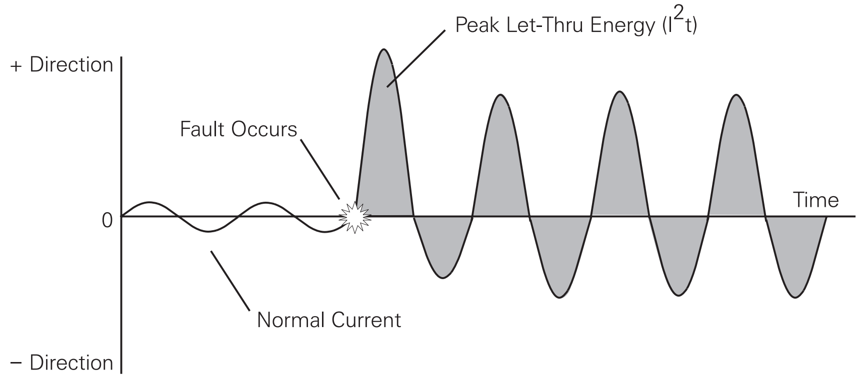
$$I = 10{,}000 \text{ amperes}$$

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 and circuit components.

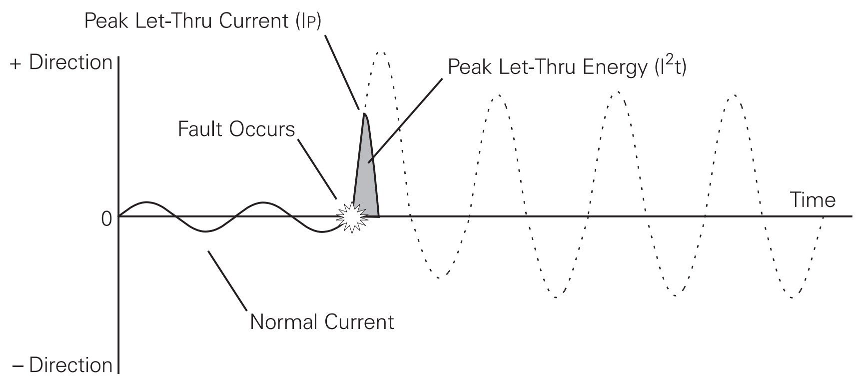


Associated with the peak let-thru current is **peak let-thru energy (I^2t)**. For an unprotected circuit, this energy is often capable of dramatic destruction of equipment and is a serious safety concern.



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 a short circuit occurs, limiting peak let-thru current (I_P) and energy (I^2t).



Main Overcurrent Protection Devices

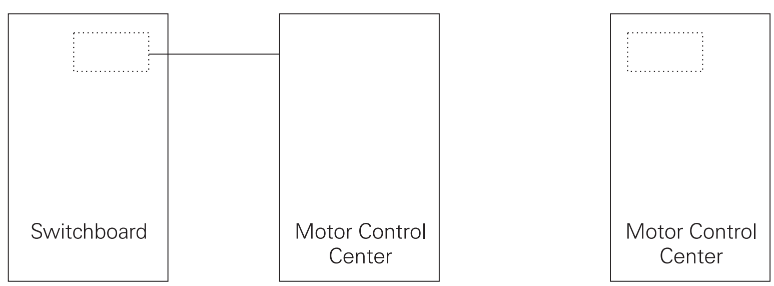
NEC® Article 240

NEC® **Article 240** covers **overcurrent protection** and **overcurrent protection devices** with nominal voltage ratings of 600 volts or less. This article applies to many types of equipment and provides important overcurrent protection guidelines. Refer to this article for additional details.

As described later in this course, various types of overcurrent protection devices are used in the combination motor control units found in motor control centers as well as in other types of circuits.

NEC® Article 430.94

In addition, NEC® **Article 430.94** requires a motor control center to have a **main overcurrent protection device** located in or ahead of the motor control center. Ahead of the motor control center means between the MCC and its source of supply. This main device must provide overcurrent protection in accordance with NEC® Article 240 and must have a continuous current rating or setting that does not to exceed the ampere rating of the MCC's main bus.



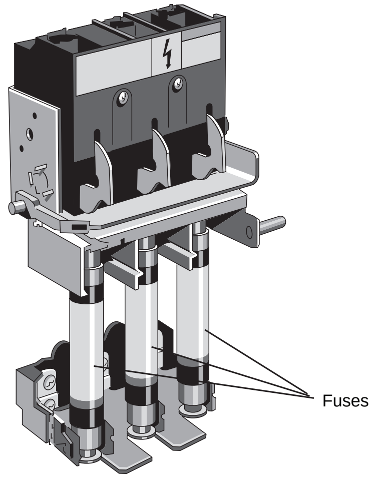
Overcurrent-Protection Device Ahead of MCC

Main Overcurrent-Protection Device Located in MCC

An overcurrent protection device must be able to recognize the difference between an overload 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

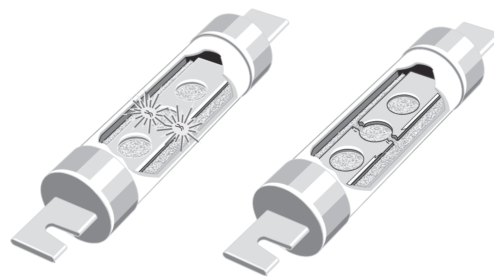
A **fusible disconnect switch** is one type of device used to provide overcurrent protection. Properly sized fuses located in the switch open the circuit when an overcurrent condition exists.



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

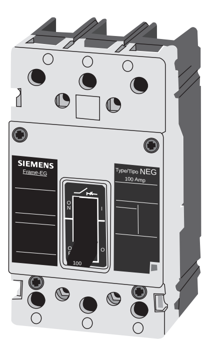
Fuses are grouped into classes based on their operating and construction characteristics. Each class has an **interrupting rating (IR)** in amperes, which is the amount of fault current this class of fuses is capable of interrupting without destroying the fuse casing. Fuses are also rated according to 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 some of the **fuse classes** and their ratings.

Fuse Class	Fuse Overload Characteristic	Ampere Ratings	AC Voltage Ratings	Interrupting Rating
H	Renewable Fuses, Fast-acting	1-600 A	250 V, 600 V	10,000 A
K5	Fast-acting	1-600 A	250 V, 600 V	50,000 A
J	Time-delay	0.8-600 A	600 V	200,000 A
J	Fast-acting	1-600 A	600 V	200,000 A
RK1	Time-delay	0.1-600 A	250 V, 600 V	200,000 A
RK1	Fast-acting	1-600 A	250 V, 600 V	200,000 A
RK5	Time-delay	0.1-600 A	250 V, 600 V	200,000 A
T	Fast-acting	1-1200 A	300 V, 600 V	200,000 A
L	Time-delay	200-6000 A	600 V	200,000 A

Circuit Breakers

Another device used for overcurrent protection is a circuit breaker. In addition to providing overcurrent protection, a **circuit breaker** provides a manual means of energizing and de-energizing 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. 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.

Fault-Current Interrupting Rating

Circuit breakers are also rated according to the level of fault current they can interrupt. Because potential fault currents vary depending on the electrical service and the position of a circuit breaker within a distribution system, Siemens offers circuit breakers with interrupting ratings from 10,000 to 200,000 amps.

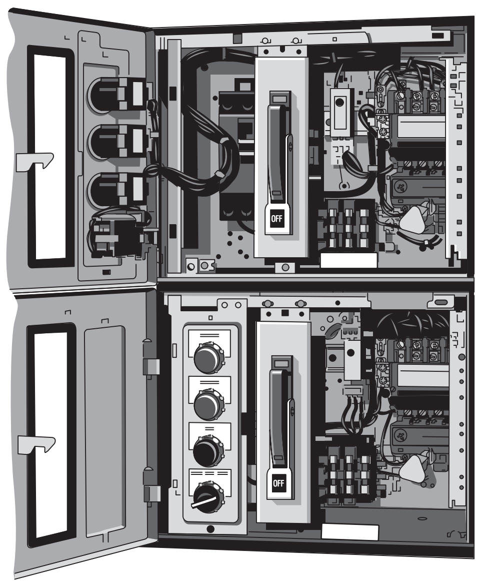
Review 2

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 capability.
3. Time-delay fuses provide ________ and short-circuit 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

According to NEMA standards publication ICS-18-2001 a motor control center is a floor-mounted assembly with the following characteristics.

- One or more enclosed vertical sections
- Horizontal and vertical buses for distributing power
- Principally contains combination motor control units



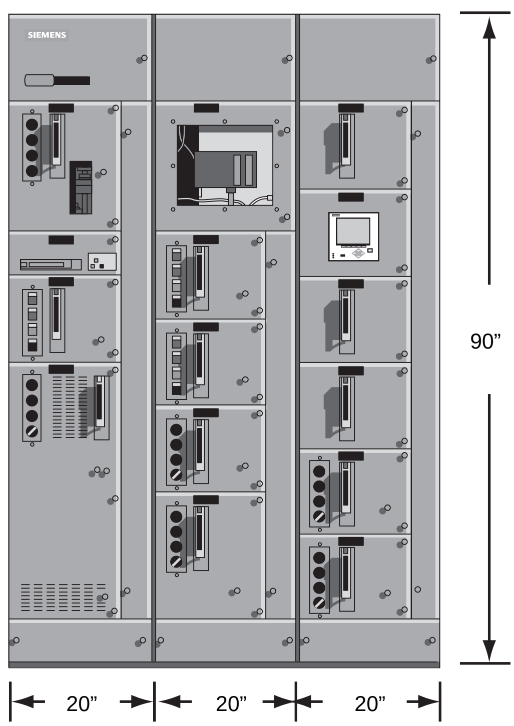
Combination Motor Control Units

Of these items, the fact that an MCC principally contains combination motor control units is what differentiates a motor control center from other power distribution equipment.

The NEMA definition for a motor control center is consistent with the definitions found in UL 845 and the NEC®.

Vertical Sections

A motor control center is made up of a steel structure that contains the combination motor control units, wireways, internal wiring, and bus bars. As the NEMA definition states, 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, and structures wider than 20” are sometimes used. Additional dimension information is provided later in this course.



Three Vertical Sections

Enclosure Types

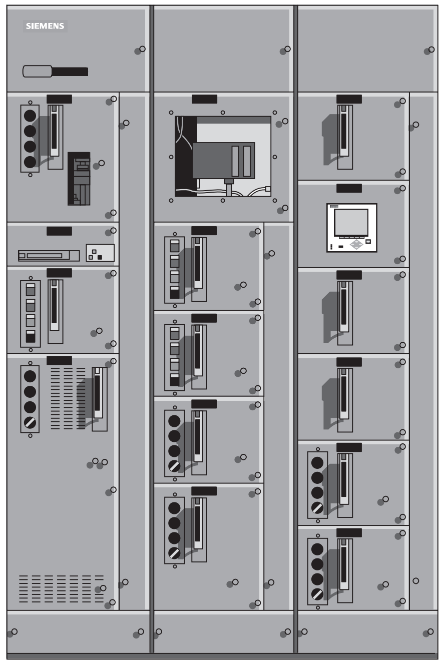
An enclosure surrounds equipment to protect personnel from contact with live buses or connections and to protect equipment from external conditions. The amount of environmental protection an enclosure provides depends on the type of enclosure.

NEMA standard 250 and UL publications 50 and 508 provide similar enclosure type definitions. The following enclosures types are available for tiastar motor control centers.

- Type 1 - Standard - Indoor
- Type 1A - Gasket Front - Indoor
- Type 2 - Drip-Proof - Indoor
- Type 12 - Dust Tight - Indoor
- Type 3R - Rainproof - Outdoor

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 1A Gasketed Front

Type 1A 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

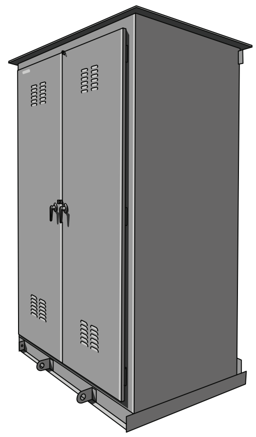
Type 2, drip-proof, indoor enclosures are intended to protect equipment from falling noncorrosive liquids and dirt. The enclosure prevents the entrance of dripping liquid at a higher level than the lowest live part within the enclosure. This design is a Type 1A gasketed front, or Type 12, with a drip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

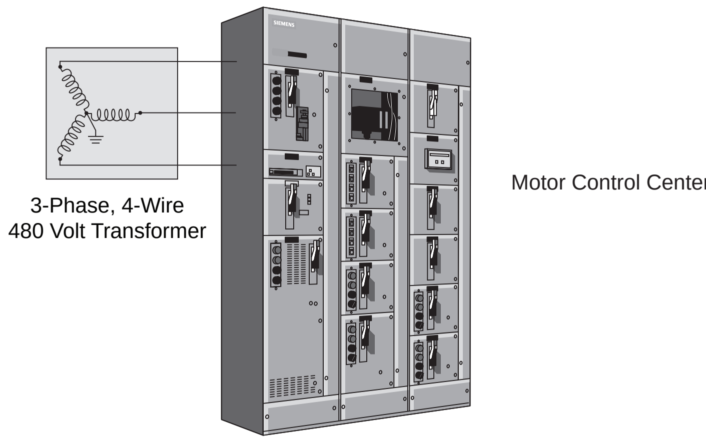
The International Electrotechnical Commission (IEC) is another organization that defines the degree of ingress protection provided by enclosures.

The IEC designation consists of the letters IP followed by two numbers. The first number indicates the degree of protection provided to prevent people from touching hazardous parts and to prevent solid objects from entering the enclosure. The second number indicates the degree of protection against the ingress of water.

tiastar motor control centers are available in the UL/NEMA enclosure types listed on the preceding pages. Tests for compliance with these enclosure types are described in UL 50 (Enclosures for Electrical Equipment). Because these tests are specific and some tests take into consideration factors such as rust or corrosion resistance, there is no exact conversion between UL enclosure types and IEC IP enclosure designations.

MCC Voltage Rating

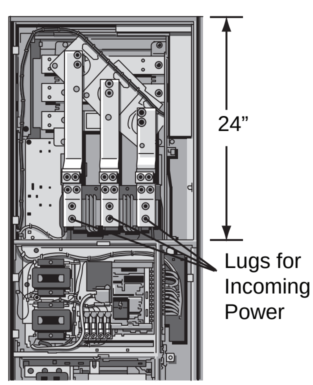
In addition to the various ratings of individual components used in motor control centers, motor control centers also have an overall rating of 600 volts. This is the maximum voltage that can be applied to a motor control center. A motor control center can be connected to a lower voltage, however, and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

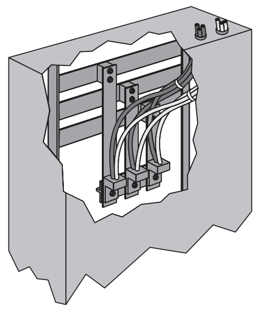
Main Lugs

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, additional vertical space is needed at the top. In this example, main lugs rated for 600 amps are located on the top of the MCC, and 24” of vertical space is required. A motor control center can also have the lugs located at the bottom.



