Pictorial Glossary

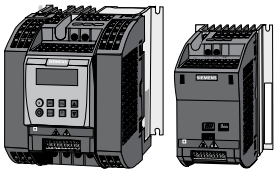
Click on a term to go directly to the definition

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

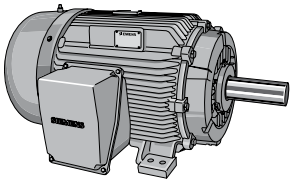
An electronic device used to control the speed of an *AC motor*. Also called a *variable frequency drive* and an *inverter*. The term *variable speed drive* applies to both *AC Drives* and *DC Drives*.



SINAMICS G110 AC Drives

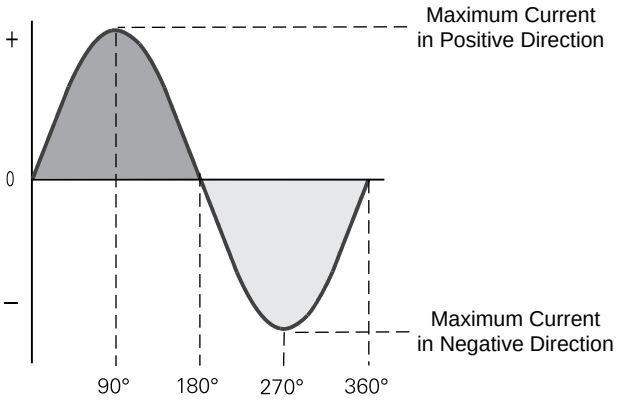
AC Motor

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.



Alternating Current (AC)

Current that periodically reverses direction.



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

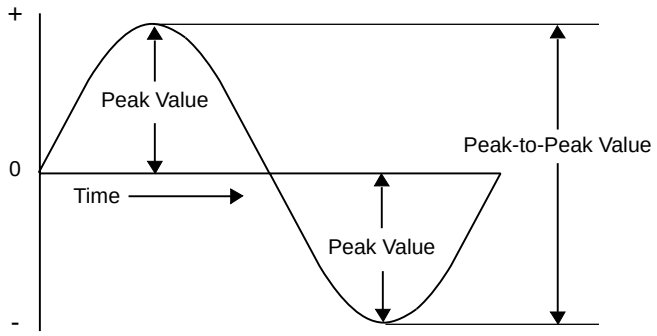
The continuous *current* rating in *amperes* for a conductor.

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*.

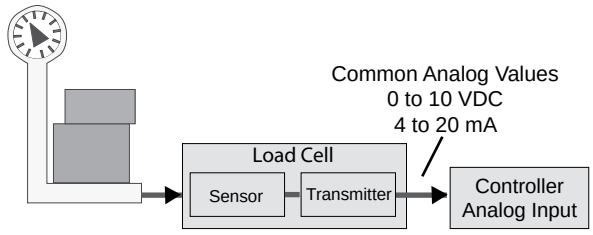


Analog

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

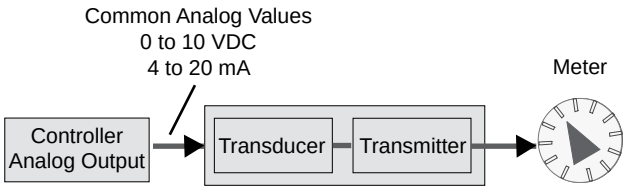
Analog Input

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.



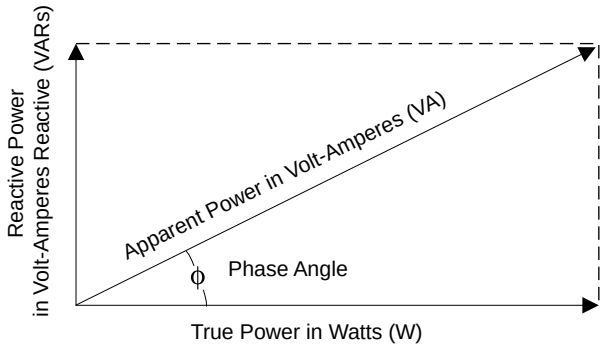
Analog Output

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.



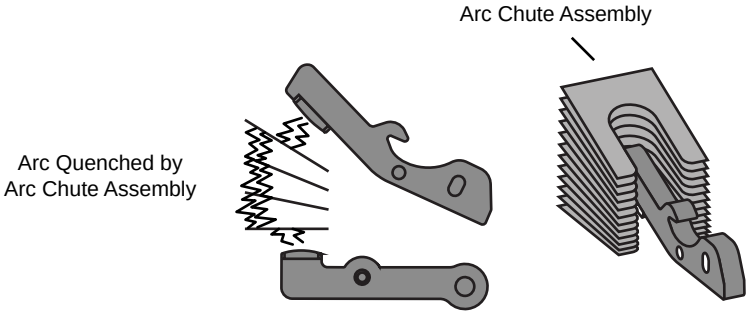
Apparent Power

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.



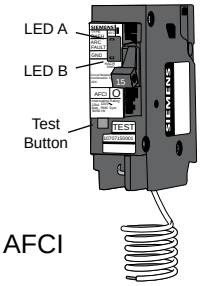
Arc Fault

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.

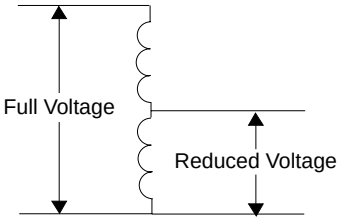
LED Indicator		Last Known Trip Condition
LED (A)	LED (B)	
OFF	OFF	Overcurrent
ON	OFF	Arc Fault
ON	ON	Arc Fault to Ground



Siemens Combination AFCI Circuit Breaker

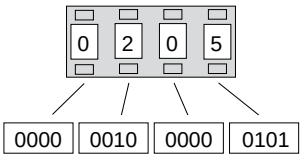
Autotransformer

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)

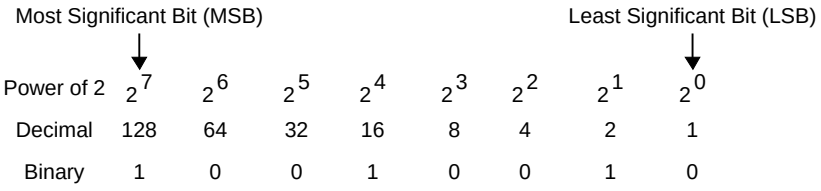
Usually refers to the 8-4-2-1 code where four *bits* are used to represent decimal digits 0 through 9.



Decimal	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

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.

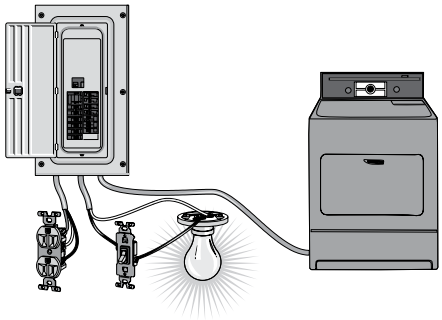


10010010 in Binary = 146 in Decimal

Bit A 1 or 0 representing one position in a *binary* number.

