Pictorial Glossary

The pictorial glossary includes definitions and illustrations for many terms that are frequently used in the electrical industry. Terms that are underlined and italicized are included in the glossary as a separate definition.

**AC Drive**

An electronic device used to control the speed of an AC motor. Also called a *variable frequency drive* and an *inverter*. The term *variable speed drive* applies to both AC Drives and DC Drives.

![SINAMICS G110 AC Drives](image1)

**AC Motor**

A motor that uses *alternating current* to convert electrical energy into mechanical energy. Many AC motors used in industrial applications are three-phase induction motors.

![AC Motor](image2)

**Alternating Current (AC)**

*Current* that periodically reverses direction.

![Alternating Current Diagram](image3)
**Ambient Temperature**

The temperature of the medium (air, water, etc.) surrounding a device.

**American National Standards Institute (ANSI)**

A nongovernmental organization that promotes and coordinates the development of standards and accredits the procedures of other organizations that develop standards.

**American Wire Gauge (AWG)**

A common method of specifying wire size (cross-sectional area). Larger numbers represent smaller wires. After AWG No. 1, the largest sizes are AWG No. 0, AWG No. 00, AWG No. 000, and AWG 0000. AWG No. 0 is called one-aught, AWG No. 00 is called two-aught, etc.

**Ammeter**

A meter designed to measure current.

**Ampacity**

The continuous current rating in amperes for a conductor.

**Ampere, Amp**

The basic unit for current. An ampere, also called an amp, is equal to a current of 1 Coulomb per second. The symbol for ampere is “A.”

**Amplitude**

The total variation of a waveform. Amplitude can be expressed as a peak value, peak-to-peak value, or effective value.

**Analog**

A value that is continuously variable. Also used to describe circuits that work with analog signals.

**Analog Input**

An input to a system that can continuously vary over a range of current or voltage such as 4 to 20 milliamps or 0 to 10 volts.
Analog Output
An output from a system that can continuously vary over a range of current or voltage such as 4 to 20 milliamps or 0 to 10 volts.

Apparent Power
The vector sum of true power and reactive power. Apparent power is calculated by multiplying current times voltage. The unit for apparent power is the volt-ampere, abbreviated “VA.”

Arc Chute Assembly
An assembly of metal plates surrounding circuit breaker or contactor contacts. Arc chutes are used to reduce contact damage by quickly extinguishing the arc created when contacts open.

Arc Fault
An electrical arc which causes current to flow in unintended ways, but often not in sufficient amounts to cause a standard circuit breaker to trip. Arc faults result from worn or damaged insulation and are a common cause of fires.
Arc Fault Circuit Interrupter (AFCI)

A circuit breaker designed to provide protection from the effects of an arc fault by recognizing the characteristics unique to arcing and de-energizing the circuit when an arc fault is detected. The most effective AFCI circuit breakers are combination AFCIs which provide protection against all three known types of arc faults.

<table>
<thead>
<tr>
<th>LED Indicator</th>
<th>Last Known Trip Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED (A)</td>
<td>LED (B)</td>
</tr>
<tr>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

Siemens Combination AFCI Circuit Breaker

Autotransformer

A type of transformer in which the secondary coil is part of the primary coil. Often the secondary voltage is adjustable via a movable tap.

Binary-Coded Decimal (BCD)

Usually refers to the 8-4-2-1 code where four bits are used to represent decimal digits 0 through 9.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>BCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<tr>
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</tr>
<tr>
<td>8</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
</tr>
</tbody>
</table>

Binary Number

A number made up only of 1’s and 0’s that represent powers of two (2). Digital equipment uses binary numbers to represent numerical values and the on or off condition of devices.

Most Significant Bit (MSB) | Least Significant Bit (LSB) |
---------------------------|-------------------------------|
Power of 2                | 2^0                            |
Decimal                   | Binary                        |
128                       | 1000000                        |
64                        | 0100000                        |
32                        | 0010000                        |
16                        | 0001000                        |
8                         | 0000100                        |
4                         | 0000010                        |
2                         | 0000001                        |
1                         | 0000000                        |

10010010 in Binary = 146 in Decimal
**Bit**  
A 1 or 0 representing one position in a *binary* number.

**Bonding**  
The permanent joining of metal parts to form an electrically conductive path.

**Branch Circuit**  
A part of a *power* distribution system extending beyond the final *overcurrent* protection device.

**Bus**  
A group of *conductors* used to supply *power*, data, or control signals.

**Bus Bar**  
A *conductor* that serves as a common connection for two or more circuits.
**Bus Plug**
A device used with plug-in busway to provide power connections close to the intended load.

**Busway**
A prefabricated electrical distribution system that uses bus bars in a protective enclosure.

**Busway Hangers**
Devices used to suspend busway from a ceiling or mount it to a wall.

**Byte**
Eight consecutive bits.

**Capacitance**
The property of a circuit or device that allows it to store an electrical charge. The symbol for capacitance is “C.” The unit for capacitance is the farad.
Capacitive Proximity Switch  A type of *sensing switch* that produces an electrostatic field to detect the presence of an object without touching the object.

