Siemens STEP 2000 Course

Power Monitor and Management

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Introduction

Welcome to another course in the STEP 2000 series, **S**iemens **T**echnical **E**ducation **P**rogram, designed to prepare our sales personnel and distributors to sell Siemens Energy & Automation products more effectively. This course covers **Power Monitoring and Management with ACCESS** and related products.

Upon completion of **Power Monitoring and Management with ACCESS** you should be able to:

- Identify five benefits of using the ACCESS system
- Explain the difference between peak, peak-to-peak, instantaneous, average, and effective values of AC current and voltage
- Identify linear and nonlinear loads
- Explain various industry terms for voltage conditions
- Describe a CBEMA curve
- Explain the effects of harmonics on a distribution system and associated equipment
- Explain the difference between true power, reactive power, and apparent power
- Identify solutions for various power supply problems
- Select appropriate power meters for use in a distribution system
- Explain various communication standards and network protocols
- Explain the use of various components in an ACCESS controlled distribution system

This knowledge will help you better understand customer applications. In addition, you will be able to describe products to customers and determine important differences between products. You should complete **Basics of Electricity** before attempting **Power Monitoring and Management with ACCESS**. An understanding of many of the concepts covered in **Basics of Electricity** is required for **Power Monitoring and Management with ACCESS**.

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

Monitoring and Managing Electrical Power with ACCESS

Siemens ACCESS™ is more than just power meters, trip units, and other hardware. The ACCESS power management and control system is a networked system comprised of a variety of devices that monitor and control an electrical distribution system. The ACCESS system provides electrical data necessary for troubleshooting, power quality studies, preventative maintenance, and cost allocation. A power monitoring and management system, such as Siemens ACCESS, can identify potential problems before they cause costly breakdowns.

There are five benefits to using the ACCESS system.

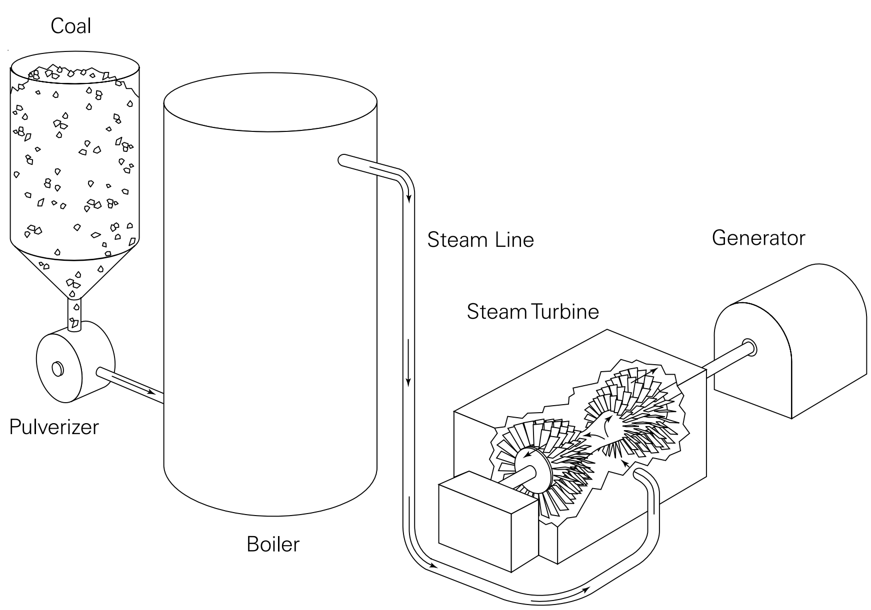
- Reduce or eliminate unplanned outages
- Proactively manage power systems to minimize utility bills
- Automate sub-billing of utility power bills
- Optimize capital equipment used in power systems
- Measure and analyze power quality

ACCESS™ Compatible

Electrical Power Distribution

Before discussing the Siemens ACCESS system an understanding of the production, distribution, and use of electric power is necessary.