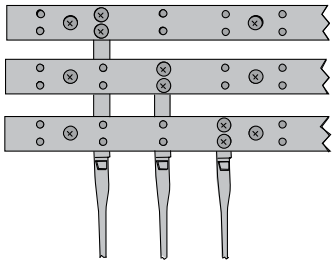
Bonding The permanent joining of metal parts to form an electrically conductive path.

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



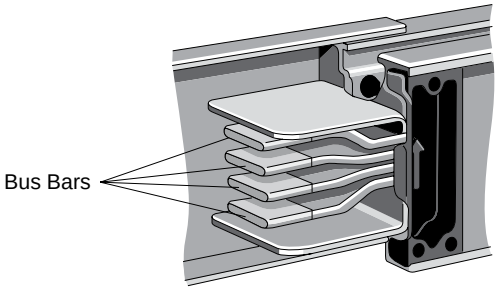
Branch Circuits

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



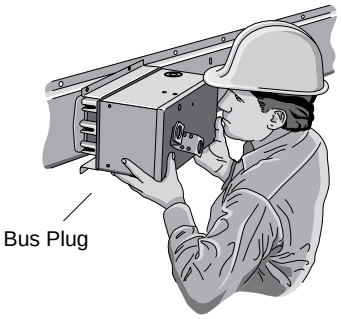
Vertical Bus

Bus Bar A *conductor* that serves as a common connection for two or more circuits.



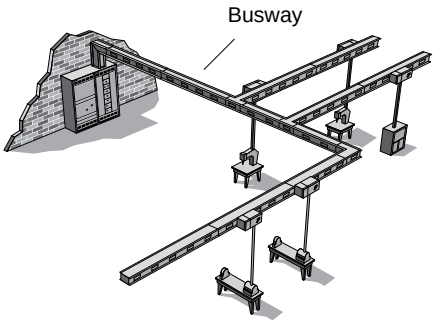
Bus Plug

A device used with *plug-in busway* to provide *power* connections close to the intended load.



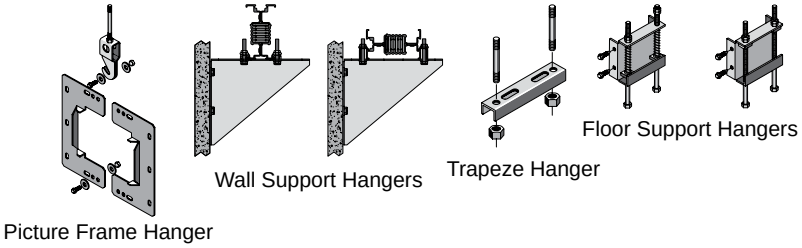
Busway

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.



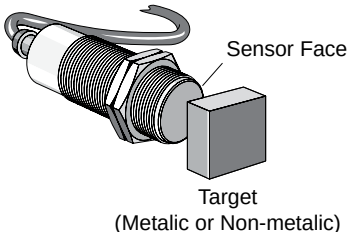
Byte

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.

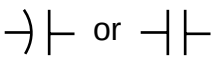


Capacitive Reactance The opposition to *alternating current* resulting from circuit *capacitance*. Capacitive reactance is inversely proportional to *frequency* (f) and capacitance (C). The symbol for capacitive reactance is "X_C." The unit for capacitive reactance is the *ohm*.

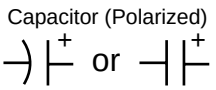
$$X_C = \frac{1}{2\pi fc}$$

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

Capacitor (Non-Polarized)

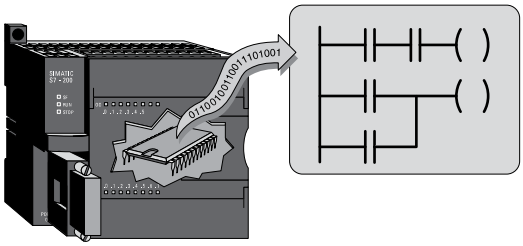


Capacitor (Polarized)



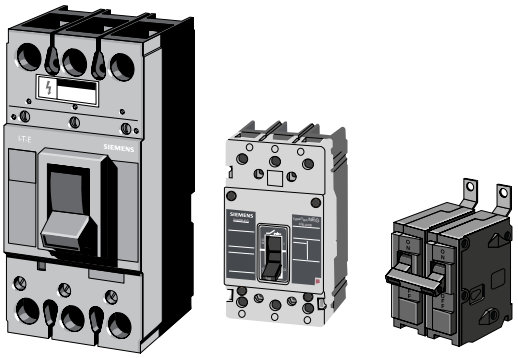
$C = k\frac{A}{d}$ — A: Area of the plates; d: Distance between plates; k: Dialectric constant

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.



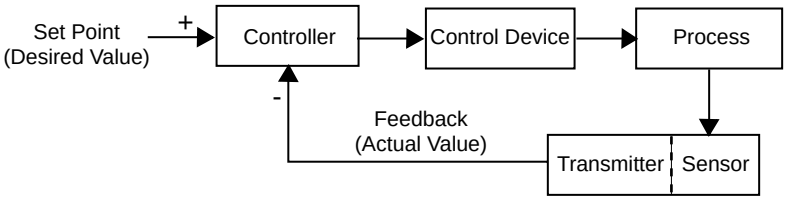
Circuit Breaker

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.

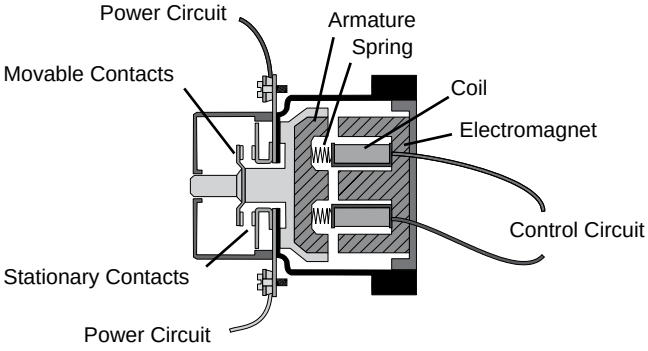


Conductor

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.

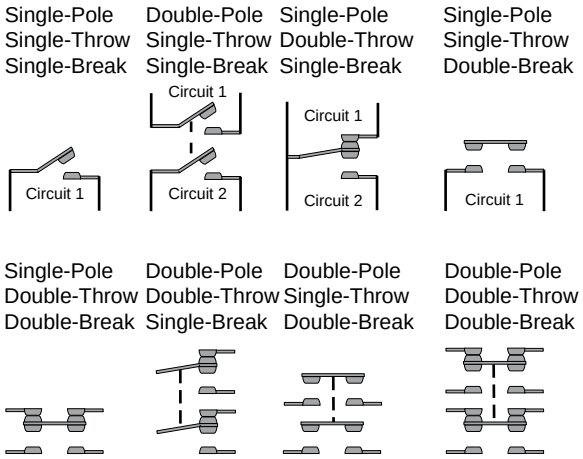
Contactor

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.



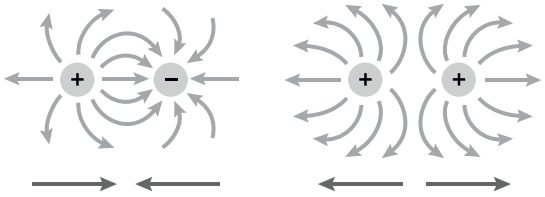
Control Relay Contact Types

Coulomb

A unit of electrical charge moved in 1 second by a current of 1 ampere. This is equal to approximately 6.24 x 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.