Capacitive Reactance  The opposition to *alternating current* resulting from circuit *capacitance*. Capacitive reactance is inversely proportional to *frequency* (f) and capacitance (C). The symbol for capacitive reactance is “X<sub>c</sub>.” The unit for capacitive reactance is the *ohm*.

\[
X_c = \frac{1}{2\pi fC}
\]

Capacitor  A device manufactured to have a specific *capacitance*.

Central Processor Unit (CPU)  The decision-making part of a computer. May also be used to describe the processing circuits together with memory and other circuits needed for processing information.
Circuit Breaker
A device that can be used to open or close a circuit manually and also opens a circuit automatically when it senses an overcurrent.

Closed-Loop Control
A control technique that compares a feedback signal representative of an actual value with a desired value and responds to minimize the error.

Conductor
A material that permits electrons to easily move through it. Copper, silver, and aluminum are examples of materials that are good conductors. Also used generically to refer to a wire, cable, or bus bar that is made from a conducting material.

Contactor
Usually refers to a device with large contacts that close when current is applied to its electromagnet; however, solid state contactors are also available. Contactors are used to control the power applied to motors, lights, or heating components.
Control Relay

Usually refers to a device with contacts that open and close electromagnetically, but solid state control relays are also available. Control relays typically handle smaller currents than contactors, but are capable of switching more rapidly.

<table>
<thead>
<tr>
<th>Circuit 1</th>
<th>Circuit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Pole</td>
<td>Double-Pole</td>
</tr>
<tr>
<td>Single-Thro</td>
<td>Double-Thro</td>
</tr>
<tr>
<td>Single-Brea</td>
<td>Single-Brea</td>
</tr>
</tbody>
</table>

Control Relay Contact Types

Coulomb

A unit of electrical charge moved in 1 second by a current of 1 ampere. This is equal to approximately $6.24 \times 10^{18}$ electrons.

Coulomb’s Law

A law that states that charged objects attract or repel each other with a force that is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.

Unlike Charges Attract  
Like Charges Repel

Counter EMF

A voltage created in an inductive circuit that opposes a change in current flow. EMF stands for electromotive force.
Crest Factor

The ratio of the peak value of an alternating current to its effective value.

\[
\text{Crest Factor} = 1.414 \quad \text{Crest Factor} < 1.414 \quad \text{Crest Factor} > 1.414
\]

Current

The flow of electrons in a circuit. Current is designated by the symbol “I” and is measured in amperes.

DC Drive

An electronic device used to control the speed of a DC motor. The term variable speed drive applies to both DC Drives and AC Drives.

DC Motor

A motor that converts direct current electrical energy into mechanical energy.

Dead Front

A front portion of a panelboard or switchboard that limits exposure to electrical connections.
Delta
A connection arrangement used for the primary and/or secondary of a three-phase transformer.

[Diagram of Delta-Delta transformer configuration]

Digital
Used to describe circuits that use on or off (binary) signals. Also used to describe equipment that includes these circuits.

DIN Rail
A mounting bracket manufactured to German Institute for Standardization (DIN) standards. Typically used to mount devices such as small PLCs, motor starters, control relays, power supplies, and other components that are DIN rail compatible.

Diode
A component with two terminals (anode and cathode) that passes current primarily in one direction. Often used as part of a rectifier circuit.

Direct Current (DC)
Current with a constant direction.

Disconnect Switch
A switch designed to disconnect electrical power from a circuit.
Discrete I/O

Inputs (I) and outputs (O) that are either on or off.

Distribution Section

A switchgear, switchboard, or power panelboard section that receives power from the service section and distributes power to other circuits.

Duty Cycle

The ratio of a device’s on time to its total cycle time. Duty cycle is normally expressed as a percentage; therefore, a device with a 50% duty cycle is on half the time.

Effective Value

A measure of the amplitude of alternating current or voltage. Also called the root-mean-square or RMS value. Test meters used to measure alternating current or voltage usually display effective values.
Electrically Erasable Programmable Read Only Memory (EEPROM)
A type of semiconductor memory often used for storage of data or programs that change less frequently than random access memory. The contents of EEPROM chips are erased with electrical pulses rather than with ultraviolet light as with erasable programmable read only memory. EEPROMs retain their contents when power is turned off.

Enclosure
A protective housing. Guidelines for various types of electrical enclosures are provided by the National Electrical Manufacturers Association (NEMA) and International Electrotechnical Commission (IEC).

Encoder
Often refers to a digital device that provides angular position information. Some encoders provide this information as incremental pulses as position changes. Other types of encoders provide a digital signal representative of absolute position.