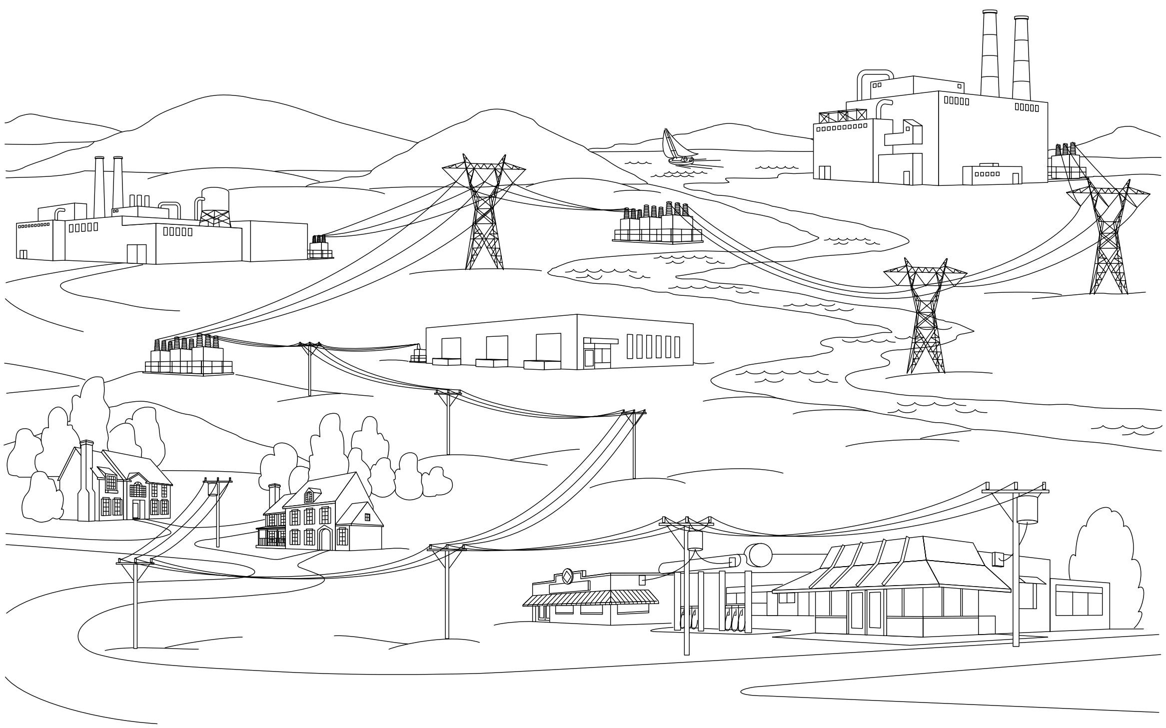
Electric power is produced by converting potential energy into electricity. There are several sources used to produce electric power. Coal, oil, and uranium are fuels used to convert water into steam which in turn drives a turbine. Some utilities also use gas or a combination of gas and steam turbines. There are other forms of electric power generation such as hydroelectric and solar energy plants.



Distribution

In order for generated power to be useful it must be transmitted from the generating plant to residential, commercial, and industrial customers. Typically, commercial and industrial applications have higher demands for electric power than residential applications. Regardless of the size of the electric system, electric power must be supplied that allows the intended loads to operate properly.

The most efficient way to transfer energy from the generating plant to the customer is to increase voltage while reducing current. This is necessary to minimize the energy lost in heat on the transmission lines. These losses are referred to as I^2R (I-squared-R) losses since they are equal to the square of the current times the resistance of the power lines. Once the electrical energy gets near the end user the utility will need to step down the voltage to the level needed by the user.