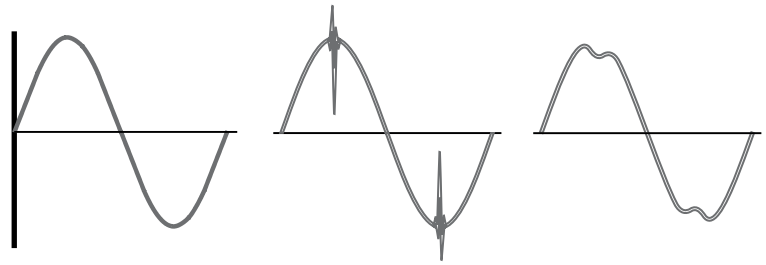
Unlike Charges Attract Like Charges Repel

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*.



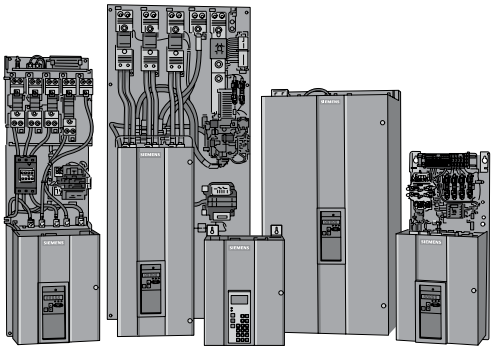
Crest Factor = 1.414 Crest Factor < 1.414 Crest Factor > 1.414

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*.



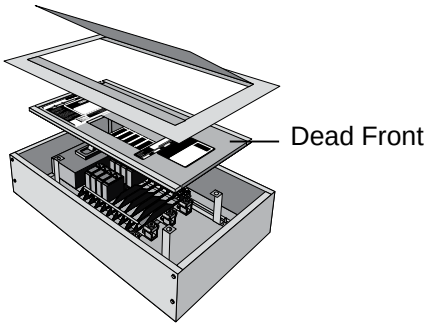
SIMOREG DC Drives

DC Motor

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

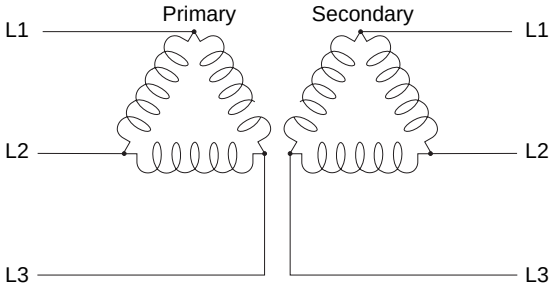
Dead Front

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*.



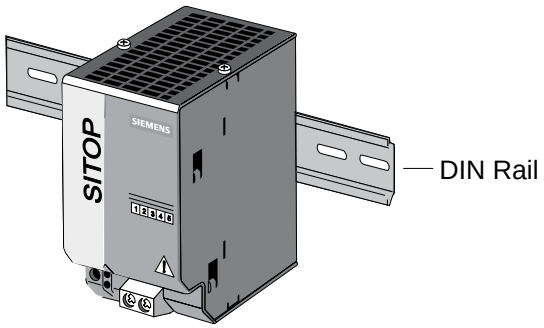
Delta-Delta (△-△)Transformer Configuration

Digital

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

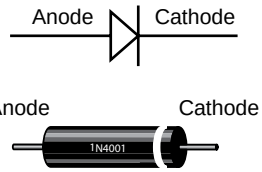
DIN Rail

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)

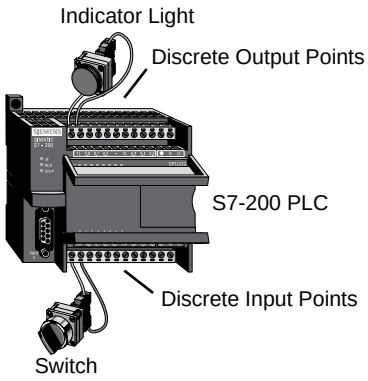
Current with a constant direction.

Disconnect Switch

A switch designed to disconnect electrical *power* from a circuit.

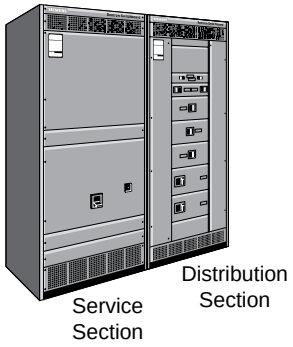
Discrete I/O

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



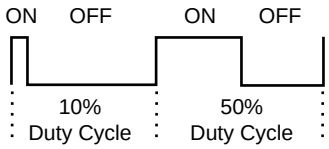
Distribution Section

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



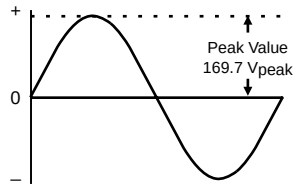
Duty Cycle

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.



169.7 V_{peak} x 0.707 = 120 V_{eff} (also expressed as VAC or Vrms)

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)

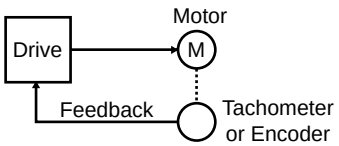
A *motor enclosure* type used in hazardous locations. Explosion proof enclosures are also available for other types of equipment.

Farad

The basic unit of *capacitance*. The symbol for the farad is "F."

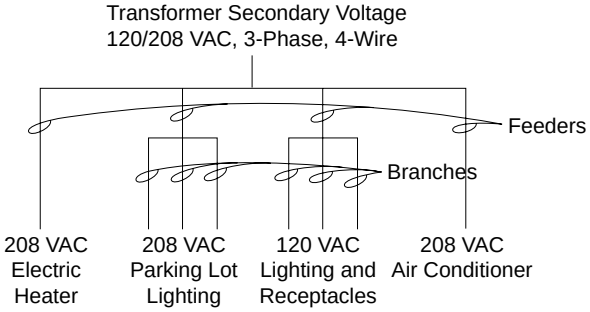
Feedback

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



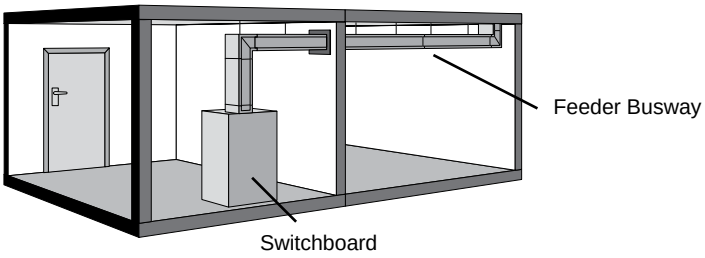
Feeder

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.

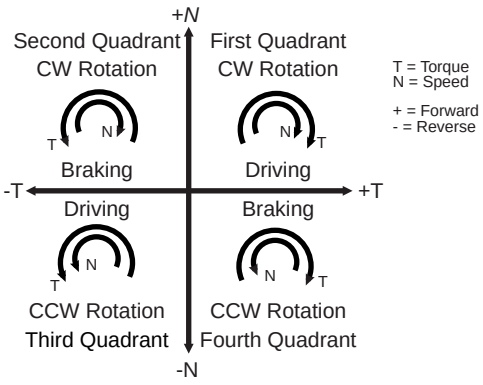


Filler Plates

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.