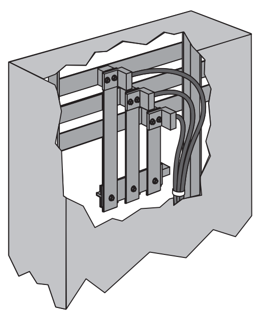
Main Lugs on Top, Top Entry

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



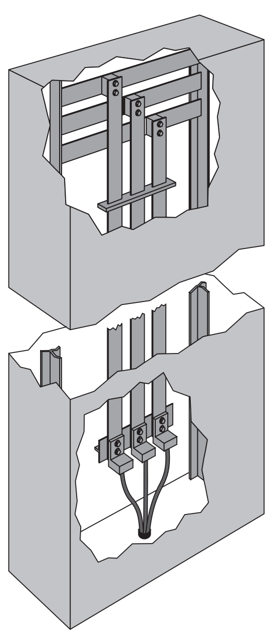
Main Lugs on Top, Bottom Entry

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.

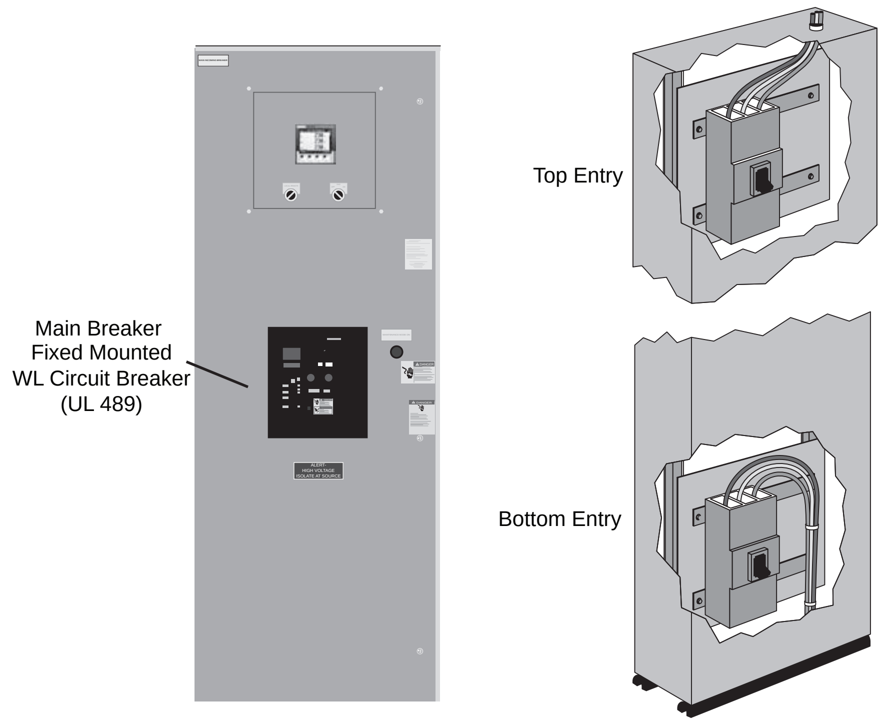


Main Disconnect Device

When a main disconnect device 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.” Cable entry can be from the top or bottom of the vertical section.

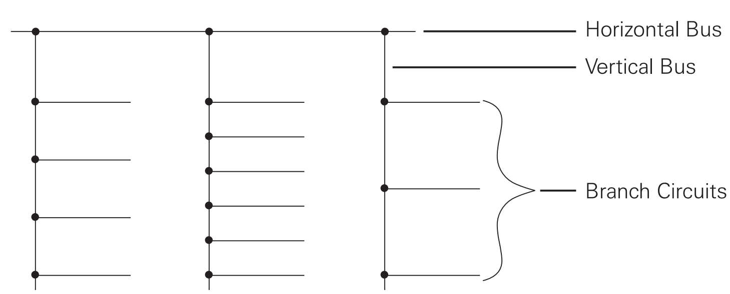
tiastar MCCs can accommodate a variety of main disconnect devices including a main circuit breaker (up to 2000 amps) or a main fusible switch (up to 1200 amps).

When a Siemens WL circuit breaker is used as a main disconnect device, this device can be configured to utilize its **Dynamic Arc Flash Sentry (DAS)** feature, which allows alternative breaker settings with a lowered potential arc flash energy to be employed when personnel are working near energized equipment.

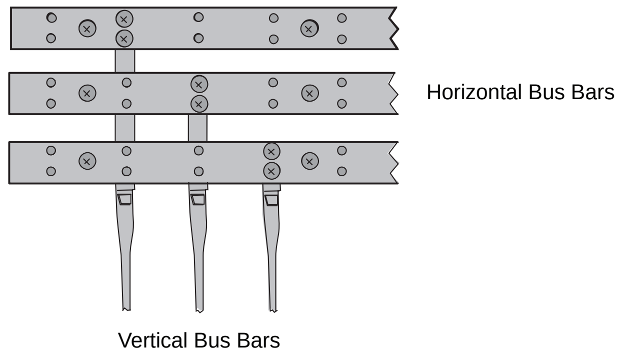


Horizontal and Vertical Bus

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 heavy-duty metal bars. 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

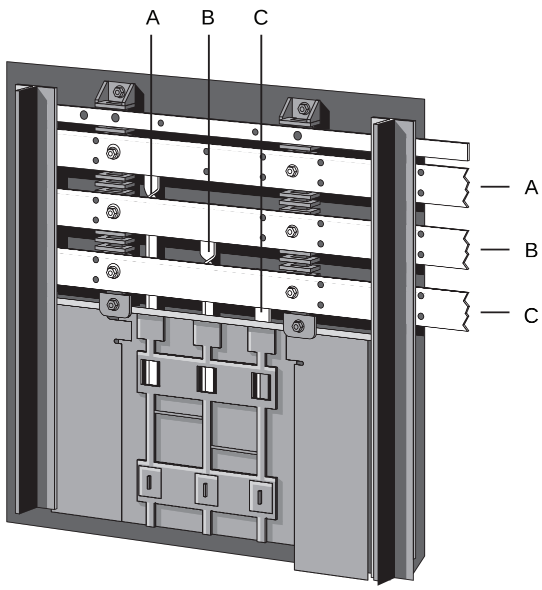
Bus bars are the major current carrying elements of the motor control center. Before a motor control center is operated, bus bars are at the temperature of the surrounding air. This is known as the **ambient temperature**. Temperature rises in the motor control center bus bars during operation. The combination 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, for a maximum operating temperature of 105°C. UL limits temperature rise to 50°C based on an ambient temperature of 40°C, 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 ambient.

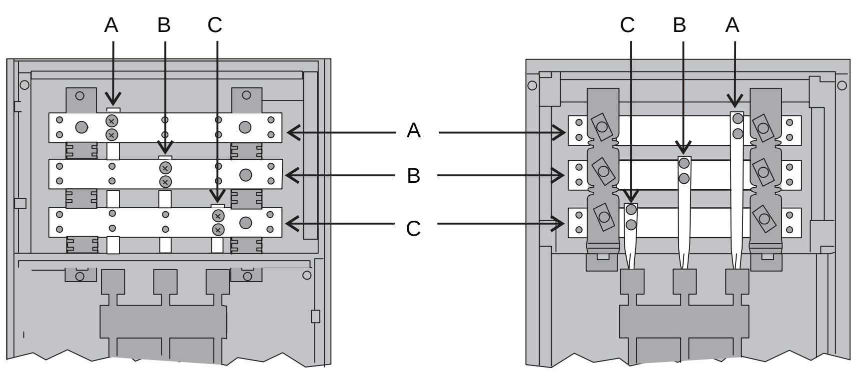
NEMA Phase Arrangement

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.



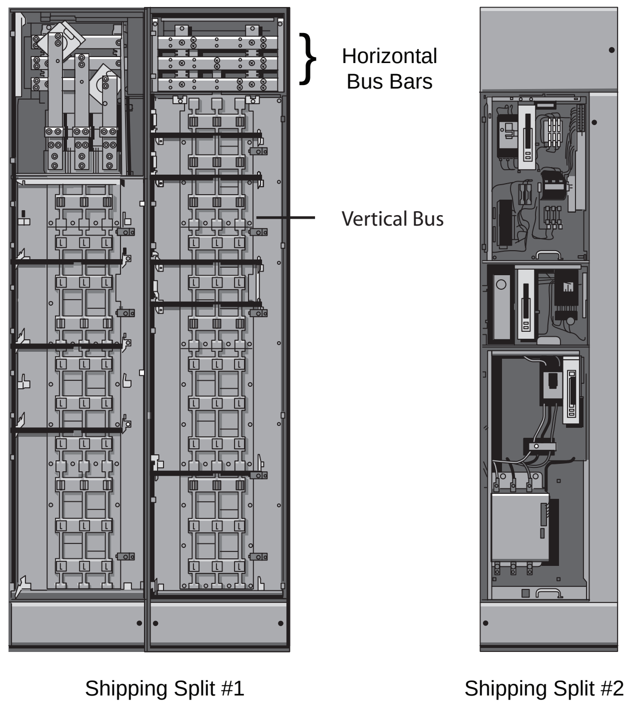
Back-to-Back Structures

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.

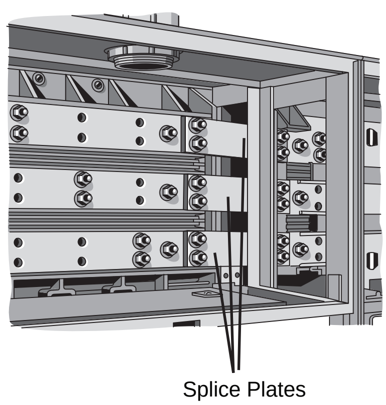


Shipping Splits

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



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.

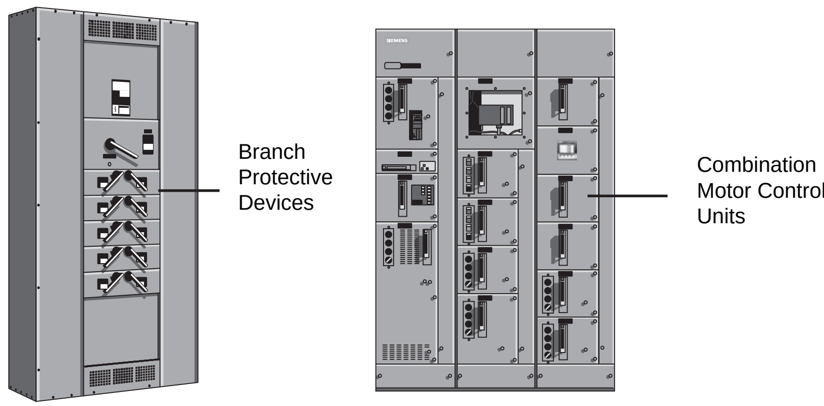


Combination Motor Control Units

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.

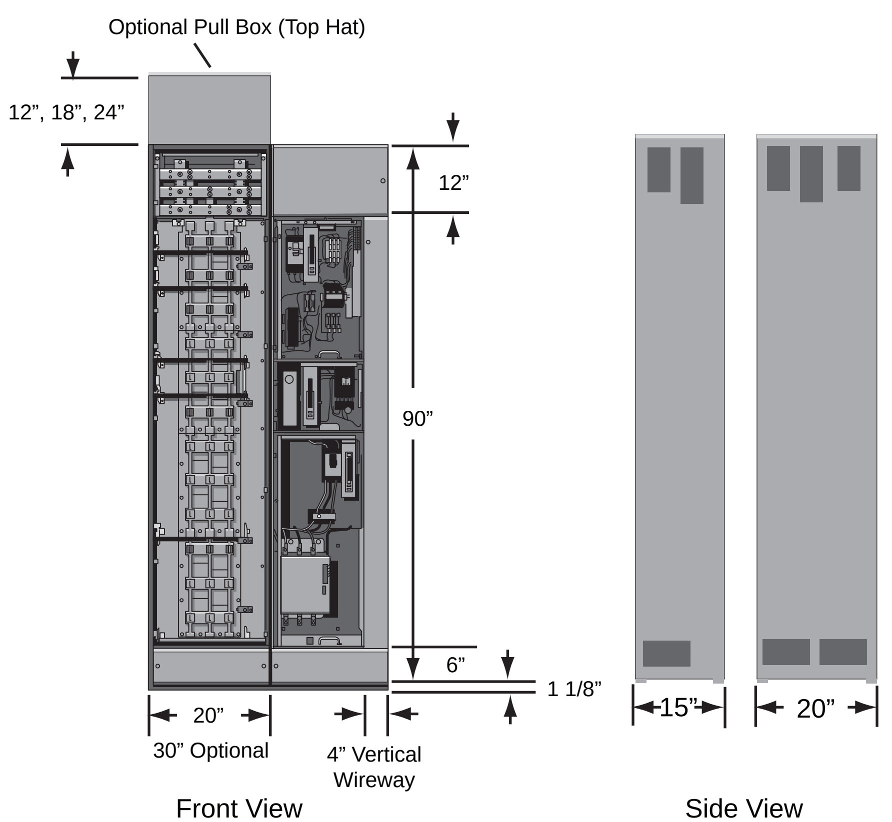
3. ________ provide power to each of the combination motor control units in a motor control center.

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

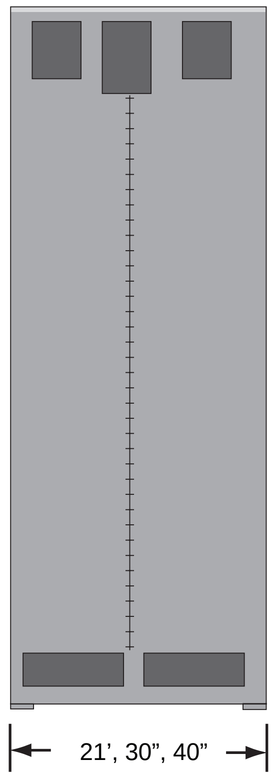
The nominal height of a tiastar motor control center is 90″. The overall height is 91 1/8,″ including a standard 1 1/8″ base channel. There are 72″ of vertical space available for combination motor control units, with 12″ at the top and 6″ at the bottom for wiring. The horizontal power bus is located behind the wireway in the top 12″ of the structure making it easier to service. Each vertical structure can 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 a large AC drive or transformer. 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.