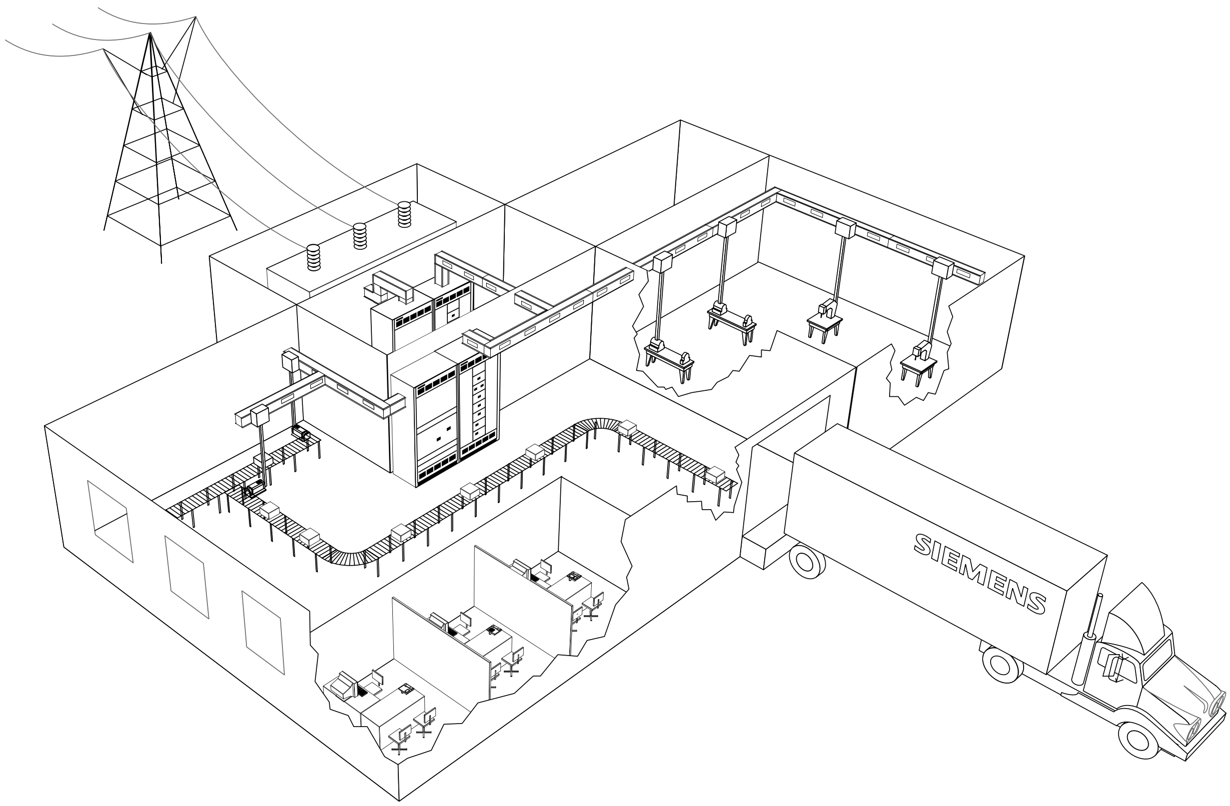


Power Quality

Electrical equipment is designed to operate on power that is a specific voltage and frequency. This power should also be free from quality problems, such as voltage spikes and harmonics. Unfortunately, power quality problems can occur from various sources. Power quality problems can affect the performance and shorten the life of electrical equipment. Power quality problems can significantly increase the operating cost of an electrical system.

Loads

Electricity is used to produce motion, light, sound, and heat. AC motors, which account for about 60% of all electricity used, are widely used in residential, commercial, and industrial applications. In today's modern commercial and industrial facilities there is increased reliance on electronics and sensitive computer-controlled systems. Electronic and computer systems are often their own worst enemy. Not only are they susceptible to power quality problems, but they are often the source of the problem.



Review 1

1. Which of the following is a benefit to using the Siemens ACCESS system?

   a. Reduce or eliminate unplanned outages
   b. Proactively manage power systems
   c. Automate sub-billing of utility power bills
   d. Optimize capital equipment used in power systems
   e. Measure and analyze power quality
   f. All of the above

2. AC motors account for about ___________ % of all electricity used.

3. The most efficient way to transfer energy from the generating plant to the customer is to increase voltage while reducing ___________ .

4. Power quality problems can significantly ___________ the operating cost of an electrical system.

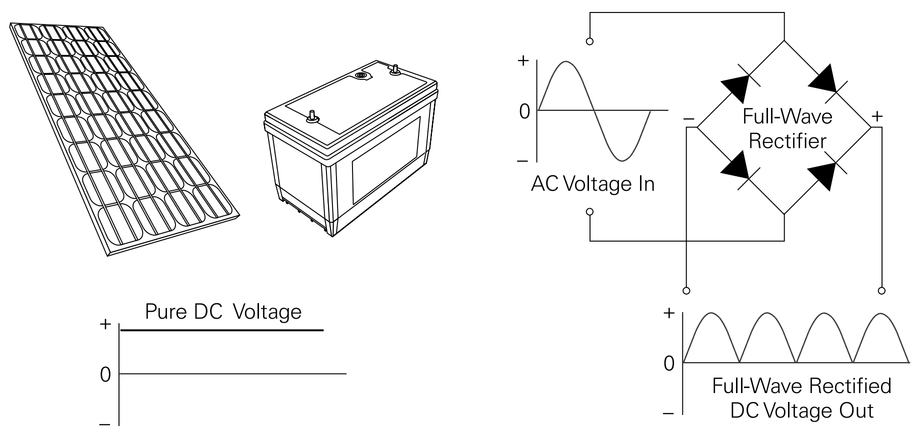
   a. increase
   b. decrease

Voltage and Current Values

An accurate measurement of voltage supplied by the utility and the current produced by the connected load is necessary in identifying power usage and power quality problems.

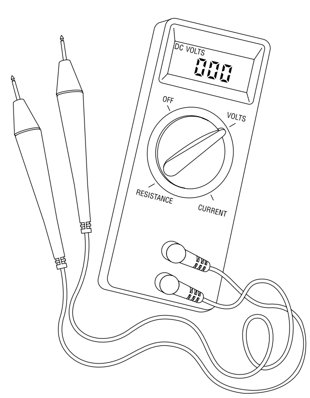
DC

Voltage is either direct current (DC) or alternating current (AC). DC voltage produces current flow in one direction. DC voltage can be obtained directly from sources such as batteries and photocells, which produce a pure DC. DC voltage can also be produced by applying AC voltage to a rectifier.