Erasable Programmable Read Only Memory (EPROM)
A type of semiconductor memory often used for storage of data or programs that change infrequently, if at all. EPROMs must be removed from the circuit to be erased and reprogrammed. EPROMs retain their contents when power is turned off.

Explosion Proof (XP)
A motor enclosure type used in hazardous locations. Explosion proof enclosures are also available for other types of equipment.

Farad
The basic unit of capacitance. The symbol for the farad is “F.”

Feedback
A signal provided to a control circuit that is representative of an actual condition in a machine or process.

Feeder
Often refers to a set of conductors that originates at a main distribution center and supplies power to one or more secondary or branch distribution centers.
**Feeder Busway**

*Busway* used to distribute *feeder* current to loads that are sometimes remote from the power source.

**Filler Plates**

Plates used to cover unused spaces in a panel.

**Four-Quadrant Operation**

Describes the operation of a *variable speed drive* that is capable of providing forward or reverse *torque* with the motor rotating in either the forward or reverse direction.

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Rotation</th>
<th>Type</th>
<th>Symbol</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>CW</td>
<td>Driving</td>
<td>$+T$</td>
<td>$+N$</td>
</tr>
<tr>
<td>Second</td>
<td>CW</td>
<td>Braking</td>
<td>$+N$</td>
<td>$-N$</td>
</tr>
<tr>
<td>Third</td>
<td>CCW</td>
<td>Braking</td>
<td>$-N$</td>
<td>$-N$</td>
</tr>
<tr>
<td>Fourth</td>
<td>CCW</td>
<td>Driving</td>
<td>$-N$</td>
<td>$+N$</td>
</tr>
</tbody>
</table>

**Frequency**

The rate of variation of a periodic waveform. The symbol for frequency is “f.” The unit for frequency is *Hertz*.

**Full-Voltage Starter**

A type of *motor starter* often used for three-phase induction motors that applies the full line *voltage* to the motor immediately. Sometimes called an across-the-line starter.
Fuse
A device designed to open a circuit when its rated current is exceeded. This is usually accomplished when a metal link in the fuse melts. Renewable fuses allow the user to replace the link and non-renewable fuses do not. Fuses are available in various sizes and types. Some have a time delay.

Fuse Class
A letter designation given to a fuse to identify its operating and construction characteristics.

German Institute for Standardization (DIN)
Recognized since 1975 as the standards organization that represents German interests nationally and internationally.

Ground
A connection to the earth or to a conductive object such as an equipment chassis.

Ground Fault
A condition in which current takes an unintentional path to ground. Ground faults can endanger people and damage equipment. For this reason, some circuits are equipped with a ground fault circuit interrupter (GFCI).

Ground Fault Circuit Interrupter (GFCI)
A device designed to interrupt current in a circuit if a ground fault is sensed. If a GFCI is installed near the receptacles it protects, overcurrent protection is required separately. A GFCI circuit breaker combines protection for ground faults, overloads, and short circuits in one device.
Harmonics

The base frequency produced by a circuit is said to be the fundamental frequency or first harmonic. Additional harmonics are multiples of the first harmonic. The 3rd harmonic of a 60 Hz power supply, for example, is $3 \times 60 \text{ Hz} = 180 \text{ Hz}$.

Harmonic Distortion

The effect of harmonics on the fundamental frequency. Harmonic distortion can interfere with the operation of electronic devices.

Henry

The basic unit of inductance. The symbol for the henry is “H.”

Hertz

A unit of frequency equal to one cycle per second. Hertz is abbreviated Hz.

Hexadecimal

A number system that uses powers of 16.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
<th>BCD</th>
<th>Hexadecimal</th>
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<td>011</td>
<td>13</td>
</tr>
<tr>
<td>20</td>
<td>10100</td>
<td>1000</td>
<td>14</td>
</tr>
</tbody>
</table>

Horsepower

A unit of power. Horsepower is abbreviated “HP.” 1 horsepower is equal to 746 watts.

IEEE

An organization open to individual membership that provides a variety of services for its members, but also develops numerous standards for technology and practices. The organization is now officially known as IEEE (pronounced eye-triple-e) and no longer refers to itself as the Institute of Electrical and Electronic Engineers.
Impedance
The total opposition to alternating current. Impedance is the vector sum of resistance and reactance. The symbol for impedance is “Z.” The unit for impedance is the ohm.

\[
Z = \sqrt{R^2 + X_C^2}
\]

Inductance
The property of an electrical circuit that opposes changes in current. Inductance is designated by the symbol “L” and is measured in henries.

Inductive Proximity Switch
A type of sensing switch that uses an electromagnetic coil to detect the presence of a metal object without coming into physical contact with it.

Inductive Reactance
The opposition to alternating current resulting from circuit inductance. Inductive reactance is directly proportional to frequency (f) and inductance (l). The symbol for inductive reactance is “X_l.” The unit for inductive reactance is the ohm.

\[
X_l = 2\pi fl
\]

Inductor
A device manufactured to have a specific inductance. An inductor is often made from a coil of wire and is sometimes called a coil or choke.
**Input/Output (I/O) System**

The part of a control system that interfaces to the real world. The I/O system accepts signals from switches and sensors, and provides signals to actuating and display devices.