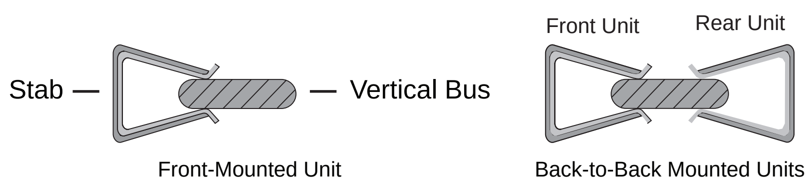


Back-to-Back Mounting

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.

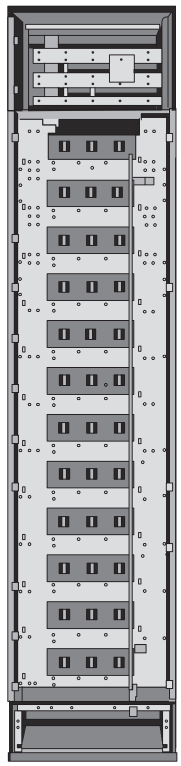


Stab-on Connections

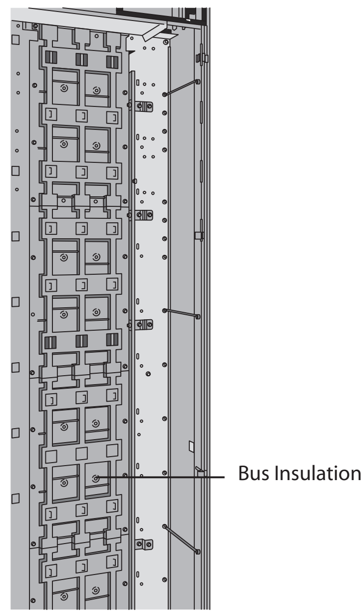
Basic Construction

tiastar motor control centers offer two vertical bus designs. Front-only structures with 42 kA or 65 kA 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 42 kA and 65 kA ampere bus bracing. The isolated and insulated vertical bus design is standard for 100 kA 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.



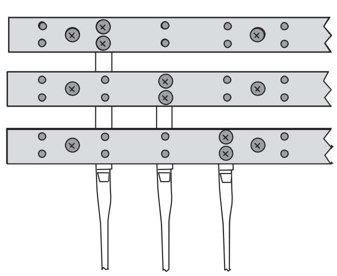
Section with
Insulated Vertical Bus



Section with Optional
Isolated, Insulated Vertical Bus

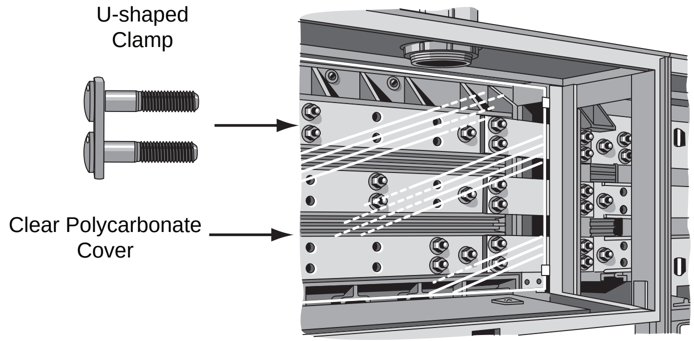
Horizontal Bus

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



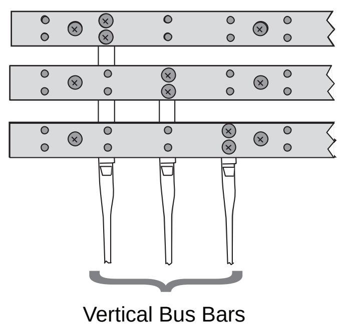
Horizontal
Bus Bars

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

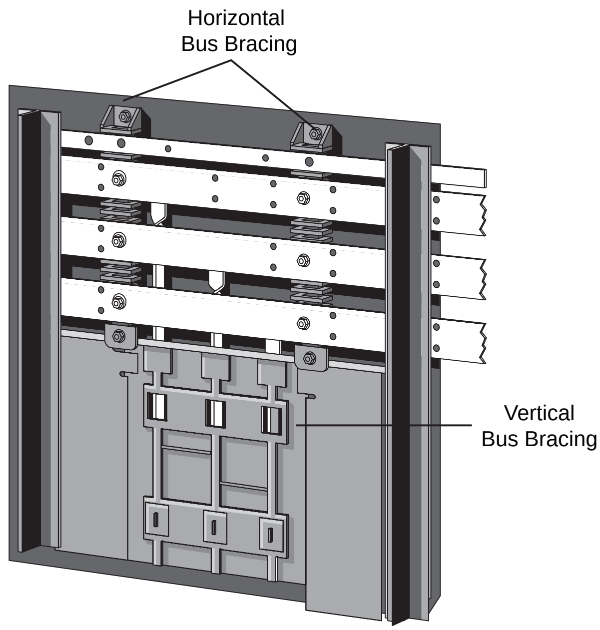
The **vertical bus** on the tiastar motor control centers are available with 300 and 600 ampere current ratings.



Bus Bracing

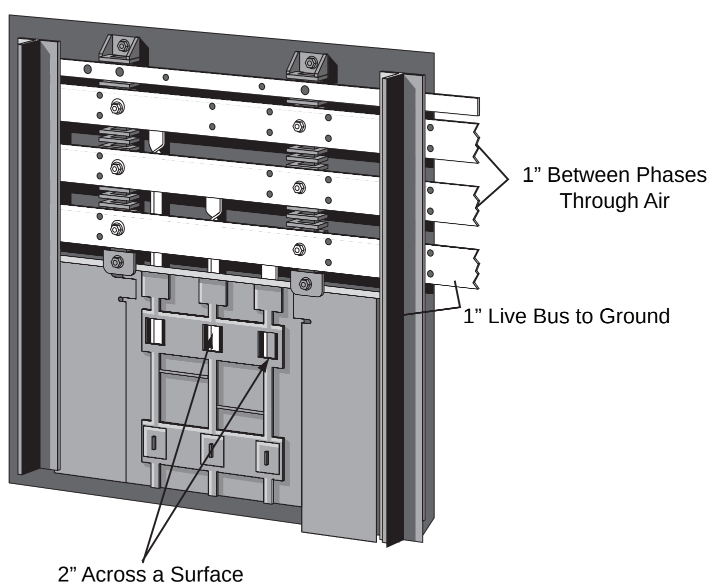
NEC® Article 430.97(A), requires motor control center busbars *t*o be protected from physical damage. Motor control centers must be capable of withstanding the largest potential short-circuit current which can occur in the selected application. The amount of short-circuit current available depends on 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 kA interrupting rating with optional bracing available to 100 kA.



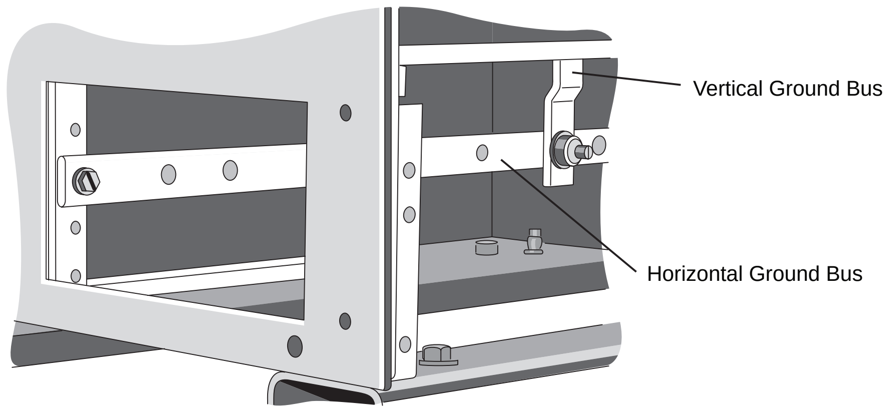
Bus Spacing

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 tiastar motor control centers.



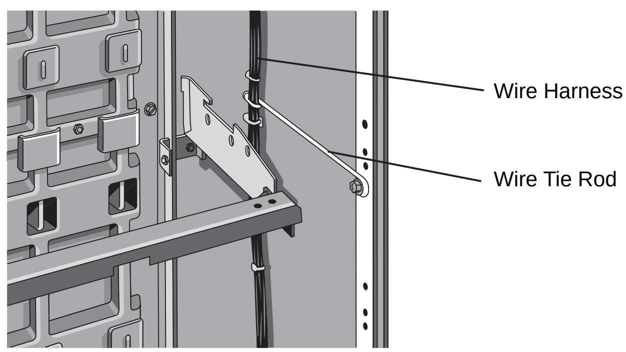
Ground Bus

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.



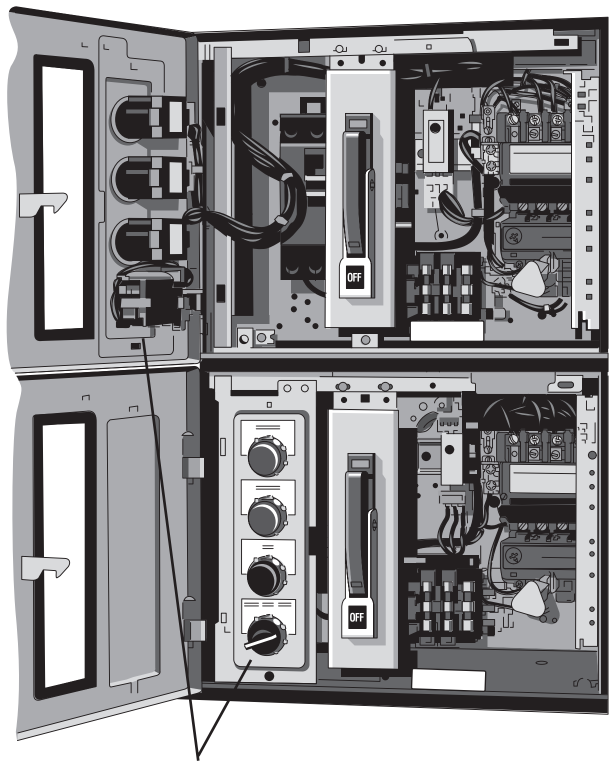
Wire Tie Rods

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



Pilot Devices

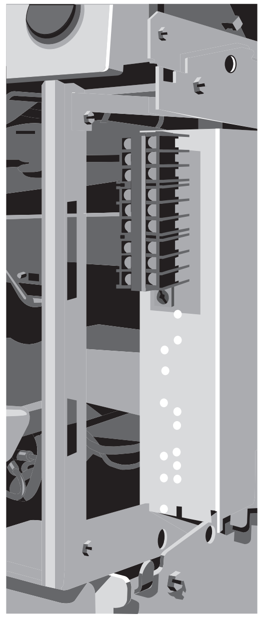
Pilot devices are mounted on a panel that attaches to the unit door with two captive screws. The pilot-device panel can be removed from the door and attached to the combination motor control unit for service or unit removal. There is room for four 22 mm or 30 mm pilot devices on the panel.



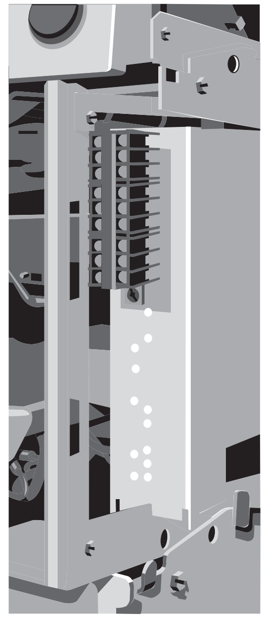
Pilot Devices Panels

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

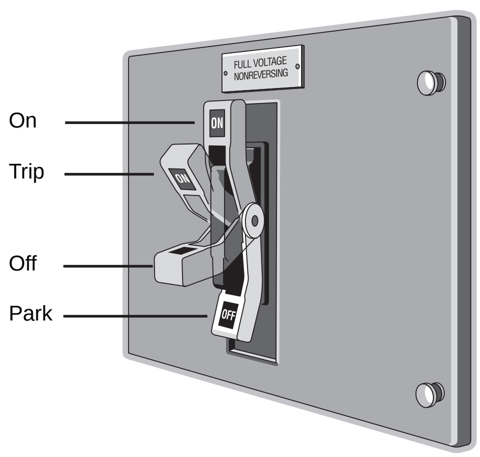


Terminal Block
in Center Position

Terminal Block
in Control Unit

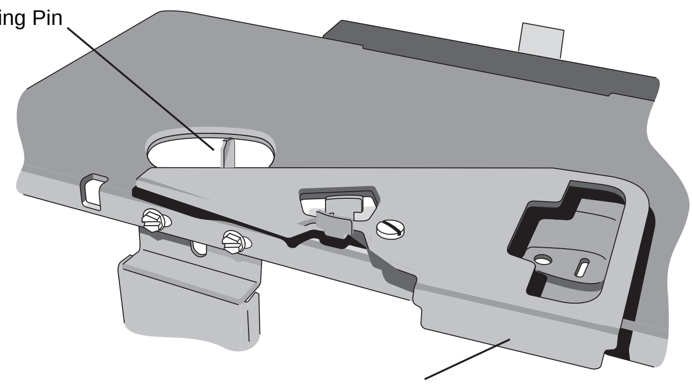
Disconnect Operating Handle

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” positions are clearly indicated by color, position, and label. The “TRIP” position applies only to circuit breaker equipped units.



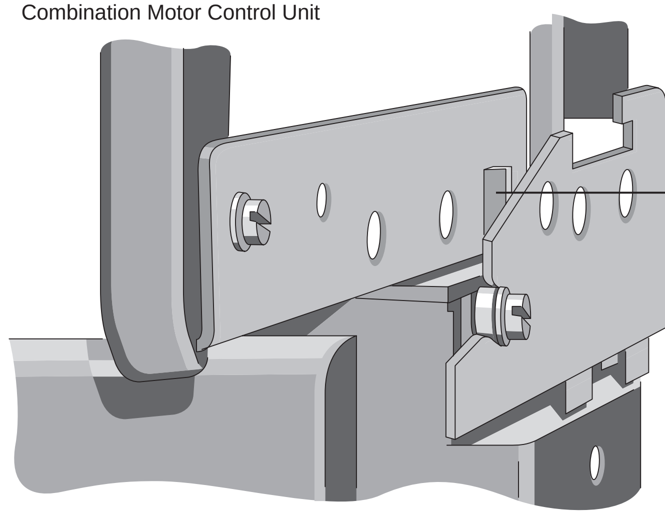
Racking Lever

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 then be pulled to a test position. The operator handle must be 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.