Measuring DC Voltage

The value of DC voltage varies. Low level DC voltages, such as 5 - 30 VDC, are commonly used in electronic circuits. Higher levels of DC voltage, such as 500 VDC, can be used in many industrial applications to control the speed of DC motors. A voltmeter is used to measure DC voltage.

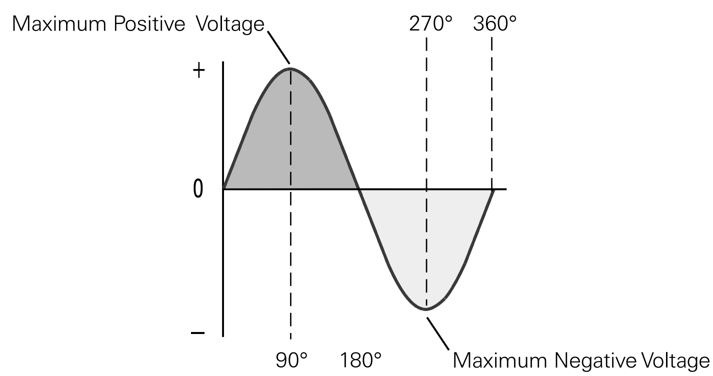


AC Voltage, Current, and Frequency

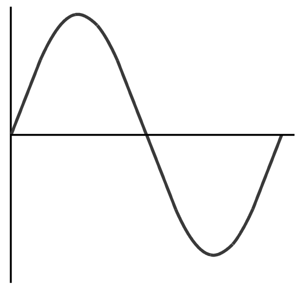
Current flow in AC voltage reverses direction at regular intervals. AC voltage and current are represented by a sine wave. Sine waves are symmetrical, 360° waveforms which represent the voltage, current, and frequency produced by an AC generator.

If the rotation of an AC generator were tracked through a complete revolution of 360°, it could be seen that during the first 90° of rotation voltage increases until it reaches a maximum positive value. As the generator rotated from 90° to 180°, voltage would decrease to zero. Voltage increases in the opposite direction between 180° and 270°, reaching a maximum negative value at 270°. Voltage decreases to zero between 270° and 360°. This is one complete cycle or one complete alternation.

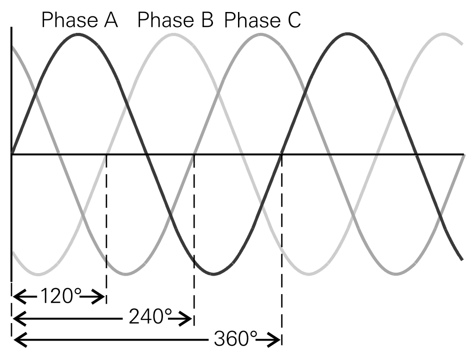
Frequency is a measurement of the number of alternations or cylces that occur in a measured amount of time. If the armature of an AC generator were rotated 3600 times per minute (RPM) we would get 60 cycles of voltage per second, or 60 hertz.



AC voltage can either be single- or three-phase. While single-phase power is needed for many applications, such as lighting, utility companies generate and transmit three-phase power. Three-phase power is used extensively in industrial applications to supply power to three-phase motors. In a three-phase system the generator produces three voltages. Each voltage phase rises and falls at the same frequency (60 Hz in the U.S., 50 Hz in many other countries); however, the phases are offset from each other by 120°.



Single-Phase



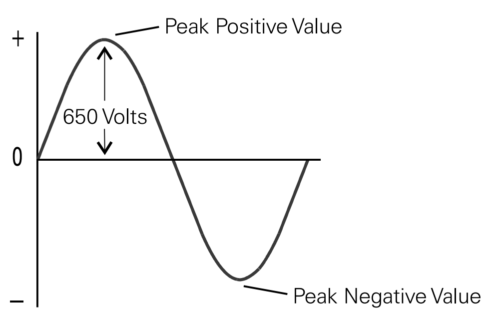
Three-Phase

Measuring AC Values

Measuring AC is more complex than DC. Depending on the situation, it may be necessary to know the peak value, peak-to-peak value, instantaneous value, average value, or the RMS (root-mean-square) value of AC.

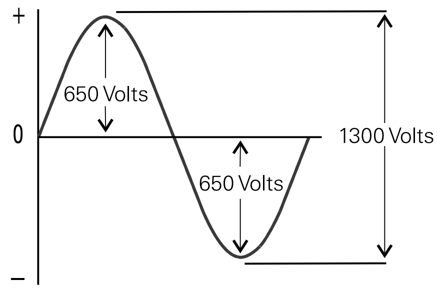
Peak Value

The peak value of a sine wave occurs twice each cycle, once at the positive maximum value and once at the negative maximum value. The peak voltage of a distribution system might be 650 volts, for example.