*Diagram*

- Processor → I/O System
- I/O System → I/O Devices

**Discrete I/O Examples**
- 5 VDC, 24 VDC, 125 VDC
- 24 VAC, 120 VAC, 240 VAC

**Analog I/O Examples**
- 0 to 10 VDC
- -10 to +10 VDC
- 4 to 20 mA

**Instrument Transformer**

A type of transformer used to sense the voltage or current of associated conductors and provide proportional electrical energy to measurement devices or circuits. A potential transformer (PT) is used for voltage measurements and a current transformer (CT) is used for current measurements.

**Insulated Case Circuit Breaker**

A type of circuit breaker that conforms to NEMA AB-1 and UL 489 standards for molded case circuit breakers and is often used as a main breaker in switchboards, motor control centers, or in other applications requiring a molded case circuit breaker with a high continuous current rating.

**Insulated Gate Bipolar Transistor (IGBT)**

A type of transistor often used as a switching device in the inverter section of a variable frequency drive. Voltage on the gate element is used to control the current flowing between the collector and emitter.

**Insulator**

A material with a high resistance to the flow of electrons. Plastic, rubber, glass, and mica are examples of materials that are good insulators.

**International Electrotechnical Commission (IEC)**

An organization based in Geneva, Switzerland with over 50 national committees as full members. ANSI represents the U. S. IEC writes international standards for electrical and electronic technologies and practices.
International Organization for Standardization (ISO)  
A network of standards organizations from over 150 countries that develops voluntary standards for business, science, and technology. The name ISO is from the Greek word “isos,” which means equal.

Interrupting Rating  
The maximum level of fault current that a circuit breaker or fuse can safely interrupt at a specific voltage. The interrupting rating is also called the ampere interrupting rating.

Inverter  
A device that converts direct current to alternating current. Inverter is also used as a synonym for an AC drive even though the AC drive usually includes other circuits.

Isolation Transformer  
A transformer used to limit the transfer of electrical noise from one circuit to another.

Joule  
The basic unit of electrical energy. 1 Joule is equal to 1 watt-second or the amount of energy transferred in one second when the power is one watt.

Knockout  
A place in an enclosure where a piece of the enclosure can be easily removed to allow for cable entry.

Ladder Logic  
A method of programming a programmable logic controller that uses symbols that evolved from the diagrams used with control relays.
Limit Switch
A type of switch that opens or closes its contacts when its actuator is moved by an object.

Load Center
An industry term used to identify a lighting and appliance panelboard designed for use in residential and light commercial applications.

Local Area Network (LAN)
A communication system that interconnects devices within a limited area, but may also connect to other networks for larger-scale communication.

Low Voltage Power Circuit Breaker
A circuit breaker, typically used as a drawout-mounted breaker in low voltage switchgear, that conforms to ANSI C37.13, C37.16, C37.17, and C37.50 and UL 1066 standards.
Main Breaker

The *circuit breaker* in or upstream from a *load center, panelboard, switchboard, switchgear* or other equipment that supplies the full current for that equipment.

![Main Breaker](image)

Main Lug Only

A designation given to indicate that a main breaker or main switch is not included.

![Main Lugs](image)

MCM

Abbreviation for a thousand circular mils. Circular mils are used to designate the cross-sectional area of a round *conductor*. One mill is equal to 1/1000 of an inch. The circular mill area of a solid, round conductor is calculated by squaring the conductor’s diameter (in mills). 1 MCM is 1000 circular mils (also shown as 1 kcmil).

Metric Unit Prefix

A prefix added to a unit of measure to increase or decrease the size of that unit of measure. For example, the metric unit prefix kilo can be added to meter to form a unit of length (kilometer) equal to 1000 meters. Metric unit prefixes are associated with powers of ten.

**Metric Unit Prefix Examples**

<table>
<thead>
<tr>
<th>Value</th>
<th>Prefix</th>
<th>Symbol</th>
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</thead>
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<tr>
<td>$1,000,000,000$</td>
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<td>G</td>
</tr>
<tr>
<td>$1,000,000$</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>$1,000$</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>$0.001$</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>$0.000001$</td>
<td>micro</td>
<td>μ</td>
</tr>
<tr>
<td>$0.00000001$</td>
<td>nano</td>
<td>n</td>
</tr>
</tbody>
</table>
Molded Case Circuit Breaker  A circuit breaker enclosed in an insulated housing. In the United States, molded case circuit breakers conform to NEMA AB-1 and UL 489 specifications.

Molded Case Switch  A switch enclosed in the same type of insulated housing as a molded case circuit breaker. Siemens molded case switches employ the same operating mechanism as thermal-magnetic and magnetic only circuit breakers. A preset instantaneous function is factory installed to allow the switch to trip and protect itself at a high fault current, but the switch provides no thermal overload protection or short circuit protection.