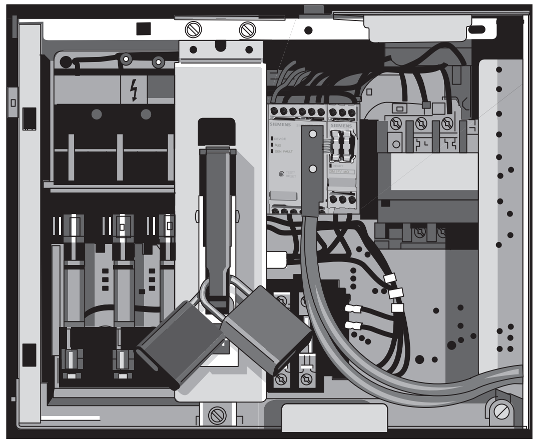
Ground Clip

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.



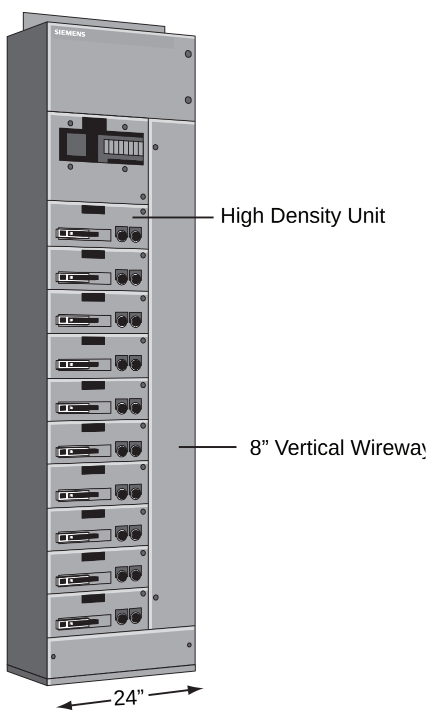
Locking

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



High Density Units

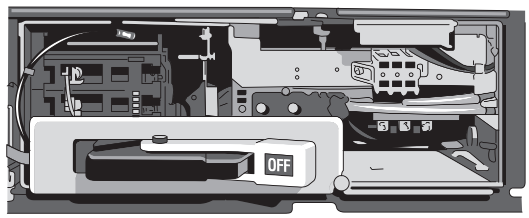
tiastar motor control centers are also available with **high density units**. High density units are 6" tall. A maximum of 12 high density units can be installed in 72" of vertical space. High density combination motor control units are available in NEMA size 0 (5 HP) and size 1 (10 HP). High density 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. Note: the 24"-wide structure allows for the increased quantity of wires typical with high density applications, but it is optional. 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.

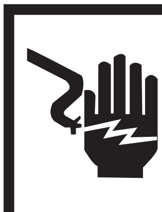


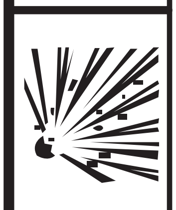
Arc Fault and Arc Flash

There are two broad categories of electrical faults, bolted faults and arc faults. **Bolted faults** occur in conductors that are solidly connected when no arcing occurs. A standard design motor control center withstands the mechanical forces that occur on load terminals as a result of a bolted fault (within equipment specifications) until a circuit breaker or fuse has time to interrupt the fault current.

Arc faults occur when electricity flows through air. Arc faults can be caused by a variety of conditions such as overvoltage, corrosion, excess humidity, aging or overstress of insulation, improper installation and maintenance practices, the intrusion of small animals, etc.

At voltage and current levels found in MCC applications, an arc fault can result in an **arc flash**, where heat energy is suddenly and often explosively produced. An arc flash can cause temperatures and explosive forces sufficient to vaporize materials and propel them at high velocities.





DANGER

Hazardous voltage.
Hazard of electrical arc flash.
Will cause death or serious injury.

Turn off and lock out all power supplying equipment before working inside to avoid the hazard.

Installation and maintenance of this equipment should only be done by a qualified person.

Appropriate personal protective equipment (PPE) must be worn and safe work practices must be followed.

See NFPA 70E for information on PPE and safe work practices.

Replace all covers and close all doors before restoring power to this equipment.

Apply label in accordance with NEC Section 110.16 if required.

Arc Resistant Description

Because the causes for internal arcing and the potential for an arc flash cannot be eliminated, and it is not always possible to de-energize power distribution equipment when someone is nearby, companies are required to comply with a number of standards intended to improve workforce safety. Even the best safety practices, however, cannot guarantee worker safety.

One additional step that companies can consider when replacing existing motor control centers or designing new or expanded facilities, is to use Siemens arc resistant motor control centers, but what does arc resistant mean in this context?

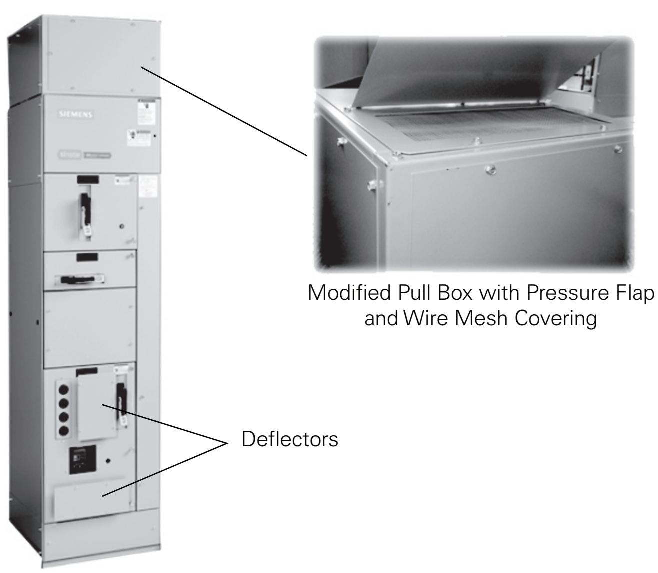
For one thing, it means that the motor control center has successfully completed testing in accordance with I**EEE standard C37.20.7-2007**. This is the best indication that the equipment has been constructed to provide an additional degree of protection in the event of an arc flash.

This specification identifies two zones of accessibility in relation to the equipment that specify the area for which additional protection is provided. Equipment tested to provide **type 1 accessibility** provides additional protection only from the front. Equipment tested to provide **type 2 accessibility** provides additional protection from the front, back, and sides. Each of these accessibility types requires that all equipment covers and doors are installed and closed.

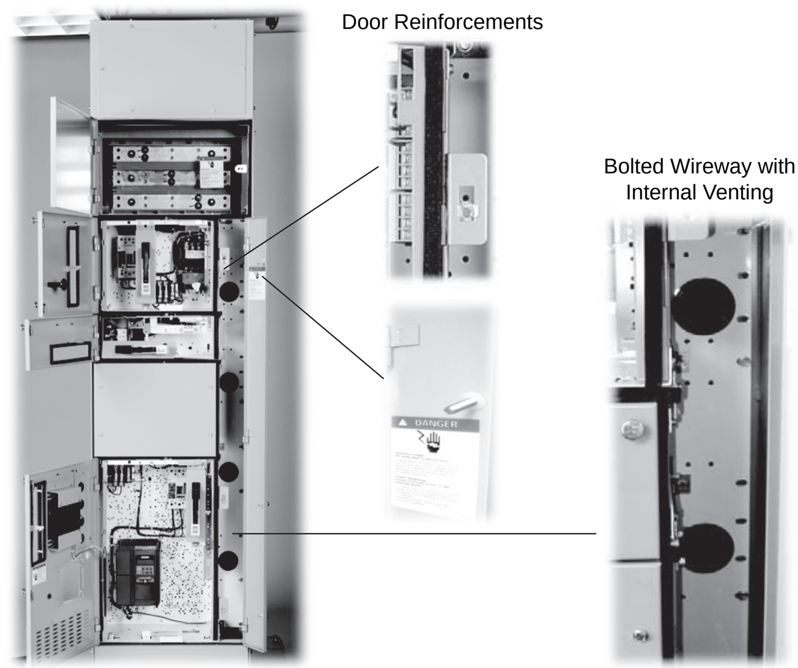
Siemens **tiastar arc resistant MCC** has type 2 accessibility and its C37.20.7-2007 compliance testing was witnessed by UL.

tiastar Arc Resistant MCC Innovations

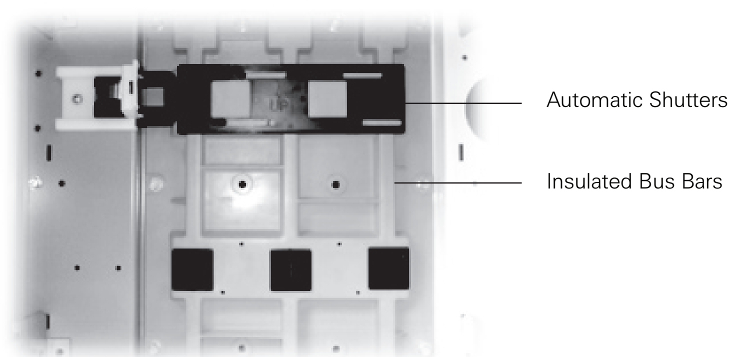
The tiastar arc resistant MCC design incorporates a number of key innovations that allow it to achieve IEEE C37.20.7-2007 compliance and type 2 accessibility. For example, in units with ventilation requirements, deflector plates reduce the direct launching of arc flash by-products to the front of the MCC while the modified pull box with pressure flap provides an escape path for heat energy and the wire mesh covering over the top ventilation opening limits the expulsion of projectiles.



tiastar arc resistant MCCs also feature reinforced cabinet doors to contain the pressure associated with an arc fault. The internal wireway is bolted to ensure its integrity and ventilated to channel exhaust gasses out the top of the enclosure.



tiastar arc resistant MCCs are equipped with shutters that open and close automatically as a combination motor control unit is removed or inserted. This feature combined with insulated bus bars prevents accidental contact with live bus bars and reduces the ability of an arc fault to propagate.



As mentioned previously, when a Siemens WL circuit breaker is used as a main disconnect device for a tiastar MCC, this device can be configured to utilize its Dynamic Arc Flash Sentry (DAS) feature which allows alternative breaker settings with a lowered potential arc flash energy to be employed when personnel are working near energized equipment.

The accompanying chart provides additional information about tiastar arc resistant MCCs.

Technical Specifications	
Enclosure Types	NEMA 1 and 1A
Main Device Options	Main Lug, Main Breaker, Main Switch (1600 A max.)
Horizonal Bus	1600 A max., 50°C Rated
Vertical Bus	800 A max., Insulated and Isolated, Ground Bus, Auto Shutters
Short Circuit Withstand Rating	65 kA
Arc Flash Duration Rating	50 msec.
Voltage Rating	600 VAC
Dimensions	
Modified Pull Box Height	12 in.
Section Depth	20 in.
Section Width	20 or 30 in.
Total MCC Height	102 in.
Room Requirements	112 in. Ceiling Height (min.)
	38 in. Aisle (min.)
Options	
High Density (6 in. Motor Control Units)	Available
Variable Frequency Drives	Available
Solid State Reduced Voltage Starters	Available
Back-to-back Structures	Not Available

Note: An arc resistant MCC should not be spliced to a non-arc-resistant MCC

Review 4

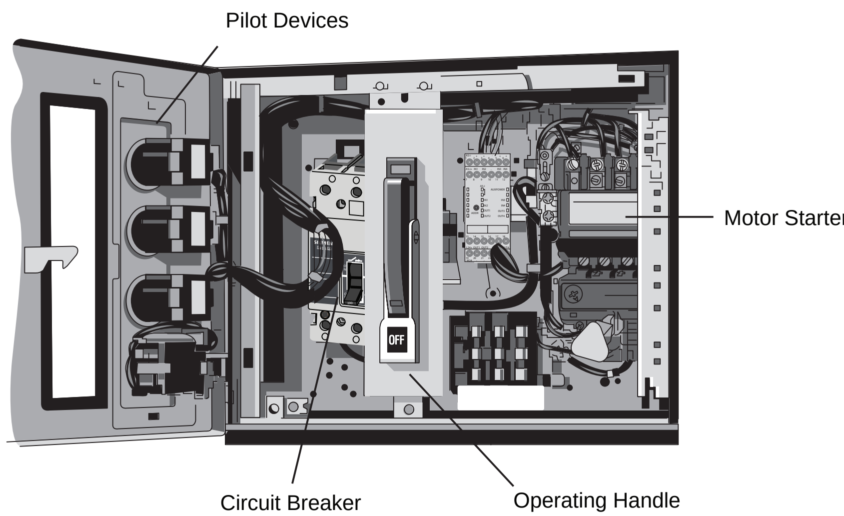
1. Mounting tiastar motor control centers back to back allows for ___ combination motor control units to be mounted in 72” of vertical space.
2. tiastar motor control centers are available with horizontal bus current ratings of 600 to ______ amperes.
3. tiastar motor control centers are available with vertical bus ratings of 300 and ____ amperes.
4. The operating handle for a combination motor control unit with a circuit breaker 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.
6. The tiastar arc resistant MCC design incorporates a number of key innovations that allow it to achieve ________ compliance and type ___ accessibility.

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.

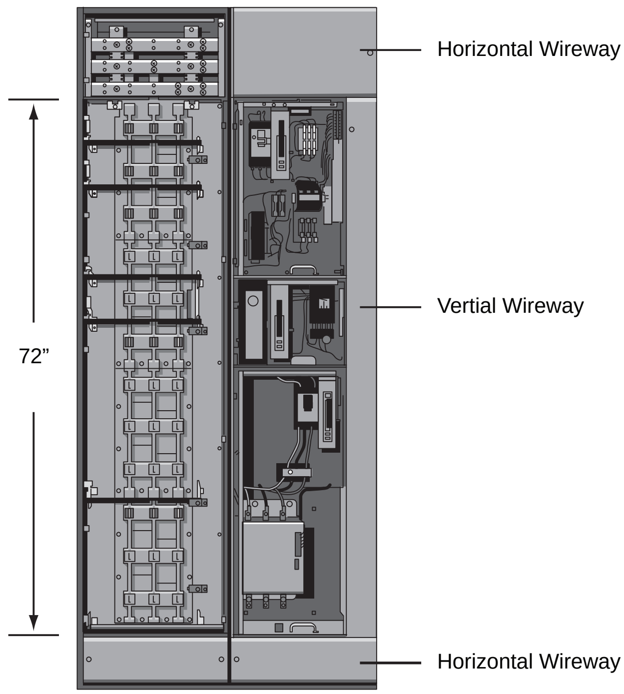
The combination motor control unit in the following example uses a molded case circuit breaker to provide a circuit disconnecting means and branch-circuit overcurrent protection. The circuit breaker is opened and closed using the operating handle located on the front of the unit.