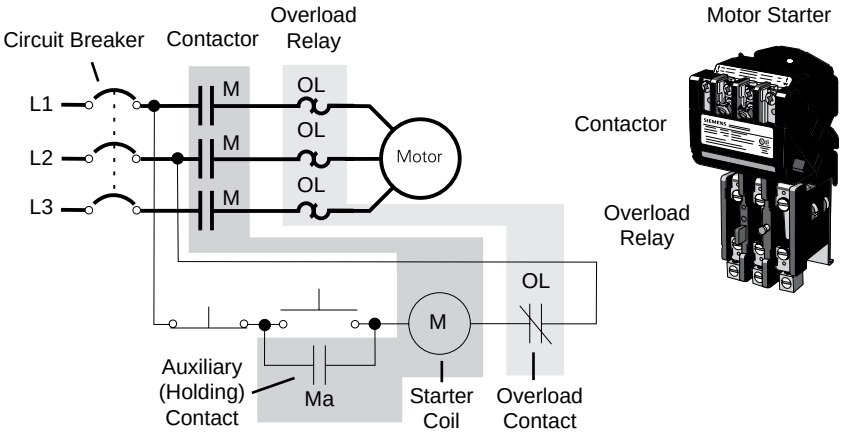


Frequency

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

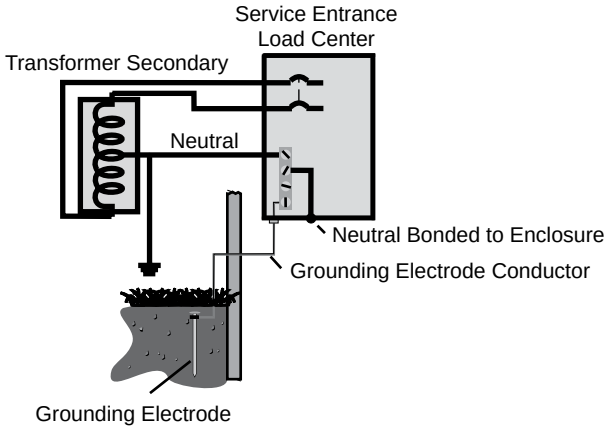
A letter designation given to a *fuse* to identify its operating and construction characteristics.

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.

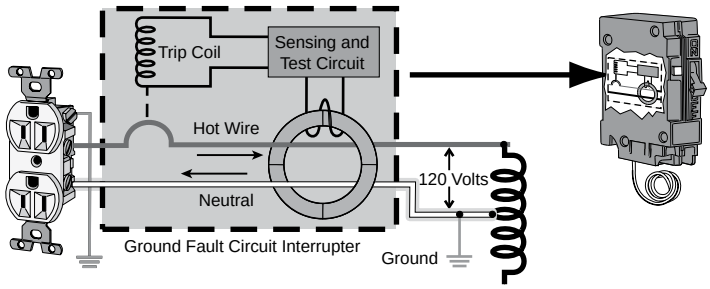


Ground Fault

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.

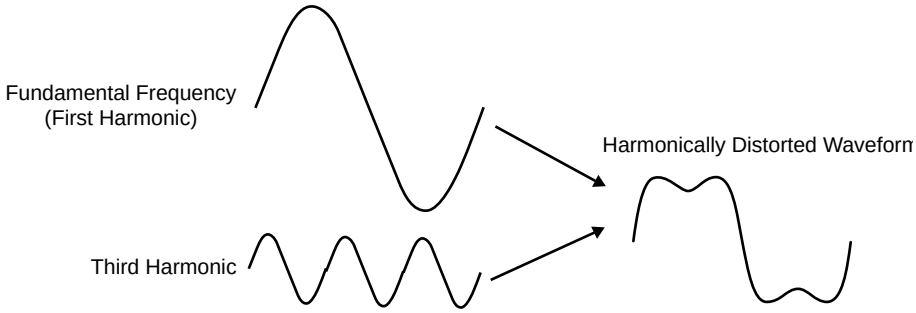


Harmonics

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 x 60 Hz = 180 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.

Decimal	Binary	BCD	Hexadecimal
0	0	0000	0
1	1	0001	1
2	10	0010	2
3	11	0011	3
4	100	0100	4
5	101	0101	5
6	110	0110	6
7	111	0111	7
8	1000	1000	8
9	1001	1001	9
10	1010	0001 0000	A
11	1011	0001 0001	B
12	1100	0001 0010	C
13	1101	0001 0011	D
14	1110	0001 0100	E
15	1111	0001 0101	F
16	10000	0001 0110	10
17	10001	0001 0111	11
18	10010	0001 1000	12
19	10011	0001 1001	13
20	10100	0010 0000	14

Horsepower

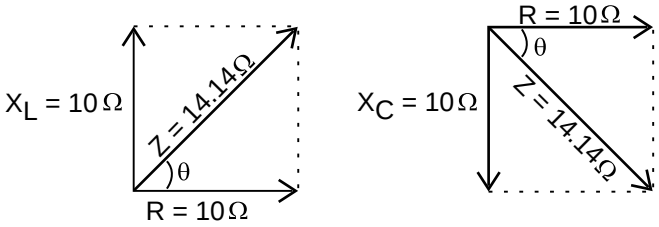
A unit of *power*. Horsepower is abbreviated "HP." 1 horsepower is equal to 746 *watts*.

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*.

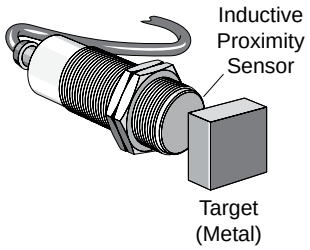


Inductance

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*.

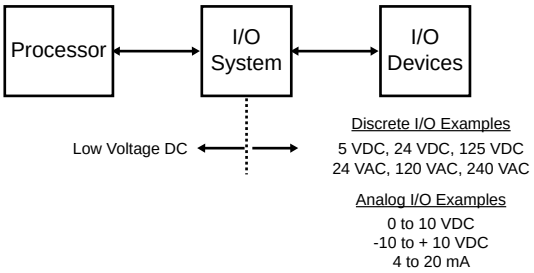
$X_L = 2\pi fl$

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.



Instrument Transformer

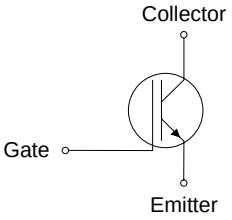
A type of *transformer* used to sense the *voltage* or *current* of associated *conductors* and provide proportional electrical energy to measurement devices or circuits. A potential transformer (PT) is used for voltage measurements and a current transformer (CT) is used for current measurements.

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)

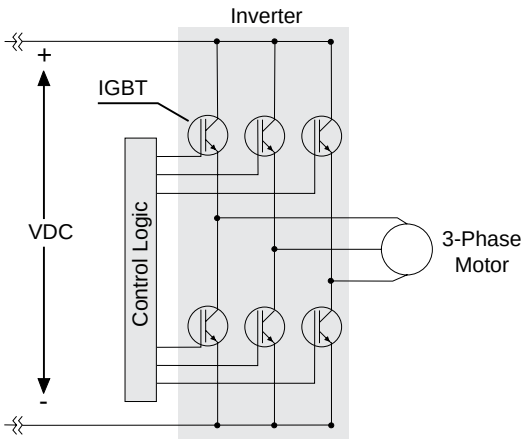
A network of standards organizations from over 150 countries that develops voluntary standards for business, science, and technology. The name ISO is from the Greek word "isos," which means equal.