Peak-to-Peak Value

The peak-to-peak value is measured from the maximum positive value to the maximum negative value of a cycle. If the peak voltage is 650 volts, the peak-to-peak voltage is 1300 volts.

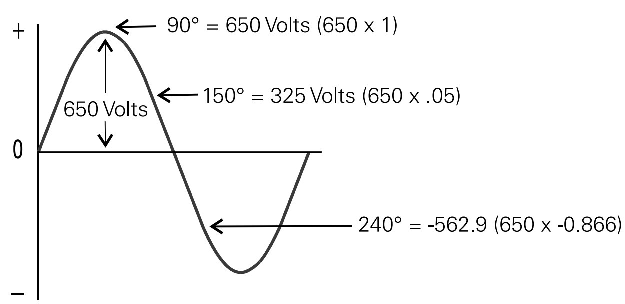


Instantaneous Value

The instantaneous value is the value at any one particular time along a sine wave. Instantaneous voltage is equal to the peak voltage times the sine of the angle of the generator armature. The sine value is obtained from trigonometric tables. The following table shows a few angles and their sine value.

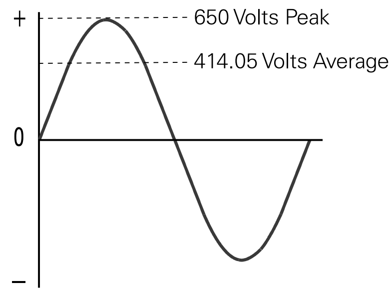
Angle	Sin θ	Angle	Sin θ
30°	0.5	210°	-0.5
60°	0.866	240°	-0.866
90°	1	270°	-1
120°	0.866	300°	-0.866
150°	0.5	330°	-0.5
180°	0	360°	0

The instantaneous voltage at 150° of a sine wave with a peak voltage of 650 volts, for example, is 325 volts (650 x 0.5).



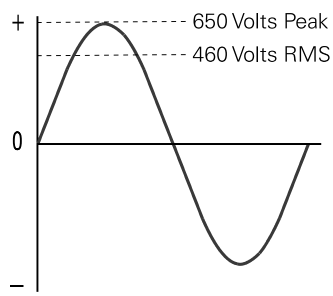
Average Value

The average value of a sine wave is zero. This is because the positive alternation is equal and opposite to the negative alternation. In some circuits it may be necessary to know the average value of one alternation. This is equal to the peak voltage times 0.637. The average value of a distribution system with 650 volts peak, for example, is 414.05 volts (650 x 0.637).



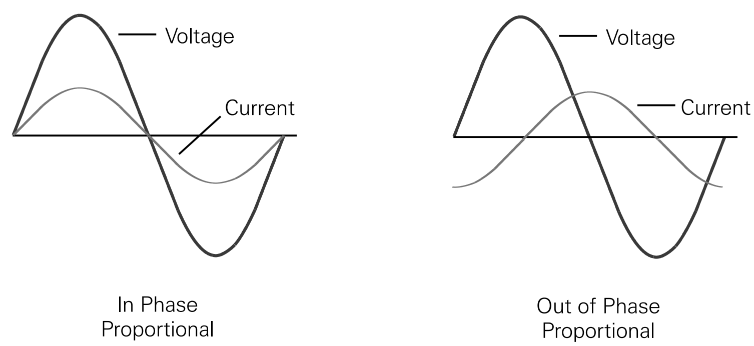
Effective Value

The effective value, also known as RMS (root-mean-square), is the common method of expressing the value of AC. The effective value of AC is defined in terms of an equivalent heating effect when compared to DC. One RMS ampere of current flowing through a resistance will produce heat at the same rate as a DC ampere. The effective value is 0.707 times the peak value. The effective value of a system with 650 volts peak, for example, is 460 volts (650 x 0.707 = 459.55 volts).



Linear Loads

It is important at this point to discuss the differences between a linear and nonlinear load. A linear load is any load in which voltage and current increase or decrease proportionately. Voltage and current may be out of phase in a linear load, but the waveforms are sinusoidal and proportionate. Motors, resistive heating elements, incandescent lights, and relays are examples of linear loads. Linear loads can cause a problem in a distribution system if they are oversized for the distribution system or malfunction. They do not cause harmonic distortion, which will be discussed later.