Motor (Electric)  A device that transforms electrical energy into mechanical energy.

Motor Control Center  A metal structure containing multiple motor control units. Typically, individual control circuits are mounted in removable containers, often referred to as pans or buckets.
Motor Insulation Class  Standards established by the National Electrical Manufacturers Association (NEMA) to meet motor temperature requirements found in different operating environments. The combination of an ambient temperature of 40°C and allowed temperature rise equals the maximum winding temperature of a motor. A margin is also allowed to provide for a point at the center of the motor’s windings where the temperature is higher.

Motor Starter  Often refers to a contactor and an overload relay assembled together to remotely control the operation of a motor while providing overload protection. This definition applies to a full voltage starter. A variety of other starter types are also available.

Mutual Induction  A process that occurs when varying lines of magnetic flux from one conductor induce a voltage in an adjacent conductor. This is the basic operating principle of a transformer.

National Electrical Manufacturers Association (NEMA)  An organization of manufacturers of electrical equipment that, among other things, develops standards for electrical equipment.

National Electrical Code® (NEC®)  A document revised every three years based upon inputs to and recommendations of volunteer committee members of the National Fire Protection Association. The intent of the NEC®, also called NFPA 70®, is to describe safe electrical practices. Although the NEC® is an advisory document, its use is often mandated by state and local building codes.

National Fire Protection Association (NFPA)  A private, nonprofit organization with international membership. The NFPA has been the sponsor of the National Electrical Code® (NEC®) since 1911.

NEMA Enclosure Type  A designation given to an enclosure based on standards published by the National Electrical Manufacturers Association. The NEMA type identifies the degree of protection provided by the enclosure.

<table>
<thead>
<tr>
<th>NEMA Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intended for indoor use, provides protection against a limited amount of falling dirt.</td>
</tr>
<tr>
<td>3R</td>
<td>Intended for outdoor use, provides protection against rain, sleet, and damage from external ice formation.</td>
</tr>
<tr>
<td>4</td>
<td>Intended for indoor or outdoor use, provides protection against windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.</td>
</tr>
<tr>
<td>4X</td>
<td>Intended for indoor and outdoor use, provides protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.</td>
</tr>
<tr>
<td>12</td>
<td>Intended for indoor use, provides protection against circulating dust, falling dirt, and dripping noncorrosive liquids.</td>
</tr>
</tbody>
</table>
NEMA Frame Size  
A designation that identifies motor dimensions based upon standards provided by the *National Electrical Manufacturers Association*. Motors too large to correspond to NEMA frame sizes are referred to as above NEMA motors.

NEMA Motor Design  
A letter designation based upon standards established by the *National Electrical Manufacturers Association* that corresponds to a motor’s speed and torque characteristics.

Neutral  
A reference connection in a power distribution system.

Ohm  
The basic unit of resistance, reactance and impedance. The symbol for the ohm is “Ω”, the Greek letter omega.

Ohmmeter  
A meter designed to measure resistance.
Ohm’s Law

A law that states that the current in a circuit is directly proportional to the voltage and inversely proportional to the resistance.

\[ I = \frac{E}{R} \]

- \( E \) = Electromotive Force (Volts)
- \( I \) = Current in Amperes (Amps)
- \( R \) = Resistance in Ohms

Open Drip Proof (ODP)

A motor enclosure type that permits air flow through the motor, but is designed to prevent liquids or solids falling from above at angles up to 15 degrees from the vertical from entering the motor.

Open-Loop Control

A control technique that does not use a feedback signal.

Overcurrent

A current in excess of the rated current for a device or conductor. An overcurrent can result from an overload, short circuit, or ground fault.

Overload

Can refer to an operating condition in excess of the full-load rating or a current high enough to cause damage if it is present long enough. Short circuits and ground faults are not overloads.

Overload Relay

A device used to protect a motor from damage resulting from an overload.
Overload Relay Class

Defines the length of time an overload condition can exist before an overload relay trips. For example, a class 10 overload relay allows 600% of full load amperes for up to 10 seconds.

Pad-Mounted Transformer

An enclosed transformer mounted on a concrete pad.

Panelboard

A front-accessible panel containing overcurrent protection devices for use in controlling lighting and appliance or power circuits.

Photoelectric Proximity Switch

A type of sensing switch that uses light to detect the presence of an object without coming into physical contact with the object.
**Pilot Light**

An indicator light typically used to represent a condition in a machine or process.

- **RUN Pilot Light is On**
- **STOP Pilot Light is On**

**PLC Scan**

A complete execution cycle of a *programmable logic controller*. The PLC scan involves updating the status of inputs, executing the user program, performing diagnostic and communication functions, and updating the status of outputs. A PLC scan is repetitively executed.