The motor starter controls power to the motor and provides overload protection for the motor. Pilot devices, located on the door, are used to start and stop the motor as and provide a visual indication of the motor's status.



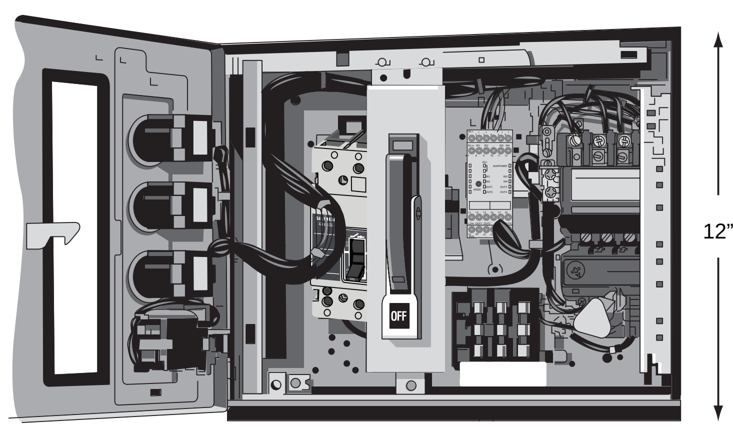
Vertical Space

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.



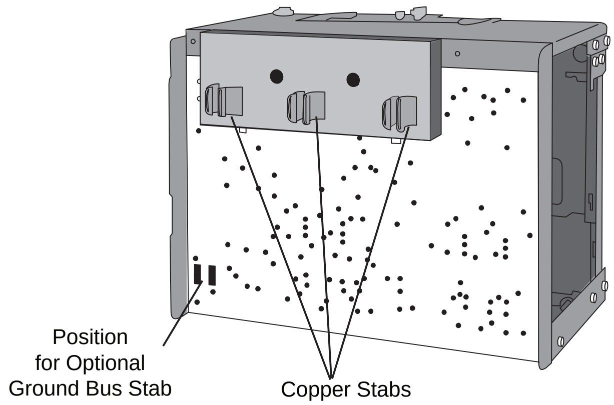
Dimensions

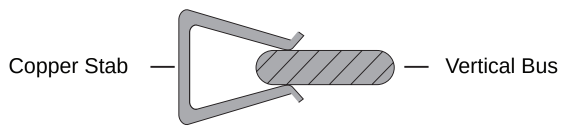
Combination motor control units are designed to fit into modular compartments. Typically, the minimum height of a combination motor control unit is 12", increasing in 6" increments (12", 18", 24", 30", up to 72") as needed. Six combination motor control units that are 12" high will fit in 72" of vertical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

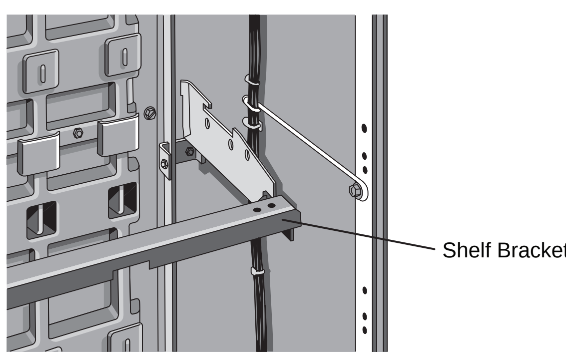




These stabs engage the vertical bus bars, making the electrical connection to the control unit. Siemens incorporates a flat vertical bus bar to ensure positive connection between the stab and the bus bar.

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

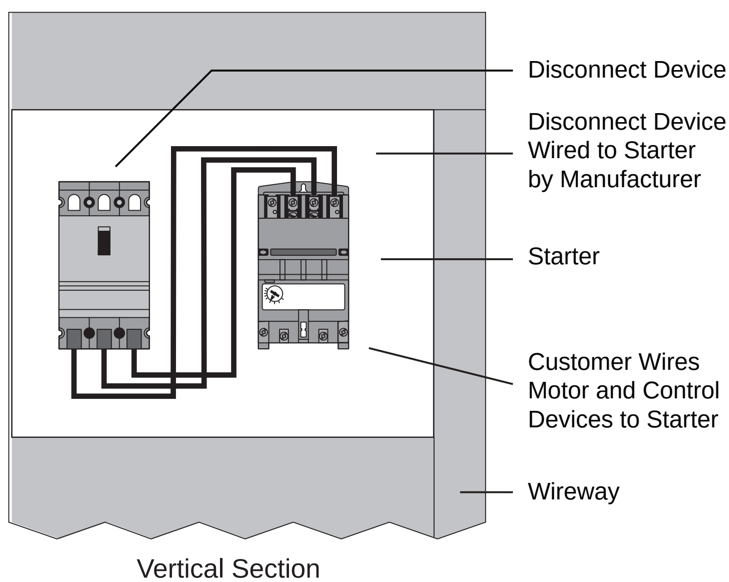
NEMA has established two classification standards (**Class I and Class II**) and three types of wiring (**A, B, and C**) used in the construction of motor control centers. The class and type used in a motor control center are specified by the customer.

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

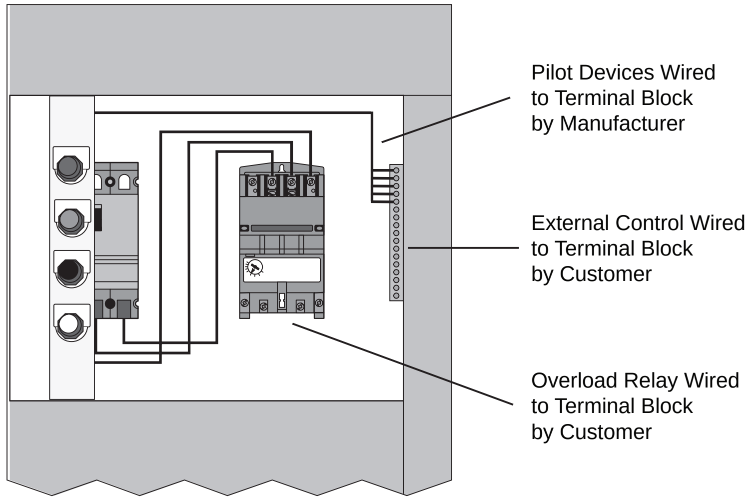
Type A wiring is only available on Class I motor control centers. Siemens connects the combination motor control unit to the vertical bus via the stabs on the back of the unit. Power is applied to the circuit breaker from the vertical bus. The circuit breaker is factory wired to the motor starter. The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



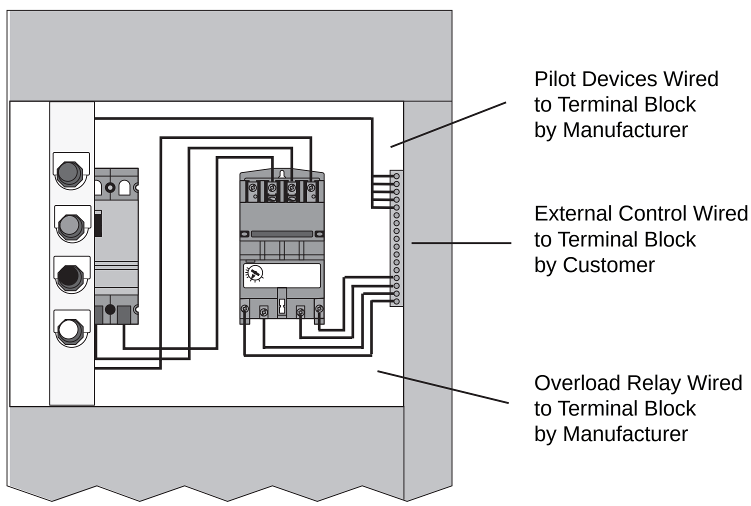
Class I, Type B Wiring

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.

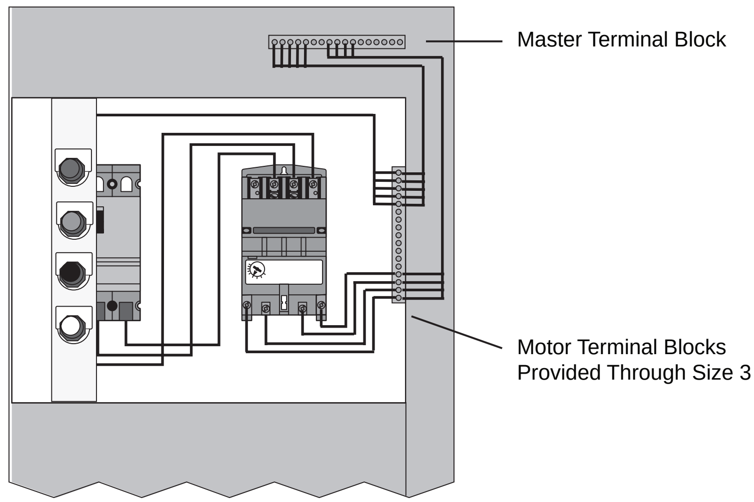


When Type B-t wiring is specified, terminal blocks are furnished near the wireway for control circuit connections and for motor starter leads. Type B-t wiring can be used on starters up to size 3.



Class I, Type C

With **Type C** wiring, a master terminal block is typically provided in either the top or bottom horizontal wiring gutter. Siemens connects the control wires from each control unit to the master terminal block. The customer connects his/her wiring 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.

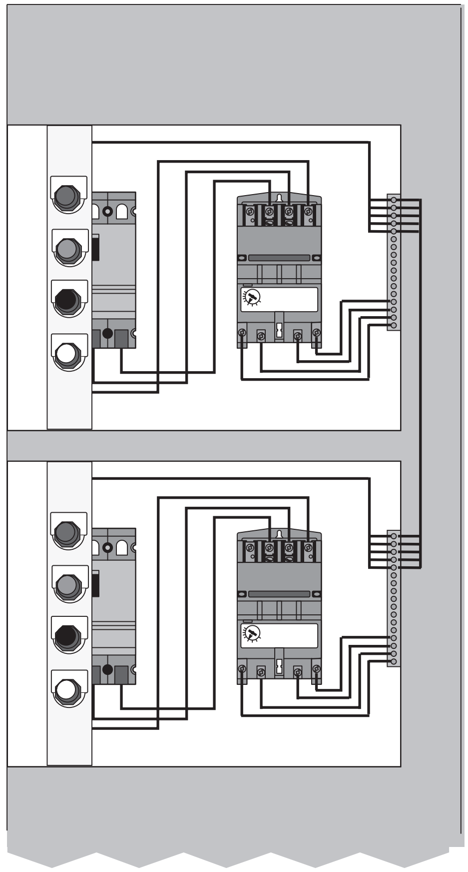


Class II

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		✓	✓	✓	✓	✓	✓
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

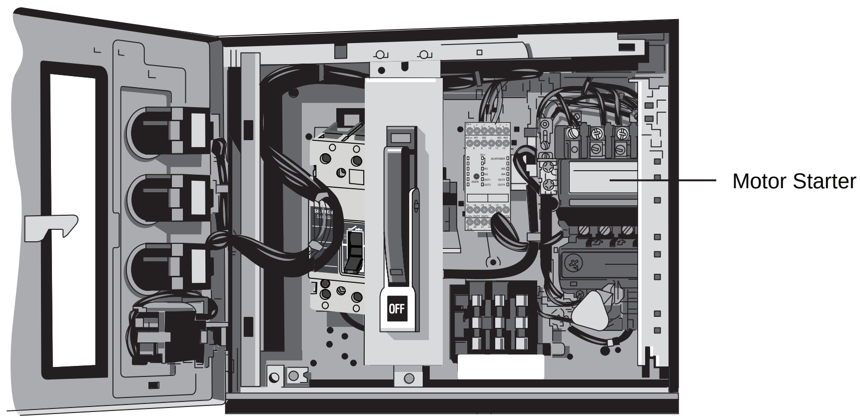
① No load terminals furnished for starters sizes 3½ through 6, main or branch circuit breaker or fusible switches, distribution transformers or lighting panelboards.

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.



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

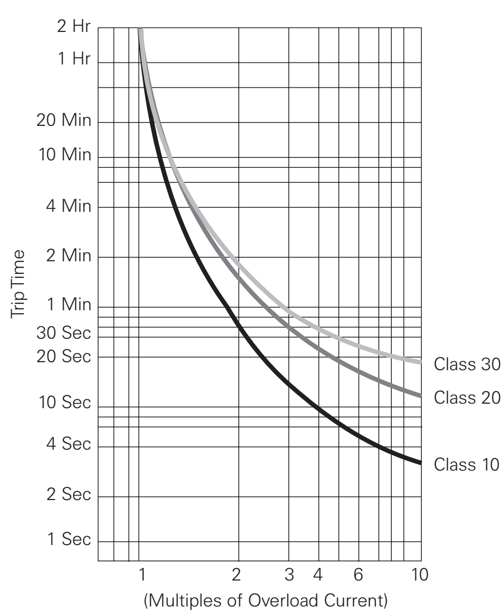
Full-voltage starters are sometimes referred to as across-the-line starters because they start an induction motor by applying the full line voltage to the motor's stator windings when the contacts of the motor starter's contactor close. The current that flows through these contacts also flows through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

Contactors and starters used in tiastar motor control centers are NEMA rated and available from size 00 to size 7, which cover the horsepower range from 2 HP to 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

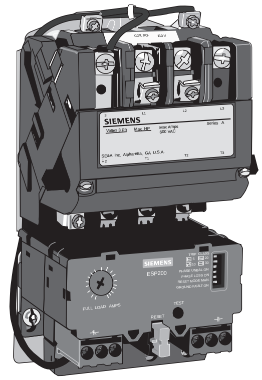
Overload Relay Trip Classes

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 Classes 10, 20, and 30. A Class 10 overload relay, for example, trips 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.

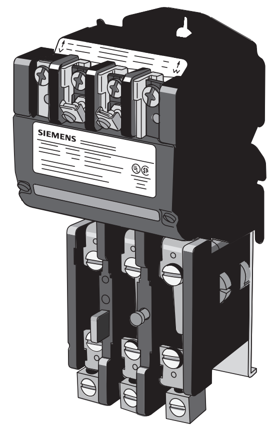


Class 14 NEMA Starters

Starters used in tiastar motor control centers can be equipped with an ambient-compensated thermal overload relay or a solid-state overload relay.



Class 14 NEMA ESP200 Starter



Class 14 NEMA Starter with Bimetal Overload Relay

Class 14 NEMA starters with a thermal overload relay 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 either a Class 10 or a Class 20 ambient-compensated bimetal overload relays.

Class 14 ESP200 starters use the same contactors as Class 14 NEMA starters equipped with a thermal overload relay (for NEMA sizes 00 through 4), but are supplied with an ESP200 electronic overload relay. In addition, these starters are available in tiastar motor control centers with contactors up to and including NEMA size 7.