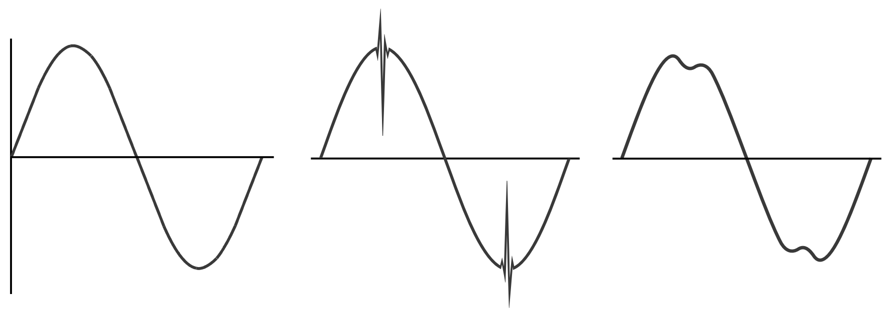


Nonlinear Loads

When instantaneous load current is not proportional to instantaneous voltage the load is considered a nonlinear load. Computers, television, PLCs, ballested lighting, and variable speed drives are examples of nonlinear loads. Nonlinear loads can cause harmonic distortion on the power supply. Harmonics will be discussed later in the course.

Crest Factor

Crest factor is a term used to describe the ratio of the peak value to the effective (RMS) value. A pure sinusoidal waveform has a crest factor of 1.41. A crest factor other than 1.41 indicates distortion in the AC waveform. The crest factor can be greater or lower than 1.41, depending on the distortion. High current peaks, for example, can cause the crest factor to be higher. Measuring the crest factor is useful in determining the purity of a sine wave.



Crest Factor = 1.41 | Crest Factor > 1.41 | Crest Factor < 1.41

Conversion Chart

When using different types of test equipment it may be necessary to convert from one AC value to another. A voltmeter, for example, may be calibrated to read the RMS value of voltage. For purpose of circuit design, the insulation of a conductor must be designed to withstand the peak value, not just the effective value.

To Convert	To	Multiply By
Peak-to-Peak	Peak	0.5
Peak	Peak-to-Peak	2
Peak	RMS	0.707
Peak	Average	0.637
RMS	Peak	1.414
RMS	Average	0.9
Average	Peak	1.567
Average	RMS	1.111

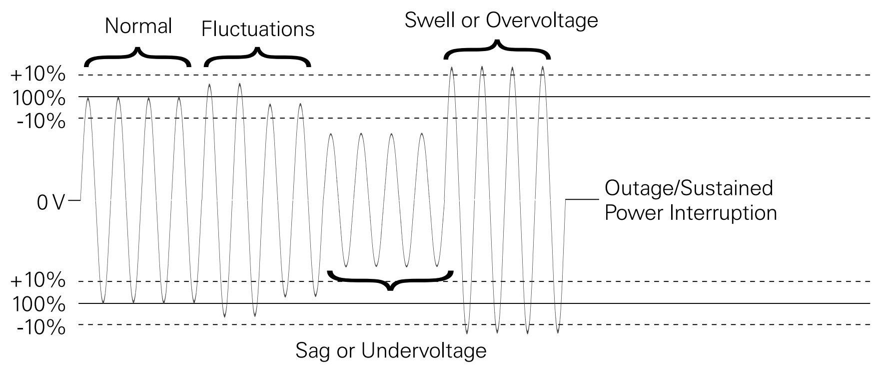
Changes in Voltage and Current

Even the best distribution systems are subject to changes in system voltage from time-to-time. The following industry terms can be used to describe given voltage conditions. Voltage changes can range from small voltage fluctuations of short duration to a complete outage for an extended period of time.

Term	Condition
Voltage Fluctuations	Increase or decrease in normal line voltage within the normal rated tolerance of the electronic equipment. Usually short in duration and do not affect equipment performance.
Voltage Sag	Decrease in voltage outside the normal rated tolerance of the electronic equipment. Can cause equipment shutdown. Generally, two seconds or less in duration.
Voltage Swell	Increase in voltage outside the normal rated tolerance of the electronic equipment. Can cause equipment failure. Generally, two seconds or less in duration.
Long-Term Under/Overvoltage	Decrease/increase in voltage outside the normal rated tolerance of the electronic equipment. Can adversly affect equipment. Lasts more than a few seconds in duration.
Outage/Sustained Power Interruption	Complete loss of power. Can last from a few milliseconds to several hours.

Sags and undervoltage can be caused when high current loads, such as large motors are started. Undervoltage may also occur when a power utility reduces the voltage level to conserve energy during peak usage. Undervoltage is also commonly caused by overloaded transformers or improperly sized conductors.