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

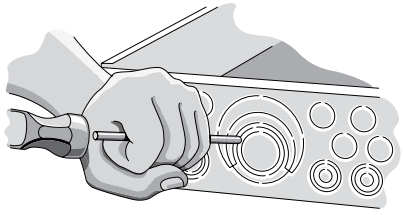
A *transformer* used to limit the transfer of electrical noise from one circuit to another.

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.

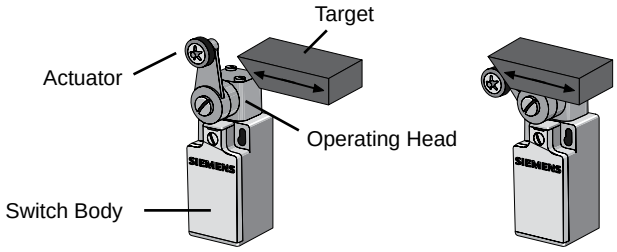


Ladder Logic

A method of programming a *programmable logic controller* that uses symbols that evolved from the diagrams used with *control relays*.

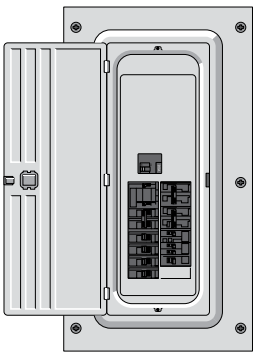
Limit Switch

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.

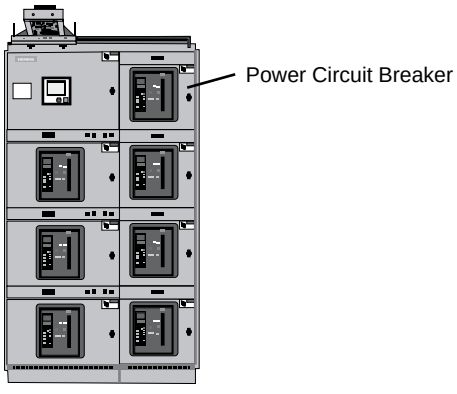


Local Area Network (LAN)

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

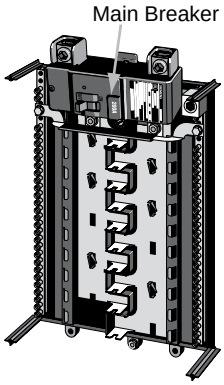
A *circuit breaker,* typically used as a drawout-mounted breaker in low voltage *switchgear,* that conforms to ANSI C37.13, C37.16, C37.17, and C37.50 and UL 1066 standards.



WL Low Voltage Switchgear

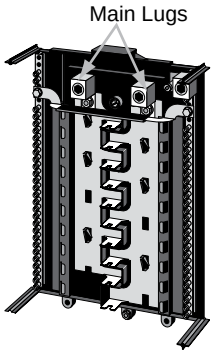
Main Breaker

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 Lug Only

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



MCM

Abbreviation for a thousand circular mils. Circular mills 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).

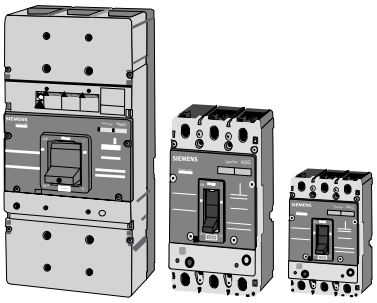
Metric Unit Prefix

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

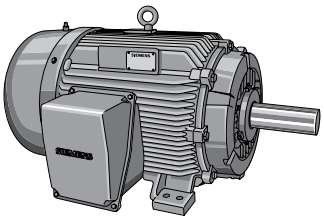
Value		Prefix	Symbol
1,000,000,000	$= 10^{9}$	giga	G
1,000,000	$= 10^{6}$	mega	M
1,000	$= 10^{3}$	kilo	k
0.001	$= 10^{-3}$	milli	m
0.000001	$= 10^{-6}$	micro	µ
0.000000001	$= 10^{-9}$	nano	n

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.

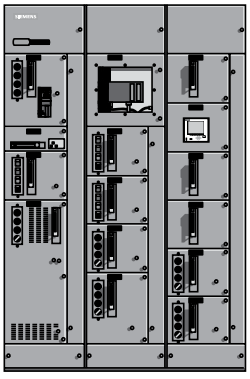


Molded Case Switch A switch enclosed in the same type of insulated housing as a *molded case circuit breaker*. Siemens molded case switches employ the same operating mechanism as thermal-magnetic and magnetic only circuit breakers. A preset instantaneous function is factory installed to allow the switch 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

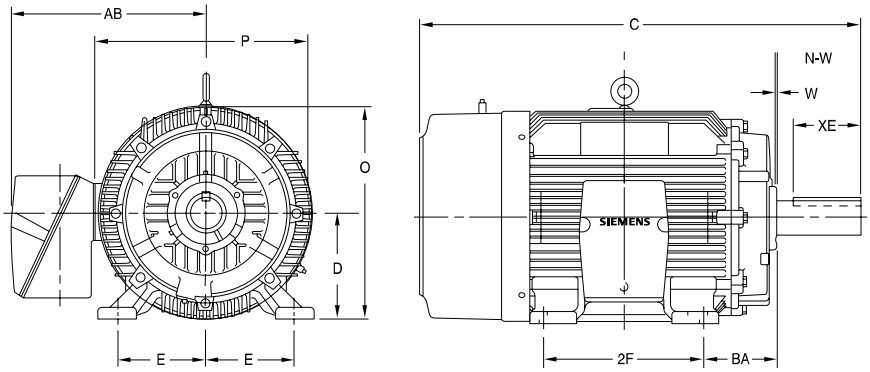
A designation given to an *enclosure* based on standards published by the *National Electrical Manufacturers Association*. The NEMA type identifies of the degree of protection provided by the enclosure.

NEMA Enclosure Type Examples

NEMA Type	Description
1	Intended for indoor use. Provides protection against a limited amount of falling dirt.
3R	Intended for outdoor use. Provides protection against rain, sleet, and damage from external ice formation.
4	Intended for indoor or outdoor use. Provides protection against windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.
4X	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.
12	Intended for indoor use. Provides protection against circulating dust, falling dirt, and dripping noncorrosive liquids.

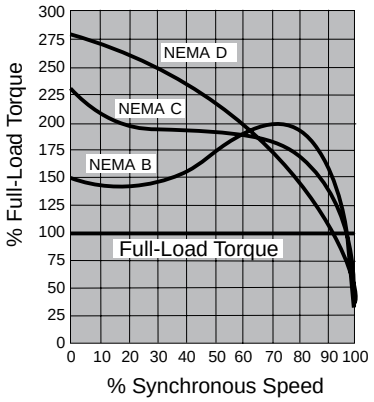
NEMA Frame Size

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.