Like other electronic overload relays, ESP200 electronic overload relays eliminate the need for heaters. In addition, the full-load ampere (FLA) dial allows for a wide range (4:1) of adjustment to match motor application requirements.

ESP200 electronic overload relays have two dual in-line package (DIP) switches accessible from the front that simplify selection of any of four trip classes (5, 10, 20, and 30). Additional DIP switches allow for the selection of manual or automatic reset and provide on or off settings that determine if the ESP200 will trip in the event of a phase unbalance, phase loss, or ground fault.

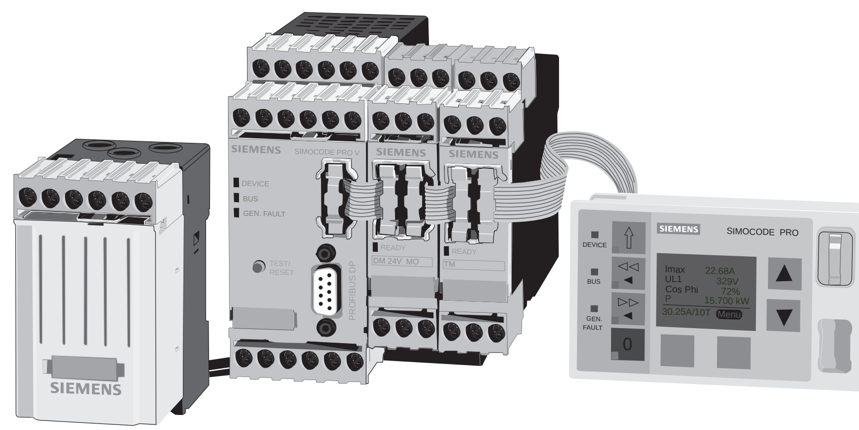
Also accessible from the front are the RESET button, for use when manual reset is selected, and the TEST button, that triggers a complete electronic functions test.

SIMOCODE pro Motor Management System

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 is a compact, economical system for full-voltage forward and reversing starters. Each SIMOCODE pro C includes a basic unit connected by a single cable to a current measuring module. An optional operator panel may also be connected to the basic unit.

SIMOCODE pro V is a variable system with an even greater range of functions. In addition to a basic unit, it can include either a current measuring module or a combination current/voltage measuring module, up to five expansion modules, and an optional operator panel (with or without display). Expansion modules are available for discrete input/output, analog input/output, ground fault detection, and temperature sensing.



SIMOCODE pro V Motor Management System

SIRIUS Soft Starters

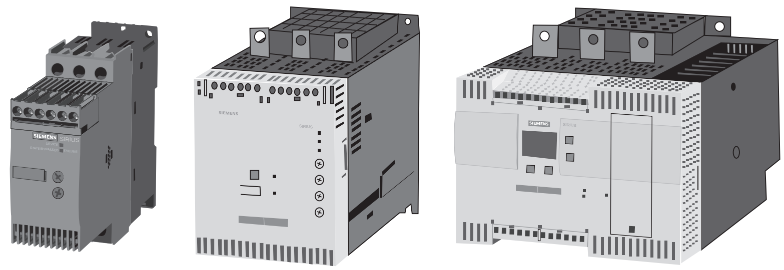
Solid-state, reduced-voltage starters, often called **soft starters**, limit motor starting current and torque by ramping up the voltage applied to the motor during the selectable starting time.

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**.

Once the start up has completed, SIRIUS soft starters use integrated bypass contacts to bypass power switching devices (thyristors). This improves efficiency, minimizes heat, and reduces stress on these switching devices.

Some soft starters (such as SIRIUS 3RW40 and 3RW44) also allow the 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 modular system of components includes SIRIUS 3RW30 and 3RW40 soft starters for standard applications and SIRIUS 3RW44 soft starters for high feature applications



3RW30 3RW40 3RW44

SIRIUS 3RW30 soft starters have an especially compact design that saves space and easily integrates with other SIRIUS components.

3RW30 soft starters are available for supply voltages up to 480 VAC and operating current up to 106 amps at 40º C.

Potentiometers on the front of the unit provide settings for ramp-up time and starting voltage.

SIRIUS 3RW40 soft starters have all the advantages of 3RW30 soft starters, but have more features and are available for current up to 432 amperes at 40 degrees C.

Features include: selectable motor overload protection (Class 10, 15, 20), manual or remote reset, and optional thermistor motor protection. 3RW40 soft starters are also equipped with integrated intrinsic device protection to prevent thermal overloading of the power switching devices (thyristors).

Potentiometers on the front of the unit provide settings for current limit, starting voltage, and ramp-up and ramp-down times.

SIRIUS 3RW44 soft starters make soft starting and stopping attractive for difficult starting applications and combine a high degree of functionality and extensive diagnostics.

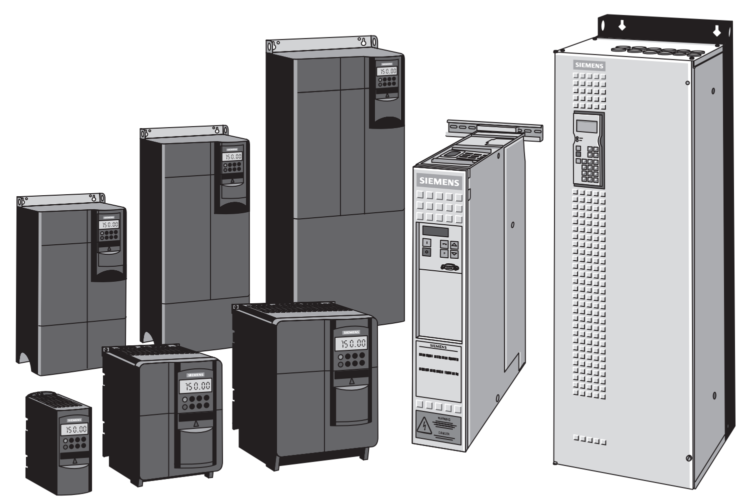
3RW44 soft starters are available for operating current up to 1214 amps at 40 degrees C. A backlit display with 4-key operation simplifies the process of changing parameters. Features include, but are not limited to:

- Motor overload protection
- Thermistor motor protection
- Selectable current limiting
- Multiple starting and stopping/braking modes
- Intrinsic device protection for thyristors
- Optional PROFIBUS DP communication

Variable Frequency Drives

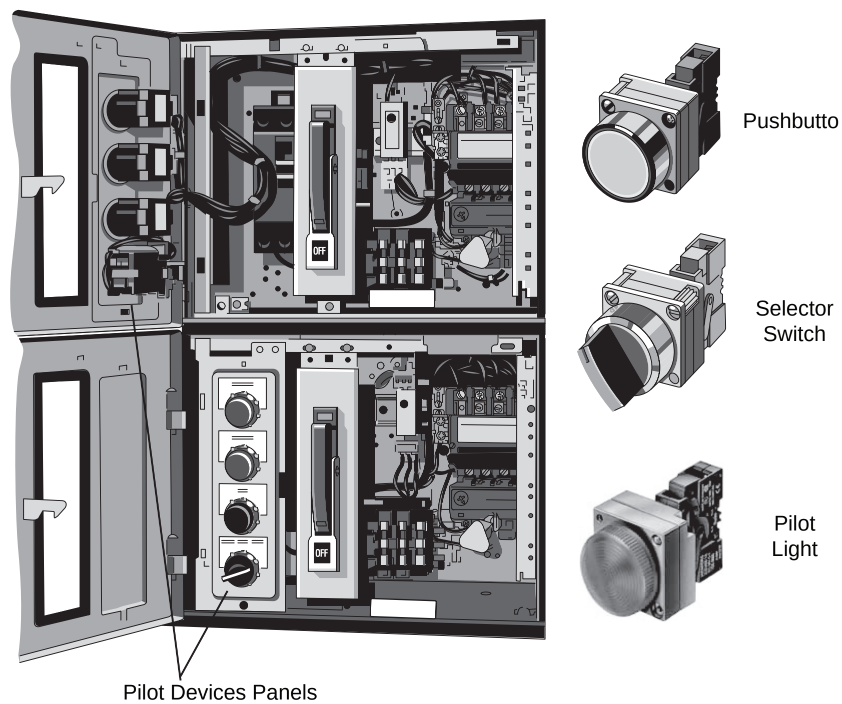
An **AC drive** is an electronic device that, in addition to controlling speed, may control other quantities, but that depends upon the capabilities of the drive and the needs of the application. Because the type of motor being controlled is often an AC induction motor and the speed of this motor is 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.



Pilot Devices

A variety of **pilot devices** with mounting diamenters of 22 mm or 30 mm can be used in Siemens tiastar motor control centers. Pilot devices include pushbuttons, selector switches, and pilot lights.



A **pushbutton** is a control device used to manually open and close a set of contacts. Pushbuttons are available in a flush or extended mount, with a mushroom head, and with or without illumination. Pushbuttons come with either normally open, normally closed, or a combination contact block.

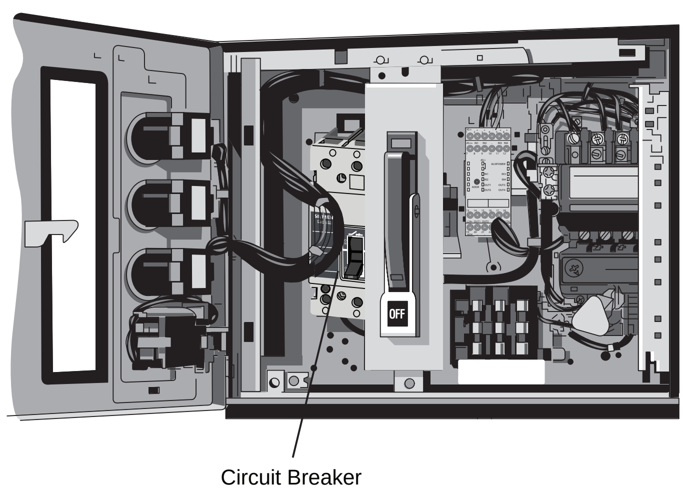
Selector switches are also used to manually open and close contacts. Selector switches can be maintained, spring return, or key operated. Selector switches are available in 2-position, 3-position, and 4-position types.

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 come with a color lens, such as red, green, amber, blue, white, or clear.

Circuit Breakers

Circuit breakers are used for multiple applications within a motor control center. These applications may use thermal-magnetic or solid state circuit breakers depending upon application requirements. Siemens offers a broad selection of both thermal-magnetic and solid state circuit breakers and, as previously mentioned, tiastar motor control centers can accommodate a circuit breaker main with a continuous current rating up to 2000 amps.

Circuit breakers used as a disconnect device for a combination motor control unit are typically **instantaneous-trip-only** circuit breakers, also referred to as **magnetic-only** or **Type ETI circuit breaker**. Type ETI circuit breakers provide short circuit protection but do not provide overload protection. Overload protection for the motor is typically provided by one of the motor starter types previously discussed.

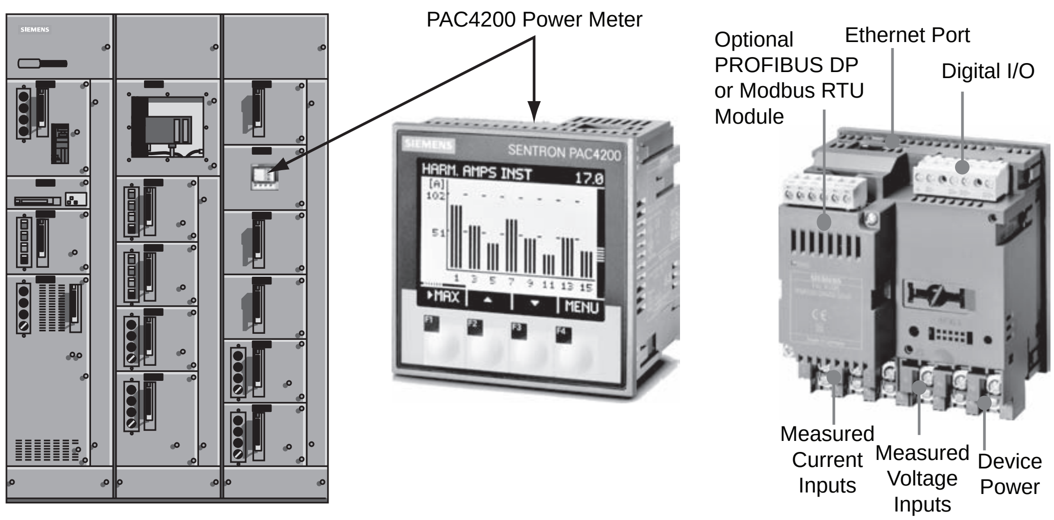


Other Types of Devices in MCCs

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.

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 power meters such as **PAC3100** and **PAC3200** for basic applications and the full-featured **PAC4200** for more advanced capabilities. Various communication options available with these meters allow these devices to be easily integrated into a tiastar motor control center and to share information with other systems.

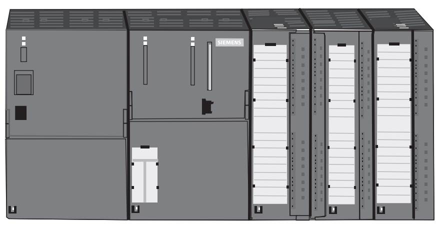


PLCs

tiastar motor control centers can also accommodate selected models of **programmable logic controllers (PLCs)**, such as Siemens **SIMATIC S7-300** and **S7-400 PLCs**, which are widely used for machine and process control applications.

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.

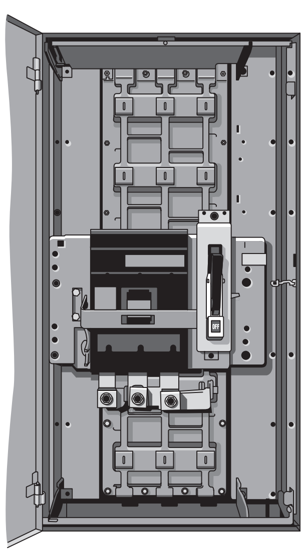


SIMATIC S7-300

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.



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. A full-voltage motor starter is made up of a ________ and a ________.

3. A NEMA size 5 full voltage starter is rated for _____ HP.

4. With an ESP200 electronic overload relay, the overload class and selected additional features are set using ________.

5. ________ is a modular motor management system that provides multi-functional solid state protection for constant speed motors.

6. The SIRIUS modular system of components includes SIRIUS ________ and ________ soft starters for standard applications and SIRIUS ________ soft starters for high feature applications.