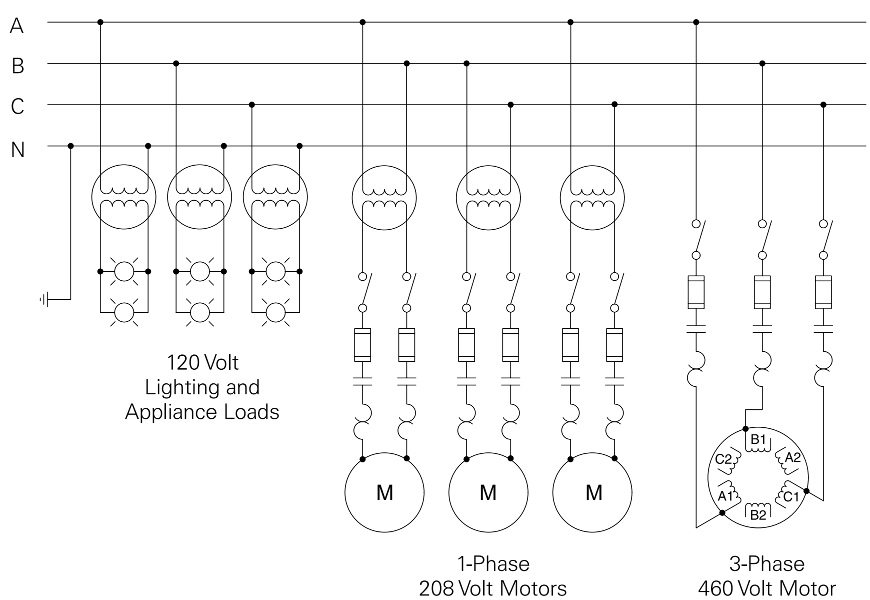
Swells and overvoltage can be caused when high current loads are switched off, such as when machinery shuts down. Overvoltage may occur on loads located near the beginning of a power distribution system or improperly set voltage taps on a transformer secondary.



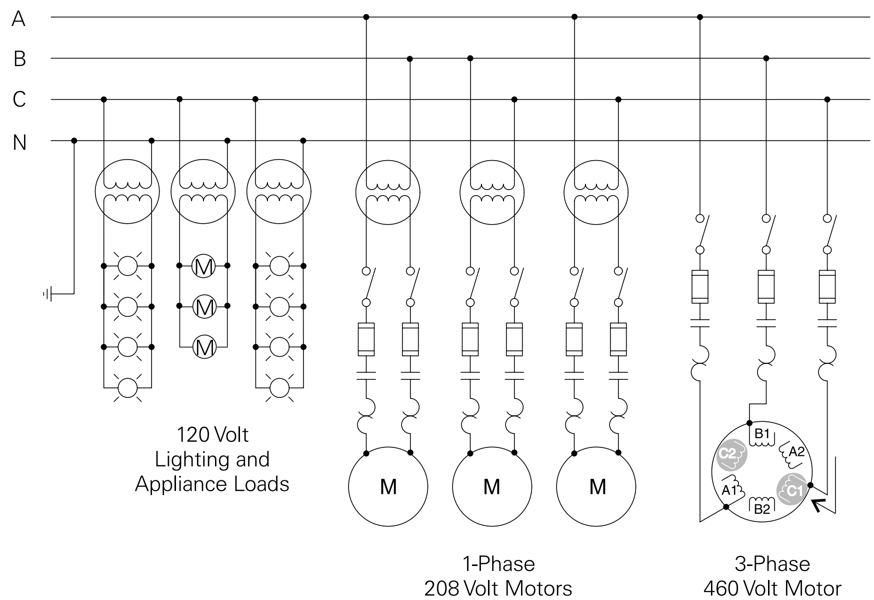
*Based on Equipment with Normal Rated Voltage Tolerance of ±10%

Voltage and Current Unbalance

Voltage unbalance occurs when the phase voltages in a three-phase system are not equal. One possible cause of voltage unbalance is the unequal distribution of single-phase loads. In the following illustration loads are equally divided.

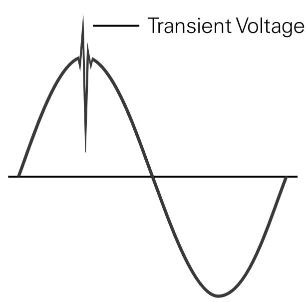


In this illustration, however, loads are unevenly divided. A large number of lighting and small appliance loads are connected to phase C . This can cause the voltage on phase C to be lower. Because a small unbalance in voltage can cause a high current unbalance, overheating can occur in the C phase winding of the 3-phase motor. In addition, the single-phase motors connected to phase C are operating on a reduced voltage. These loads will also experience heat related problems.



Transient Voltage

A transient voltage is a temporary, undesirable voltage that appears on the power supply line. Transient voltages can range from a few volts to several thousand volts and last from a few microseconds to a few milliseconds. Transients can be caused by turning off high inductive loads, switching large power factor correction capacitors, and lightning strikes.