**Plug-in Busway**

*Busway* that incorporates plug-in units, called *bus plugs*, to allow loads to be distributed over the length of the run.
Power

The rate at which work is done or energy is transformed. In an electric circuit, power is measured in *watts*, or sometimes in *horsepower*. The term power is also often used to refer to electrical energy and as an adjective to describe devices or circuits designed to carry a high level of current.

Power Factor

The ratio of *true power* to *apparent power* in a circuit. Power factor is also equal to the cosine of the phase angle.

Programmable Logic Controller (PLC)

A type of industrial computer used to control machines and processes. The PLC accepts inputs from switches and sensors and uses these inputs together with other data and program logic to control output devices.

Proportional-Integral-Derivative (PID) Control

A *closed-loop control* technique that seeks to minimize error by reacting to three values, one that is proportional to the error, one that is representative of the error over time, and one that is representative of the rate of change of the error.

Proximity Sensor

A type of *sensing switch* that detects the presence or absence of an object without physical contact.

Pulse Width Modulation (PWM)

As applied to *variable frequency drives*, this is a technique for controlling the *voltage* applied to an AC motor by varying the pulse width while also controlling the frequency of the pulses.

Pushbutton

A control device used to manually open and close a set of contacts.
**Random Access Memory (RAM)**

Usually refers to a type of semiconductor memory often used for temporary storage. RAM requires the continual application of power to retain information. For some systems, battery backup is used to prevent data or program loss in the event of a power outage.

**Reactance**

The opposition to alternating current resulting from circuit inductance and capacitance. The symbol for reactance is “X.” The unit for reactance is the ohm.

**Reactive Power**

Power associated with inductance or capacitance. The unit for reactive power is the var.

**Read Only Memory (ROM)**

Usually refers to a type of semiconductor memory often used for permanent storage of data or programs that do not change.

**Rectifier**

A device or circuit that converts alternating current to direct current.

**Reduced-Voltage Starter**

A type of motor starter that applies less than the full-line voltage to a three-phase induction motor while it is starting. There are a variety of reduced-voltage starters. Some types use electromechanical components and others use electronic components. Electronic reduced voltage starters are often referred to as solid-state reduced voltage starters or soft starters.

**Resistance**

A property of a material or circuit that opposes current flow. Resistance is symbolized by “R” and is measured in ohms.

**Resistance Temperature Detector (RTD)**

A device used to sense temperature that varies in resistance as temperature changes.
**Resistor**

A device manufactured to have a specific amount of resistance or to be variable within a specific range of resistance. A rheostat is a type of two-lead variable resistor and a potentiometer is a type of three-lead variable resistor.

![Fixed Value Resistor, Rheostat, Potentiometer](image)

**Root-mean-square or RMS Value**

The effective value of a current or voltage. Root-mean-square is descriptive of the mathematical process used to calculate the effective value of a periodic current or voltage.

**Rotor**

The rotating element in the magnetic circuit of a rotating machine such as a motor.

![Rotor](image)

**Safety Switch**

A type of enclosed switch that may also include provisions for fuses. Single-throw safety switches are used to provide a means for disconnecting power. Double-throw switches are used to transfer loads from one power source to another or to transfer power from one load to another.

![Safety Switches](image)
Secondary Unit Substation
A coordinated design consisting of one or more transformers mechanically and electrically linked to switchgear or switchboard assemblies with an outgoing voltage rated below 1000 volts.

Selective Coordination
Applying circuit breakers in a manner that minimizes the extent of an outage in the event of a fault. Circuit breakers are typically installed in a branching arrangement. In the event of a fault, the breaker electrically closest to the fault should trip first. This can be accomplished by properly sizing and adjusting all breakers.

Selector Switch
A manual switch with multiple contact positions.

Semiconductor
A type of material, such as silicon, with more resistance than a conductor, but less than that of an insulator. Semiconductors can be manufactured to produce devices such as diodes, transistors, thyristors, etc.
Sensing Switch  A device, sometimes called a sensor, that turns on or off to indicate presence or absence of an object or material. Examples include limit switches and photoelectric, inductive, capacitive, and sonar proximity switches.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit Switch</td>
<td>High Current Capability, Low Cost, Familiar “Low-Tech” Sensing</td>
<td>Requires Physical Contact with Target, Very Slow Response, Contact Bounce</td>
<td>Interlocking, Basic End-of-Travel Sensing</td>
</tr>
<tr>
<td>Photoelectric</td>
<td>Senses all Kinds of Materials, Long Life, Largest Sensing Range, Very Fast Response Time</td>
<td>Lens Subject to Contamination, Sensing Range Affected by Color and Reflectivity of Target</td>
<td>Packaging, Material Handling, Parts Detection</td>
</tr>
<tr>
<td>Inductive</td>
<td>Resistant to Harsh Environments, Very Predictable, Long Life, Easy to Install</td>
<td>Distance Limitations</td>
<td>Industrial and Machines, Machine Tool, Senses Metal-Only Targets</td>
</tr>
<tr>
<td>Capacitive</td>
<td>Detects Through Some Containers, Can Detect Non-Metallic Targets</td>
<td>Very Sensitive to Extreme Environmental Changes</td>
<td>Level Sensing</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>Senses all Materials</td>
<td>Resolution, Repeatability, Sensitive to Temperature Changes</td>
<td>Anti-Collision, Doors, Web Brake, Level Control</td>
</tr>
</tbody>
</table>

Service Entrance  The place where power cables enter a building.