Smart MCCs

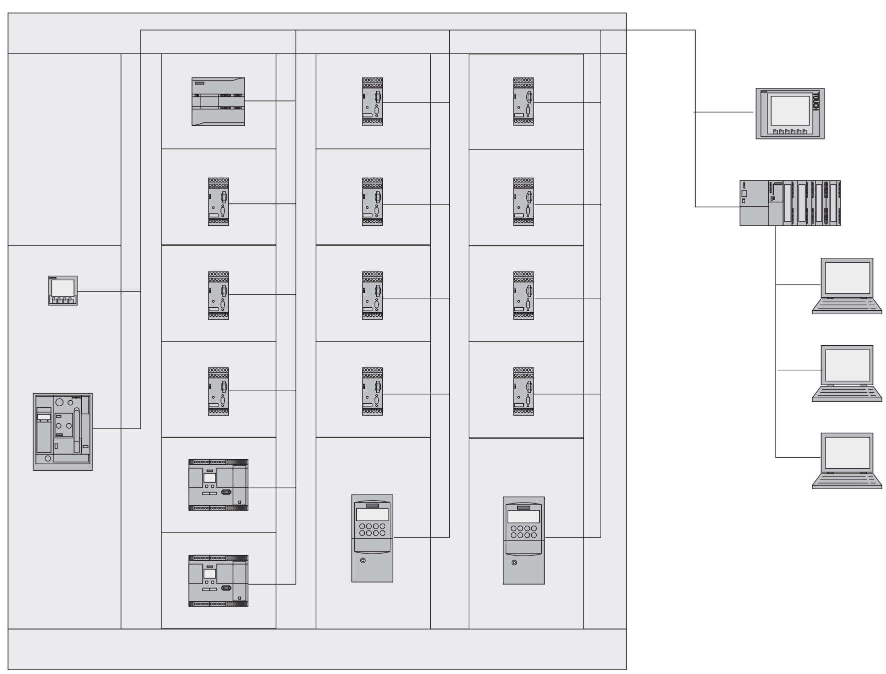
What is a Smart MCC?

Like a traditional MCC, a **smart MCC** complies with the NEMA definition for an MCC in that it is composed of vertical sections that incorporate vertical and horizontal power buses and wiring and principally contains combination motor control units.

Beyond this, however, a smart MCC incorporates intelligent devices to control motors and monitor their operation; to monitor energy consumption, power quality, and system operation; and to rapidly communicate with a PLC or process control system via a data network.

While it is true that traditional MCCs often incorporate some intelligent devices and may include some data networking, they do so in only a limited way. With smart MCCs, however, use of intelligent devices and data networking is a central feature that provides a number of key advantages.

Smart MCC



Advantages of Smart MCCs

In essence, use of intelligent devices and networking are not only the items that differentiate a smart MCC, they also form the key to unlocking the following advantages of smart MCCs:

- Reduced system installation and commissioning costs
- Reduced maintenance cost
- Reduced energy costs
- Reduced downtime
- Increased system efficiency
- Increased system information

How the functions of a smart MCC are linked to these advantages is discussed on the following paragraphs, but, at a high level, it all comes down to reducing cost and increasing profitability.

Controlling and Monitoring Motors

The most common types of electromechanical motor starters are capable of starting a motor at full voltage or reversing the direction of rotation. Some types of motor starters can do a limited type of reduced voltage starting. Other types can switch some types of motors between predesigned motor speeds. These devices also provide basic overload protection. With the addition of a solid-state overload relay, they can provide a few additional features such as phase loss protection.

In addition to the limited capabilities of traditional motor starters, consider that they are incapable of efficiently communicating information about the factors that affect motor life such as: number of starts, number of overload trips, running time, heat, mechanical shock, vibration, etc. Some of this data can be communicated by contact closures at a significant cost in wiring and on-going maintenance, but other data is simply not available.

In a smart MCC, motor control is performed using various intelligent devices. Soft starters are capable of ramping the applied voltage up at the start and down at the stop. Variable frequency drives (VFDs) control speed and sometimes other factors such as torque. When speed control is not an issue, smart MCCs utilize intelligent motor control devices that, like soft starters and VFDs, are capable of monitoring and protecting motors and communicating important motor data via a network to a PLC or process control system. This data can also be communicated to HMI devices or a process visualization system so that operation and maintenance personnel are aware of system conditions.

The increased capabilities of Smart MCCs enable condition-based maintenance practices that reduce downtime and maintenance costs and increase system efficiency. These factors alone are more than enough to justify the transition to smart MCCs, but there is more to the story.

Monitoring Energy Usage and Power Quality

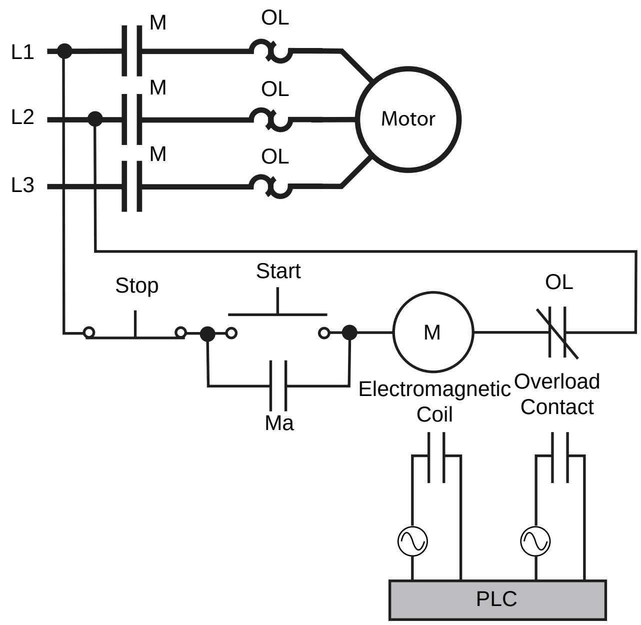
According to one study, process industries consume 80 percent of the energy used in the U.S. industrial sector and electric motors consume 64 percent of the energy used in a process plant. For other types of facilities that use MCCs, the percentages may be proportionally less, but still significant. For example, a typical electric motor consumes 10 to 25 times its initial purchase price each year of operation.

Additionally, motors, and the devices that control them, can negatively affect power quality. Reduced power quality, in turn, reduces the lifespan of many system components, including motors.

Smart MCCs are capable of monitoring energy consumption and power quality in a variety of ways. This capability can be obtained by inclusion of an intelligent main circuit breaker, a power meter or power quality meter can be installed in an MCC section, and various intelligent motor control devices can also provide useful information. Because the information collected can be communicated via a network to a PLC or process control system and HMI devices or a process visualization system, operation and maintenance personnel can stay informed and can take corrective actions as needed.

Monitoring System Operation

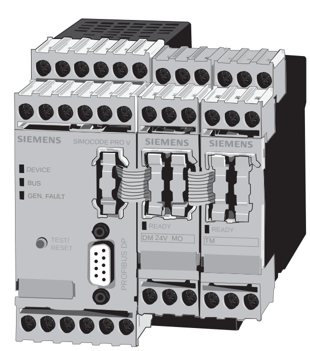
Historically, MCCs have played a limited roll in monitoring system operation. In order to understand why, consider the basic start-stop motor control circuit in the following illustration. In this circuit, two PLC inputs are connected to normally open contacts. One contact closes when the motor starter coil energizes. The other contact closes when an overload occurs.



Just providing this basic information to the PLC not only adds to the initial cost of the system, especially when multiple motors are involved, but also provides very little useful information. Some additional information can be obtained by connecting more devices, but at increased expense. As the complexity of the system increases, the number of wires and the cost required to gain even a moderate amount of information increases as well.

In contrast, smart MCCs incorporate intelligent devices that, in addition to providing expanded protection as previously described, are capable of efficiently communicating information that is difficult to obtain or unavailable when traditional motor starters are used. The following table shows examples of the types of information that can be communicated.

Motor Operation	Power Conditions	Status of External Events
Operational status	Phase currents	Discrete inputs
Number of starts	Phase voltages	Analog inputs
Operating time	Phase failure	Results of internal logic
Stop time	Phase imbalance	
Number of forward starts	Ground fault	
Number of reverse starts	Energy consumed	
Motor/bearing temperature	Real power	
Number of overload trips	Apparent power	
Time to trip	Power factor	
Last trip current		
Cool down period		

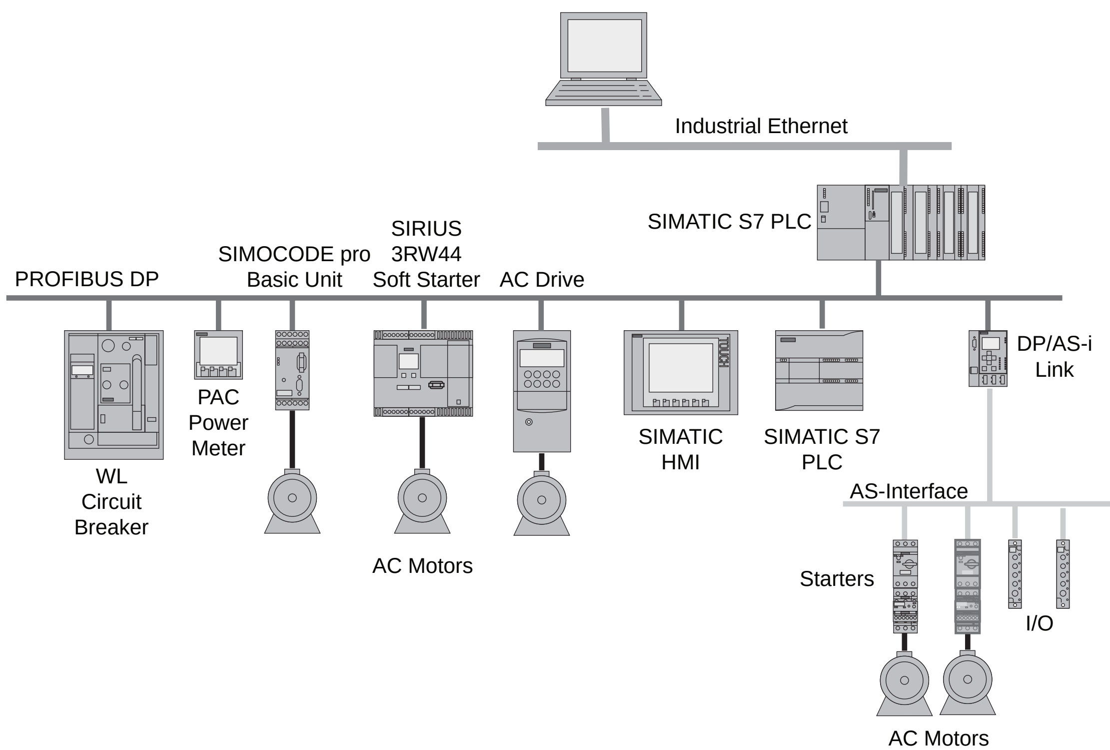


Network Communication

As previously mentioned, network communication and use of intelligent devices are the enabling technologies for smart MCCs. Intelligent devices provide a wealth of useful information, but, without a fast, effective, and inexpensive way to communicate, there would be no practical way to take advantage of this information.

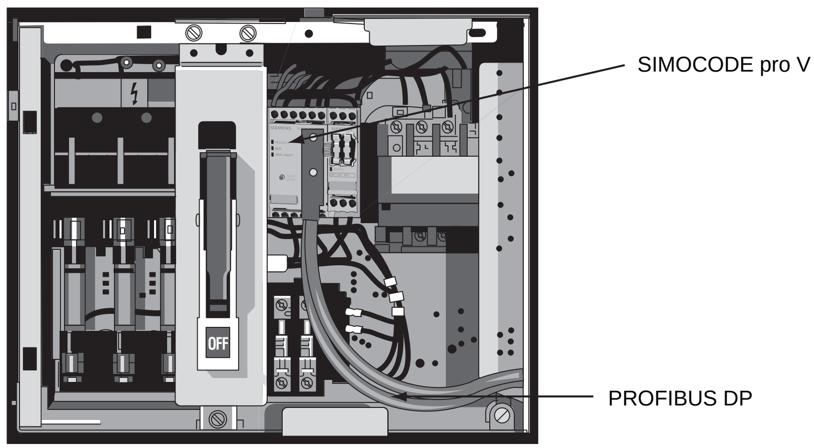
Over time, a number of networks have been developed for use in industrial applications. Some of these networks, like Industrial Ethernet or PROFINET, are intended for higher level communication, and others are designed for control applications. A network intended to interconnect distributed control devices is often referred to as a field bus.

Field buses, like **PROFIBUS DP** and **Actuator-Sensor Interface** (**AS-Interface** or **AS-i**), not only provide efficient communication, enabling the use of distributed intelligence, but also allow a smart MCC to be installed and commissioned in less time and at a lower cost than when traditional wiring is used.



tiastar Smart MCCs

By definition, a **tiastar Smart MCC** incorporates intelligent devices such as SIMOCODE pro C and V motor management systems, SIRIUS 3RW44 soft starters, SIMATIC PLCs, various Siemens VFDs, and other components. These devices are internally interconnected using PROFIBUS DP. Additional components may be connected using AS-i networking. External connections to these or other networks may also be incorporated.



tiastar Smart MCCs utilize the same rugged and reliable construction as other tiastar MCCs and many of the components of a tiastar Smart MCC have already been covered. Therefore, most of the remaining content of this course involves selected networking concepts.

As previously mentioned, the TIA portion of the tiastar name stands for **Totally Integrated Automation**. TIA is a strategy developed by Siemens that emphasizes the seamless integration of automation, networking, drive, and control products.

SIMATIC NET

Collectively, the various networking elements incorporated into TIA are referred to as **SIMATIC NET**. The following tables provide summary information for a few of the networks included under the SIMATIC NET umbrella.