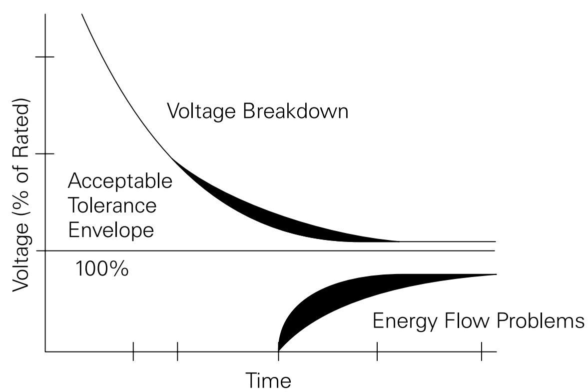


CBEMA and IEEE

The U.S. Department of Commerce, working with the Computer Business Equipment Manufacturers Association (CBEMA), published a set of guidelines for powering and protecting sensitive equipment. These guidelines were published in 1983 in FIPS Publication 94. As the use of computers has grown, other organizations have made additional recommendations. The Institute of Electrical and Electronic Engineers (IEEE) published IEEE 446-1987 which recommends engineering guidelines for the selection and application of emergency and standby power systems. While it is beyond the scope of this book to discuss in detail the recommendations of these documents it is useful to discuss their intent.

CBEMA Curve

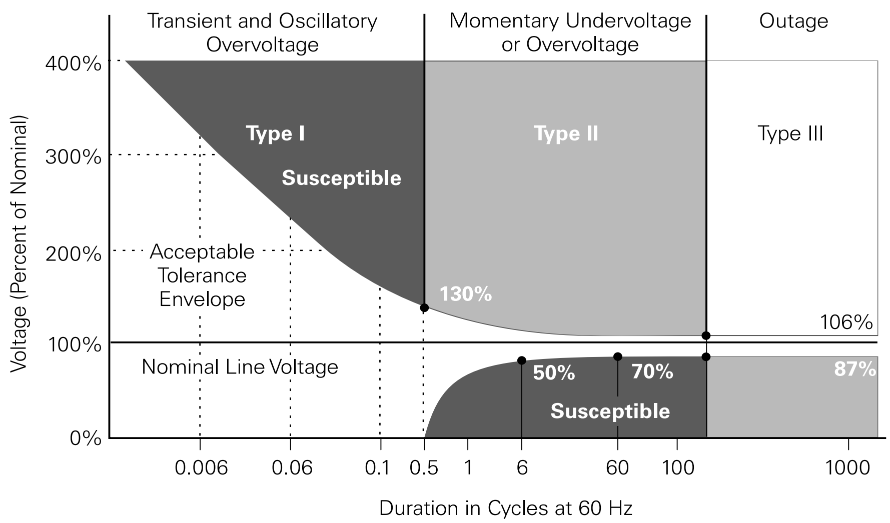
The CBEMA curve is a useful tool that can be used as a guideline in designing power supplies for use with sensitive electronic equipment. The vertical axis of the graph is the percent of rated voltage applied to a circuit. The horizontal axis is the time the voltage is applied. The CBEMA curve illustrates an acceptable voltage tolerance envelope. In general, the greater the voltage spike or transient, the shorter the duration it can occur. Voltage breakdown and energy flow problems can occur when the voltage is outside the envelope.



Power Disturbance Types

There are three types of power disturbances. Type I disturbances are transient and oscillatory overvoltages lasting up to 0.5 Hz. Type I disturbances can be caused by lightning or switching of large loads on the power distribution system. Type II disturbances are overvoltages and undervoltages which last from 0.5 to 120 Hz. Type II disturbances can be caused by a fault on the power distribution system, large load changes, or malfunctions at the utility. Type III disturbances are outages lasting greater than 120 hertz.

Studies have shown that sensitive computer equipment is most vulnerable during a Type I overvoltage disturbance and a Type II undervoltage disturbance. Type II undervoltage disturbances are the most common cause of failure in sensitive computer equipment. It is important to note that the precise extent to which computers and other sensitive equipment is susceptible is difficult to determine.



Review 2

1. ___________ is a measurement of the number of alternations between positive and negative peak values in a measured amount of time.

   a. voltage
   b. current
   c. frequency
   d. power

2) The peak-to-peak value of an AC voltage with a peak voltage of 600 volts is ___________ .

3) The instantaneous voltage measured at 120° of a sine wave with a peak voltage of 650 volts is ___________ .

4) The most common method of expressing the value of AC voltage and current is ___________ value.

   a. average
   b. effective
   c. peak
   d. instantaneous

5) A pure sinusoidal waveform has a crest factor of ___________ .

6) Computer equipment is most vulnerable during a Type I overvoltage disturbance and a Type ___________ undervoltage disturbance.

   a. I
   b. II
   c. III