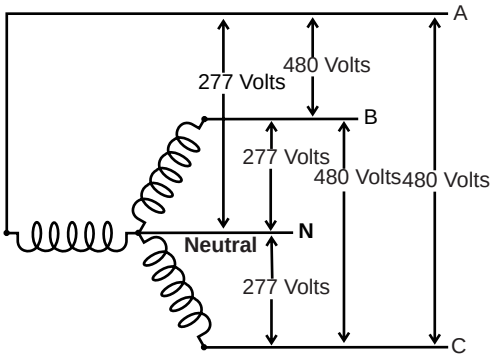
NEMA Motor Design

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*.

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

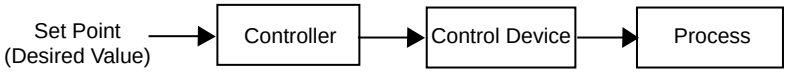
E = Electromotive Force (Voltage) in Volts
I = Current in Amperes (Amps)
R = Resistance in Ohms

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

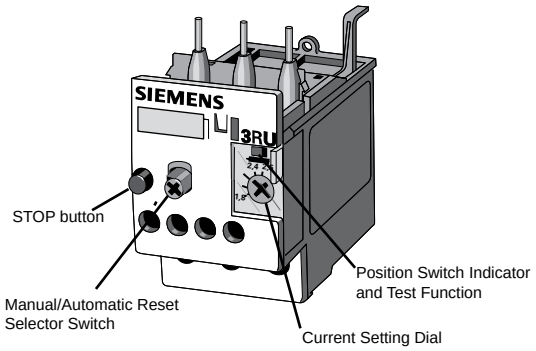
A *current* in excess of the rated current for a device or *conductor*. An overcurrent can result from an *overload*, *short circuit*, or *ground fault*.

Overload

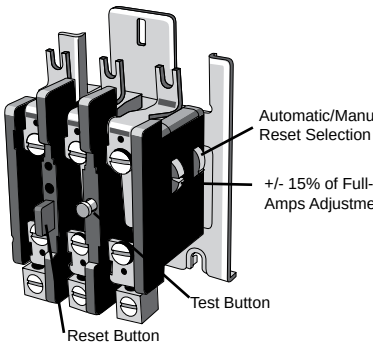
Can refer to an operating condition in excess of the full-load rating or a *current* high enough to cause damage if it is present long enough. *Short circuits* and *ground faults* are not overloads.

Overload Relay

A device used to protect a motor from damage resulting from an *overload.*



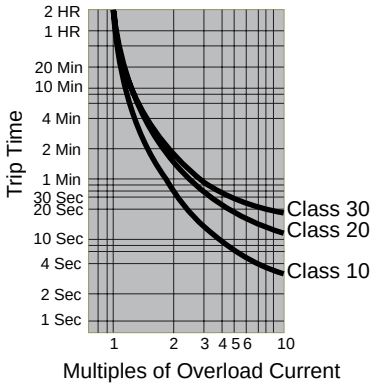
Solid State Overload Relay



Ambient Compensated
Bimetal Overload Relay

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.

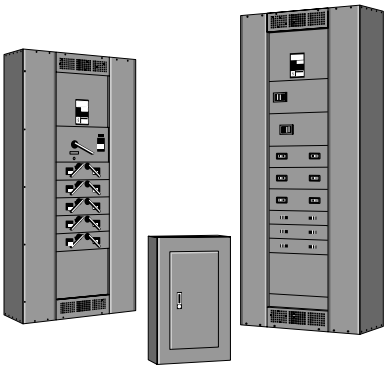


Pad-Mounted Transformer

An enclosed *transformer* mounted on a concrete pad.

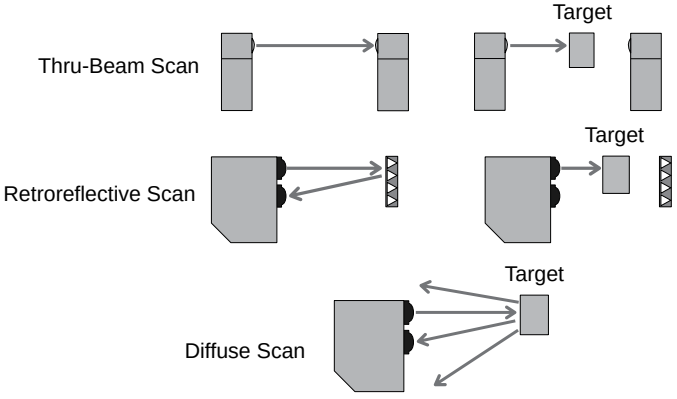
Panelboard

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



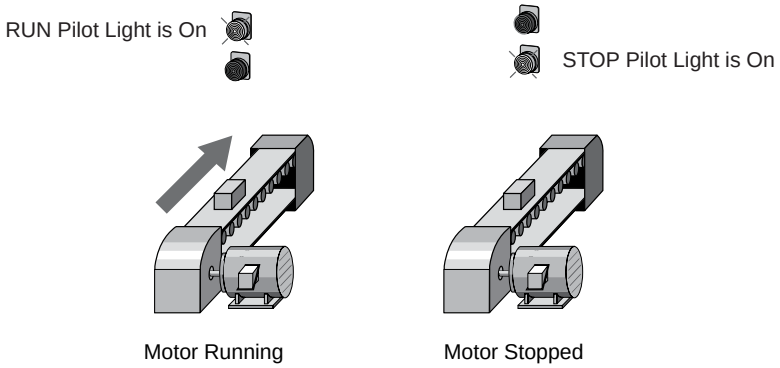
Photoelectric Proximity Switch

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



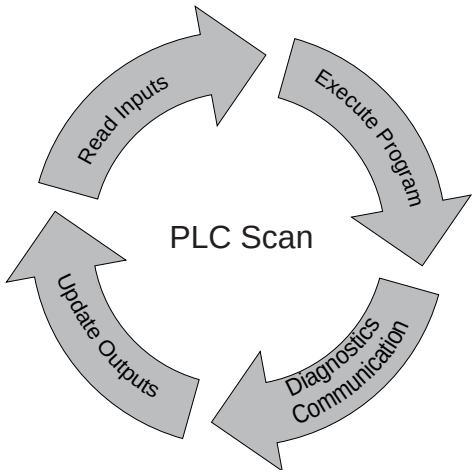
Pilot Light

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



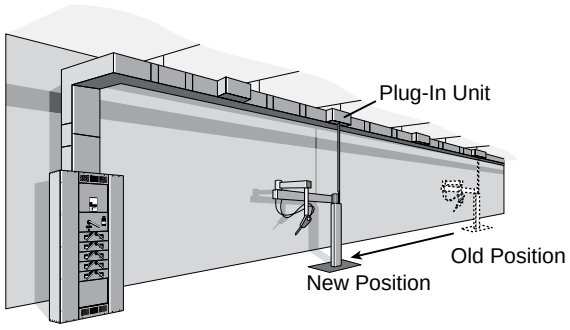
PLC Scan

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

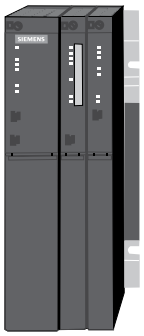
The rate at which work is done or energy is transformed. In an electric circuit, power is measured in *watts,* or sometimes in *horsepower*. The term power is also often used to refer to electrical energy and as an adjective to describe devices or circuits designed to carry a high level of current.