Service Factor  A numerical value that is multiplied by a motor’s rated horsepower to determine the maximum horsepower at which the motor should be operated.

Service Head  A device used to connect busway at the service entrance.

Service Section  The switchgear, switchboard, or power panelboard section connected to incoming power.
**Servo Drive**

Usually refers to an electronic device used to control the speed and **torque** of a **servo motor** as part of a closed-loop positioning control system.

![Servo Drive Diagram](image)

**Servo Motor**

A **motor** designed with the dynamic response required for precision closed-loop positioning applications.

![Servo Motors](image)

**Set Point**

The value used by a control circuit as the desired value of a process variable.

**Short Circuit**

A normally unintended low **resistance** path for **current**.

![Short Circuit Diagram](image)

**Shunt Trip**

A circuit breaker accessory used to remotely trip a **circuit breaker**.

![Shunt Trip Accessory](image)
Single Quadrant Operation
Describes the operation of a variable speed drive that can provide torque to drive the motor, but cannot provide braking torque.

Slip
The difference between the synchronous speed of a three-phase induction motor and the rotor speed. Slip is often expressed as a percentage.

\[
\% \text{ Slip} = \left( \frac{N_S - N_R}{N_S} \right) \times 100
\]

\(N_S = \text{Synchronous Speed}\)
\(N_R = \text{Rotor Speed}\)

Solid-State
Used to describe equipment that contains semiconductor devices in an electronic circuit.

Speed-Torque Curve
A graphical representation of the torque provided by a motor over a range of speeds.

Splice Plates, Splice Bars
Plates or bars used to join the horizontal bus bars of adjoining switchboard or motor control center sections.
Starter Ratings

Motor Starters are rated according to size and type of load. NEMA and IEC rate motor starters differently. IEC-rated devices are rated according to maximum operational current. NEMA specifies sizes from size 00 to size 9.

<table>
<thead>
<tr>
<th>NEMA Size</th>
<th>Continuous Amp Rating</th>
<th>HP @ 230 VAC</th>
<th>HP @ 460 VAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>9</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>18</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>30</td>
<td>50</td>
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<tr>
<td>4</td>
<td>135</td>
<td>50</td>
<td>100</td>
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<td>5</td>
<td>270</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>6</td>
<td>540</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>7</td>
<td>810</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>8</td>
<td>1215</td>
<td>450</td>
<td>900</td>
</tr>
<tr>
<td>9</td>
<td>2250</td>
<td>800</td>
<td>1600</td>
</tr>
</tbody>
</table>

Stator

The stationary elements of the magnetic circuit of a rotating machine such as a motor.

Step-down Transformer

A transformer with more turns of wire in its primary coil than in its secondary coil. The step-down transformer is used to step down the primary voltage to a lower secondary voltage.

\[
\begin{align*}
\text{Primary Turns} & = 1800 \\
\text{Secondary Turns} & = 900 \\
\text{Primary Voltage} & = 240 \text{ VAC} \\
\text{Secondary Voltage} & = 120 \text{ VAC} \\
\text{Primary Current} & = 5 \text{ amps} \\
\text{Secondary Current} & = 10 \text{ amps}
\end{align*}
\]
**Step-up Transformer**

A transformer with fewer turns of wire in its primary coil than in its secondary coil. The step-up transformer is used to step up the primary voltage to a higher secondary voltage.

\[
\begin{array}{c}
\text{Primary Coil} \\
\text{900 Turns} \\
\text{Secondary Coil} \\
\text{1800 Turns} \\
\end{array}
\]

\[
\begin{array}{c}
120 \text{ VAC} \\
I = 10 \text{ amps} \\
\text{Load} \\
V_{\text{load}} = 240 \text{ VAC} \\
I_{\text{load}} = 5 \text{ amps} \\
\end{array}
\]

\[
\text{Primary Turns} \quad = \quad \text{Primary Voltage} \quad = \quad \text{Secondary Current} \\
\text{Secondary Turns} \quad = \quad \text{Secondary Voltage} \quad = \quad \text{Primary Current}
\]

**Surge**

An increase of at least ten percent in current and voltage that typically lasts only a few microseconds.

**Surge Protection Device**

A device designed to provide a degree of protection for electrical equipment from the damaging effects of a surge. This term applies to both secondary surge arresters and transient voltage surge suppressors.