Selected SIMATIC NET Networks

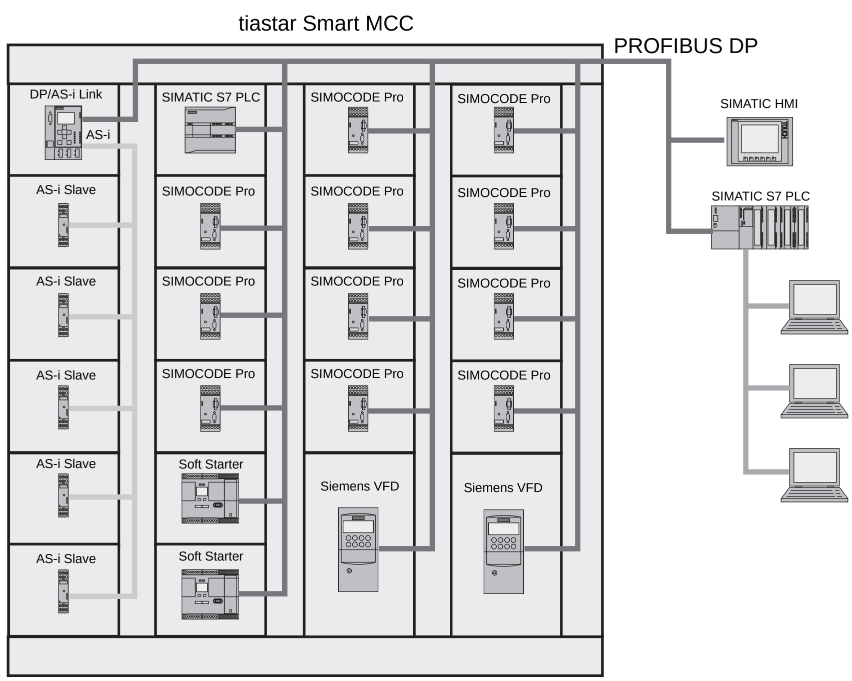
Network	Standard	Description
Industrial Ethernet	IEEE 802.3	Industrial network based on the international Ethernet standard
PROFINET	IEC 61158/61784	Open industrial Ethernet standard for automation
PROFIBUS	IEC 61158/61784	Market leading international standard for field level communication
AS-Interface	IEC 62026-2/EN 50295	International standard for two-wire communication with actuators and sensors

	Industrial Ethernet	PROFINET	PROFIBUS DP	AS-Interface
Enerprise Resource Planning (ERP)	●	o	x	x
SIMATIC PLCs and Control Systems	●	●	●	o
Siemens Motion Control	o	●	●	x
Siemens Drives	o	●	●	●
Intelligent Field Devices	x	●	●	●
Simple Field Devices	x	●	●	●
SIRIUS Motor Starters	x	●	●	●
Sensors and Actuators	x	●	●	●
Safety-oriented Communication	x	●	●	●

● = suitable use, o = possible use, x = not suitable

It is not in the scope of this course to cover the many varied networking elements included in SIMATIC NET, but, because of their importance to the tiastar Smart MCC, PROFIBUS DP and AS-Interface need some additional discussion

As previously described, PROFIBUS DP is the primary network used internal to a tiastar SMART MCC to link SIMOCODE pro C and V motor management systems, SIRIUS 3RW44 soft starters, SIMATIC PLCs, various Siemens VFDs, and other intelligent components.



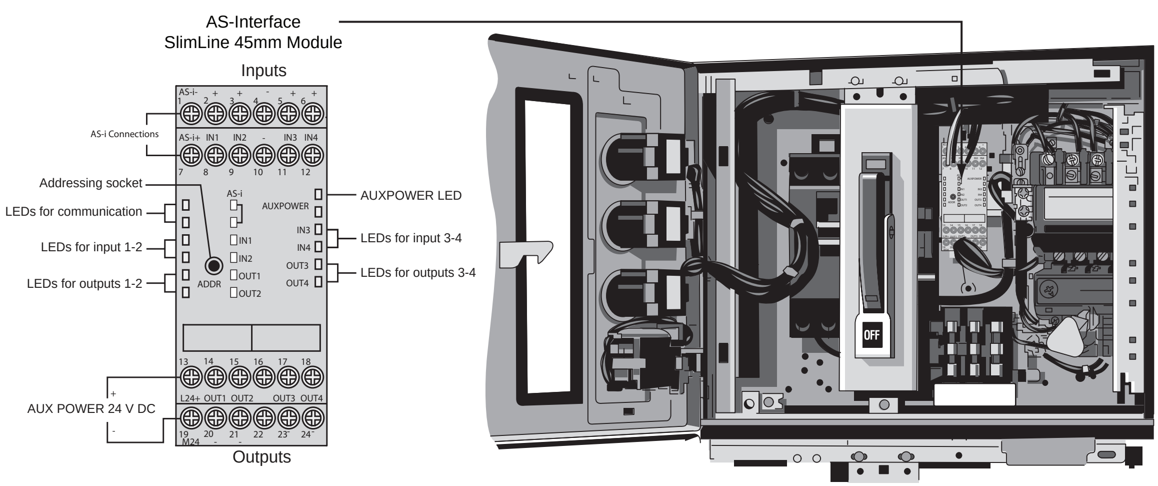
PROFIBUS is available in other forms such as PROFIBUS PA, PROFIBUS FMS, and PROFIsafe, but PROFIBUS DP is the predominant form, and a PROFIBUS DP network can link to these other networks where needed.

PROFIBUS DP is an open network based on the IEC 61158/61784 standard. As a result, multiple manufacturers have developed and tested products for connection via this network.

tiastar SMART MCCs also use motor control units with actuators and sensors not equipped for direct communication with a PROFIBUS DP network. However, information from these devices can be communicated using an AS-i network. As shown in the previous diagram, An AS-i network can be connected to a PROFIBUS DP network using a **DP/AS-i link**.

AS-Interface

AS-Interface is a simple, open, cost effective network that uses a two-wire cable for both data and power and is based on the IEC 62026-2/EN 50295 standard. AS-Interface is a master-slave network; therefore, a slave module is required to connect devices in a combination motor control unit into the network. A variety of slave modules are available. For example, an **AS-Interface SlimLine module** can be used to interface discrete I/O. The 22.5 mm module can accommodate 4 discrete inputs and the 45 mm module can accommodate 4 discrete inputs and four discrete outputs.



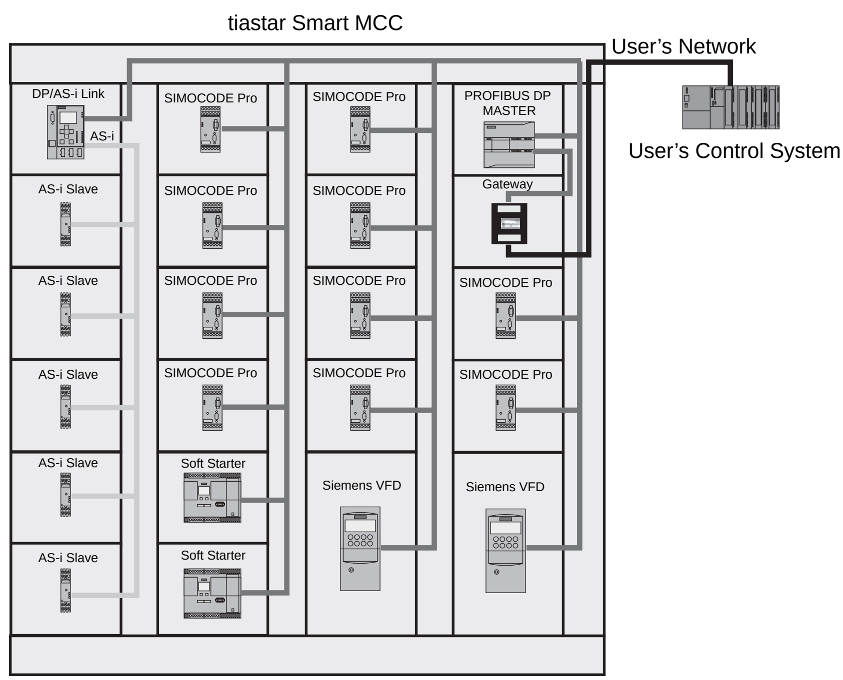
Discrete I/O can be used to communicate start or stop signals, Hand-Off-Auto (HOA) status, breaker status, contactor status, or to allow a PLC in an automatic control scheme to control run-stop conditions or rotation direction. Because up to 31 slaves can be connected to the same two-wire AS-Interface network, the savings in wiring and the reduction in wiring complexity can be significant.

Other Networks

Because many facilities currently have one or more alternative networks to interconnect components of a control system, a number of **gateways** have been developed to interface a PROFIBUS DP network to another network.

When Siemens supplies a gateway module, it is typically installed in a 12-inch bucket with the necessary power supply and additional wiring terminations. Siemens connects the internal PROFIBUS DP network to the scanner side of the gateway, and it is usually the user's responsibility to connect the adapter side of the gateway to the user's network.

A partial list of existing gateways includes **HMS Industrial Networks Anybus gateways** to the following networks: DeviceNet, Ethernet/IP, Modbus TCP/IP, Modbus RTU, and Modbus Plus.

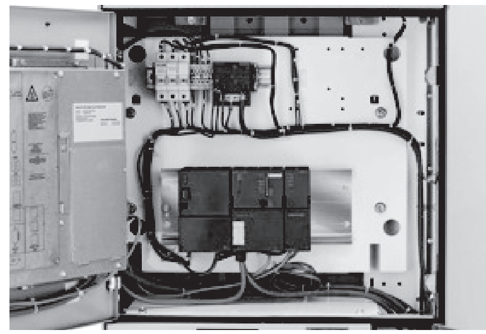


SmartStart

Siemens tiastar Smart Motor Control Center with SmartStart offers quick and easy start-up and commissioning. MCCs ordered with the SmartStart option include a preconfigured PLC and human machine interface (HMI) combination that is factory installed and tested. With no programming needed and self-configuration of the PLC, SmartStart reduces integration, installation, commissioning, implementation and maintenance time.

HMI Touch Screen

Siemens PLC with PROFIBUS DP



Standard Components
18" Fixed Mount Unit in the tiastar Smart MCC
Fusing and Control Power for the PLC and Bus
Siemens SIMATIC S7 PLC with PROFIBUS Master and Ethernet Communication
PROFIBUS DP Communications Cabling to all PROFIBUS DP Devices
12" Siemens Panel PC Touch Screen
WinCC
SmartStart Appliction for WinCC
Standard PLC Program for tiastar Smart MCC PLC

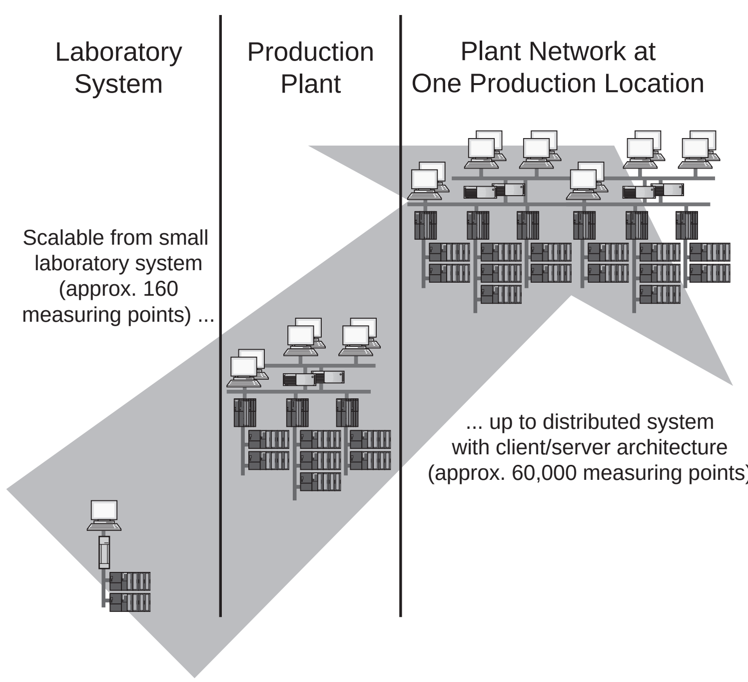
Out-of-the-Box Functionality
Display the data for: • SIMOCODE pro for full-voltage non-reversing and reversing starters • Siemens variable frequency drives • SIRIUS 3RW44 soft starters • WL circuit breaker
Provide control for each starter device via: • SmartStart Control Station mounted in the MCC • Field-mounted 120 VAC pilot devices • Ethernet-connected PLC/DCS system
Display the device lineup in groupings of vertical sections emulating the front view of the MCC

Process Visualization and Control

Not only does a tiastar Smart MCC's inherent reliance on network communication enable the advantages discussed earlier in this course, it also enables the integration of the MCC into a larger system. In that regard, it is useful to discuss SIMATIC WinCC and SIMATIC PCS 7.

SIMATIC WinCC is a scalable, Windows-based process visualization system, or what is sometimes called a supervisory control and data acquisition (SCADA) system. SIMATIC WinCC is "scalable" because it can be configured to provide complete operating and monitoring functionality for simple, single-user systems up to complex, multi-user systems with redundant servers.

Traditionally, medium to large process applications have been controlled by distributed control systems (DCS) that are based on proprietary hardware and software that often do not integrate well with other systems. By comparison, Siemens SIMATIC PCS 7 uses a more flexible approach. **SIMATIC PCS 7** uses standard hardware and software from the SIMATIC TIA family. The uniform data management, communication, and configuration capabilities of TIA provide an open platform for solutions in batch, continuous, and hybrid process applications. In addition, the uniform automation technology also facilitates the optimization of all company operations from the ERP level to the field level.



Review 6

1. A smart MCC incorporates ________ interconnected by a ________.

2. Although a smart MCC can reduce operating costs, increase system efficiency, and provide more system information, it is typically more expensive to install and commission.

   True or False

3. A tiastar Smart MCC can interconnect which of these devices using PROFIBUS DP?

   a. SIMOCODE pro C or V
   b. SIRIUS 3RW44 soft starter
   c. SIMATIC PLC
   d. Siemens VFD
   e. All of the above

4. A tiastar Smart MCC uses which of these network types to internally communicate with devices that cannot directly connect to a PROFIBUS DP network?

   a. AS-Interface
   b. Industrial Ethernet
   c. PROFIBUS PA
   d. PROFINET

5. Gateways have been developed to connect a tiastar Smart MCCs PROFIBUS DP network to external networks such as DeviceNet, Ethernet/IP, Modbus TCP/IP, Modbus RTU, and Modbus Plus.

   True or False

6. Siemens tiastar Smart Motor Control Center with ________ offers quick and easy start-up and commissioning.

Review Answers

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

Review 2 1) Underwriters Laboratories; 2) overload; 3) overload; 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; 6) IEEE C37.20.7-2007, 2.

Review 5 1) 10; 2) contactor, overload relay; 3) 200; 4) DIP switches; 5) SIMOCODE pro; 6) 3RW30, 3RW40, 3RW44.

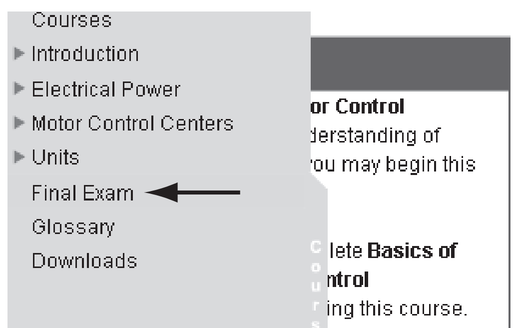
Review 6 1) intelligent devices, network; 2) False; 3) e; 4) a; 5) True; 6) SmartStart.

Final Exam

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

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

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



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

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