Power Factor

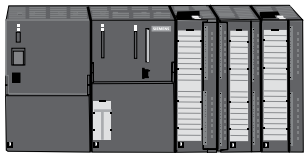
The ratio of *true power* to *apparent power* in a circuit. Power factor is also equal to the cosine of the phase angle.

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.



SIMATIC S7-400



SIMATIC S7-300

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.

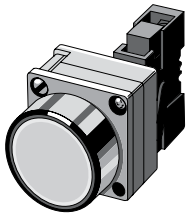
Pulse Width Modulation (PWM)

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.

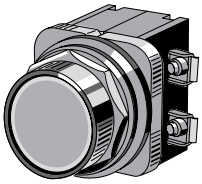
Pushbutton

A control device used to manually open and close a set of contacts.

16 mm 3SB2 Pushbutton



22 mm SIGNUM 3SB3 Pushbutton



30 mm Class 52 Pushbutton

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

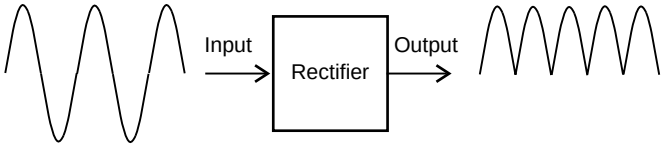
Power associated with *inductance* or *capacitance*. The unit for reactive power is the *var*.

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.

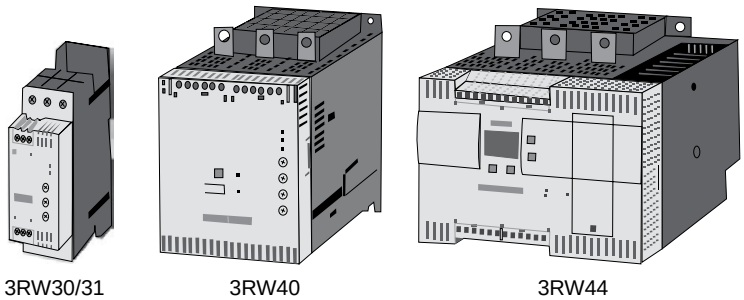
Rectifier

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.



SIRIUS 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.

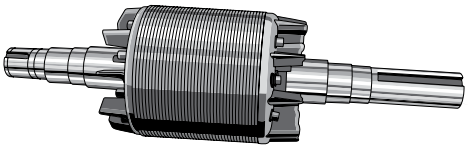
Fixed Value Resistor Rheostat Potentiometer

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.

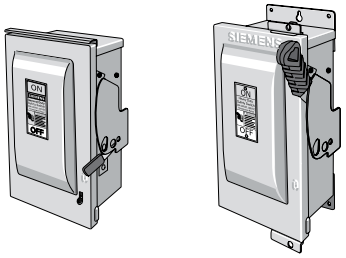
Rotor

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



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.

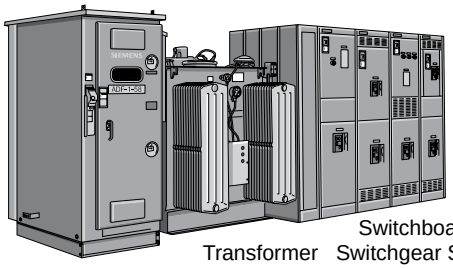


General Duty Heavy Duty

VBII Safety Switiches

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*.

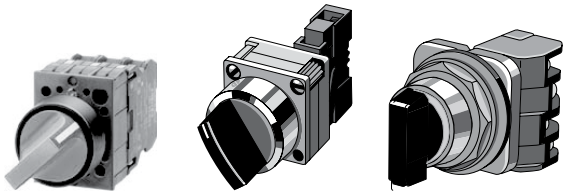


Selective Coordination

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.

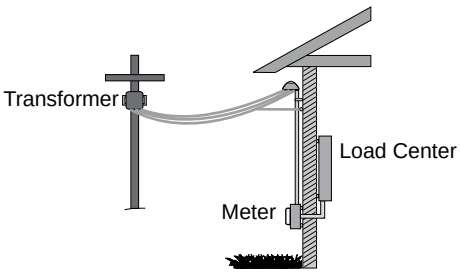
Sensing Switch

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*.

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

Service Entrance

The place where *power* cables enter a building.



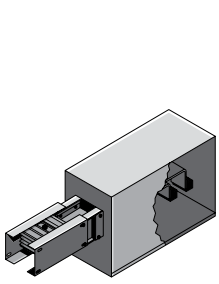
Service Entrance

Service Factor

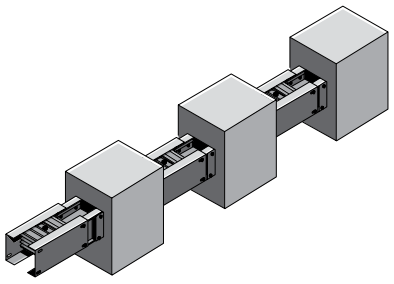
A numerical value that is multiplied by a motor's rated *horsepower* to determine the maximum horsepower at which the motor should be operated.

Service Head

A device used to connect *busway* at the *service entrance*.



3-Phase Service Head



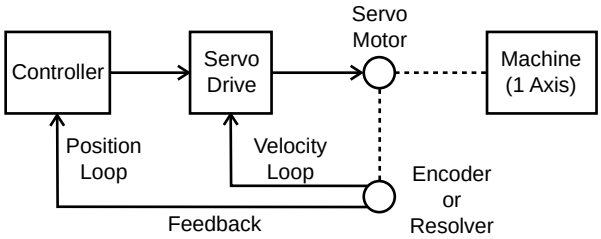
Three 1-Phase Service Head

Service Section

The switchgear, *switchboard*, or power *panelboard* section connected to incoming *power*.

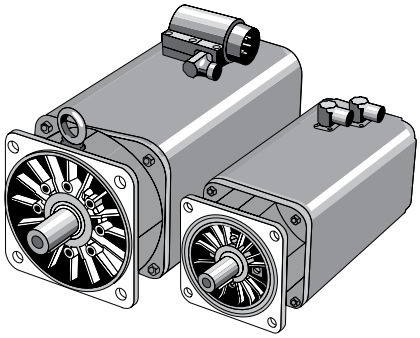
Servo Drive

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 Motor

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



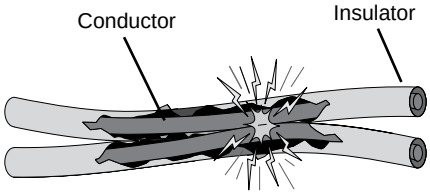
Servo Motors

Set Point

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

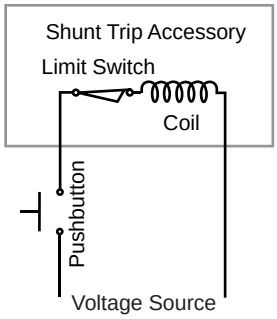
Short Circuit

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



Shunt Trip

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



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.

$$\% \ Slip = \frac{N_S - N_R}{N_S} \times 100$$

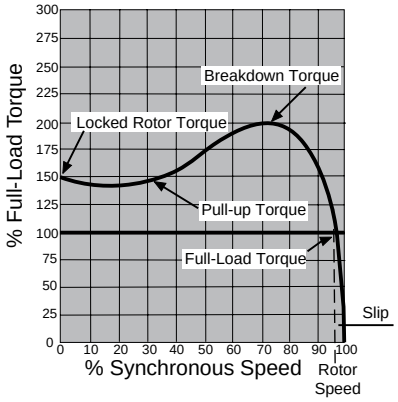
N_S = Synchronous Speed
N_R = Rotor Speed

Solid-State

Used to describe equipment that contains *semiconductor* devices in an electronic circuit.