**Switchboard**

A large panel or assembly of panels containing switches, overcurrent protective devices, buses, and associated instruments. Unlike panelboards, switchboards sometimes must be mounted away from a wall to allow access to rear-mounted equipment.

**Switchgear**

A coordinated design consisting of switching and interrupting devices and associated equipment such as control and protective devices and metering.
**Synchronous Speed**

The speed of the rotating magnetic field in a three-phase motor. Synchronous speed is determined by the line frequency and the number of motor poles.

\[
\text{Synchronous Speed (Ns)} = \frac{120f}{P}
\]

\( f = \) frequency

\( P = \) number of poles

**Thermal-Magnetic**

Used to describe a device that uses both heat and magnetism as part of its operating principles. For example, a thermal-magnetic **circuit breaker** can be tripped either by heat or magnetic force resulting from an **overcurrent**.

**Thermistor**

A device used to sense temperature that varies in **resistance** as temperature changes.

**Thyristor**

A family of multi-layer **semiconductor** devices that includes silicon controlled rectifiers (SCR), gate turnoff (GTO) thyristors, and other similar devices. Thyristors are often used in **rectifier** or **power** switching circuits.

**Time-Current Curve**

A graph showing how long before a **circuit breaker** will trip at each level of fault **current**.

![Time-Current Curve](image)

**Timing Relay**

A control relay that incorporates a preset delay in contact response. Some timing relays begin the time delay when the relay is energized. Others begin the time delay when the relay is de-energized.
**Torque**
A turning or twisting force. Since torque is expressed as a force times the length of the radius at which the force is measured, torque is represented in compound units such as pound-feet (lb.-ft.).

![Torque Diagram]

**Totally Enclosed Fan Cooled (TEFC)**
A motor enclosure type that restricts the flow of air into or out of the motor, but uses a fan to blow air over the motor's exterior.

**Totally Enclosed Non-ventilated (TENV)**
A motor enclosure type that restricts the flow of air into or out of the motor. Because there are no ventilating openings, all heat generated by the motor must be dissipated by conduction through the enclosure.

**Transformer**
Coils of wire wound on a common frame that allow electrical energy to be transferred from one circuit to another. Transformers used in low frequency applications are commonly wound around an iron core to improve energy transfer.

**Transistor**
A semiconductor device which usually has three terminals although the names of the terminals are different for different types of transistors. Some types of transistors are used as electronic switches.

**Trim**
The front cover of a panelboard which includes an access door.
**Trip Unit**

The part of the *circuit breaker* that determines when the breaker will trip. Many circuit breakers use a *thermal-magnetic* or magnetic-only trip unit. Other circuit breakers have a *solid-state* trip unit with multiple adjustments to custom fit the circuit breaker’s time current curve to the application.

![Solid State Breaker Diagram](image)

**True Power**

Also called real *power*, true power is the power dissipated by circuit *resistance*. True power is equal to $I^2R$ and is measured in *watts*. True power is also equal to the *apparent power* multiplied by the *power factor*.

**Sonar Proximity Switch**

A type of *sensing switch* that uses high *frequency* sound to detect the presence of an object without coming into contact with the object. Sometimes referred to an an ultrasonic proximity switch.

![Sonar Proximity Switch Diagram](image)

**Underwriters Laboratories (UL)**

An independent product safety certification organization, Underwriters Laboratories, Inc. develops standards and tests products for safety. Products that pass UL tests can carry a UL mark. UL has several categories of marks based upon the type of product tested.

**Var**

The basic unit for *reactive power*. Shortened from volt-ampere reactive.

**Variable Frequency Drive (VFD)**

An electronic device used to control the speed a of an *AC motor*. A VFD controls the motor speed by varying the frequency and voltage applied to the motor. Also called an *AC drive*. 

![Variable Frequency Drive Diagram](image)
**Variable Speed Drive**
An electronic drive device used to control the speed of an electric motor. This term applies to both *AC Drives* and *DC Drives*.

**Vector Control**
A technique employed by some *variable frequency drives* that involves calculations of *AC motor* current vectors and precise control of motor flux to provide excellent speed and *torque* control.

**Volt**
The basic unit of *voltage*. The symbol for volt is “V.”

**Voltage**
Also called difference of potential, *electromotive force*, or EMF. Voltage is a force that, when applied to a *conductor*, causes *current* to flow. Voltage is symbolized by “E” or “V” and is measured in *volts*.

**Voltmeter**
A meter designed to measure *voltage*.

**Volts per Hertz (V/Hz)**
Describes the operation of many *variable frequency drives* that control the speed of an AC motor by varying the *frequency* of the *voltage* applied to the motor while maintaining a constant voltage to frequency ratio.

**Watt**
The basic unit of electric *power*. The symbol for watt is “W.”

**Word**
Usually one or more *bytes* used to represent instructions or data in *digital* equipment.

**Wye**
A connection arrangement used for the primary and/or secondary of a three-phase *transformer*.

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