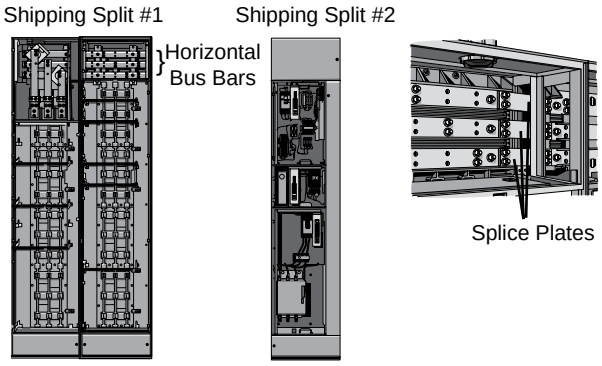
Speed-Torque Curve

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.



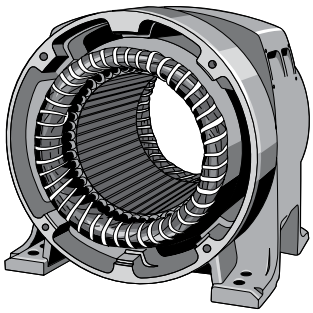
Starter Ratings

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.

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

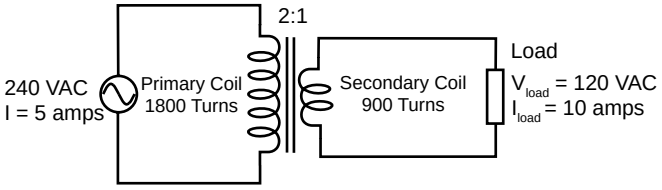
Stator

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



Step-down Transformer

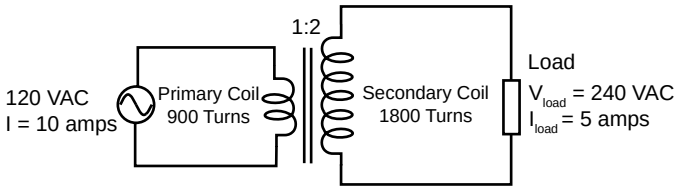
A *transformer* with more turns of wire in its primary coil than in its secondary coil. The step-down transformer is used to step down the primary *voltage* to a lower secondary voltage.



$$\frac{\text{Primary Turns}}{\text{Secondary Turns}} = \frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{Secondary Current}}{\text{Primary Current}}$$

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.



$$\frac{\text{Primary Turns}}{\text{Secondary Turns}} = \frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{Secondary Current}}{\text{Primary Current}}$$

Surge

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

Surge Protection Device (SPD)

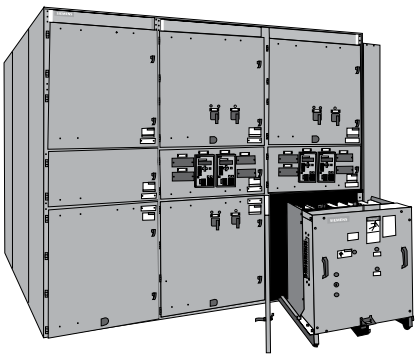
A device designed to provide a degree of protection for electrical equipment from the damaging effects of a *surge*. This term applies to both secondary surge arresters and transient voltage surge suppressors.

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

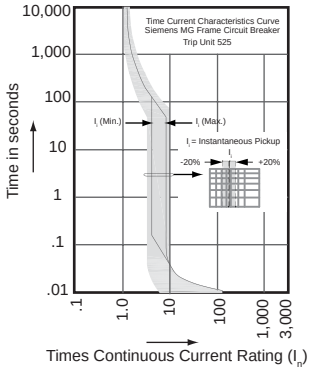
A device used to sense temperature that varies in *resistance* as temperature changes.

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*.

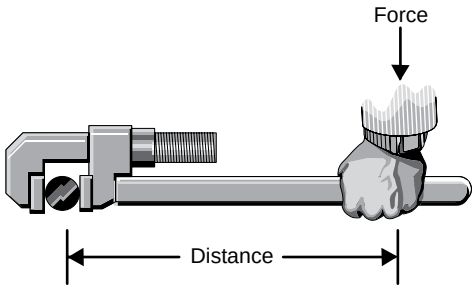


Timing Relay

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.)



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

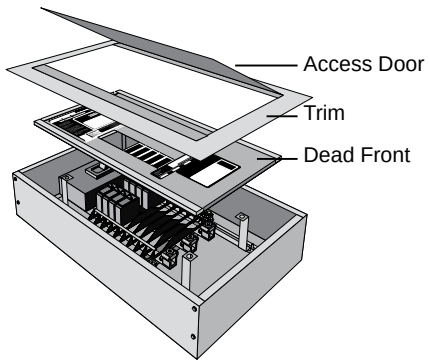
Coils of wire wound on a common frame that allow electrical energy to be transferred from one circuit to another. Transformers used in low frequency applications are commonly wound around an iron core to improve energy transfer.

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.

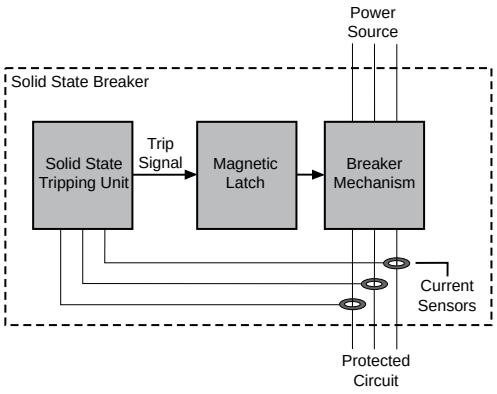
Trim

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.

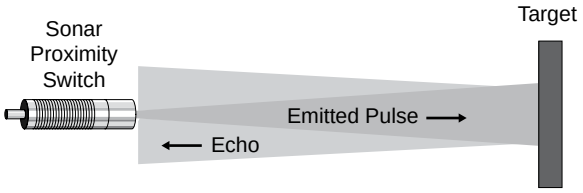


True Power

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.



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 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) Operation

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

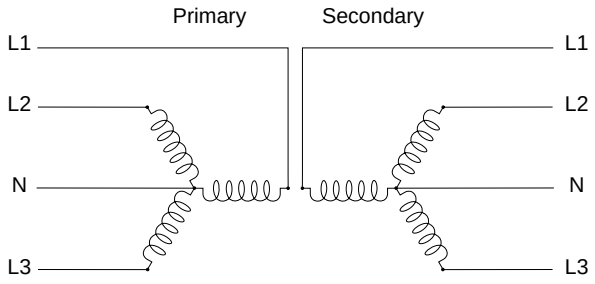
The basic unit of electric *power*. The symbol for watt is "W."

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.*



Wye-Wye (Y-Y)Transformer Configuration