Basic AC (Alternating Current) Quantities

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Basic AC (Alternating Current) Quantities

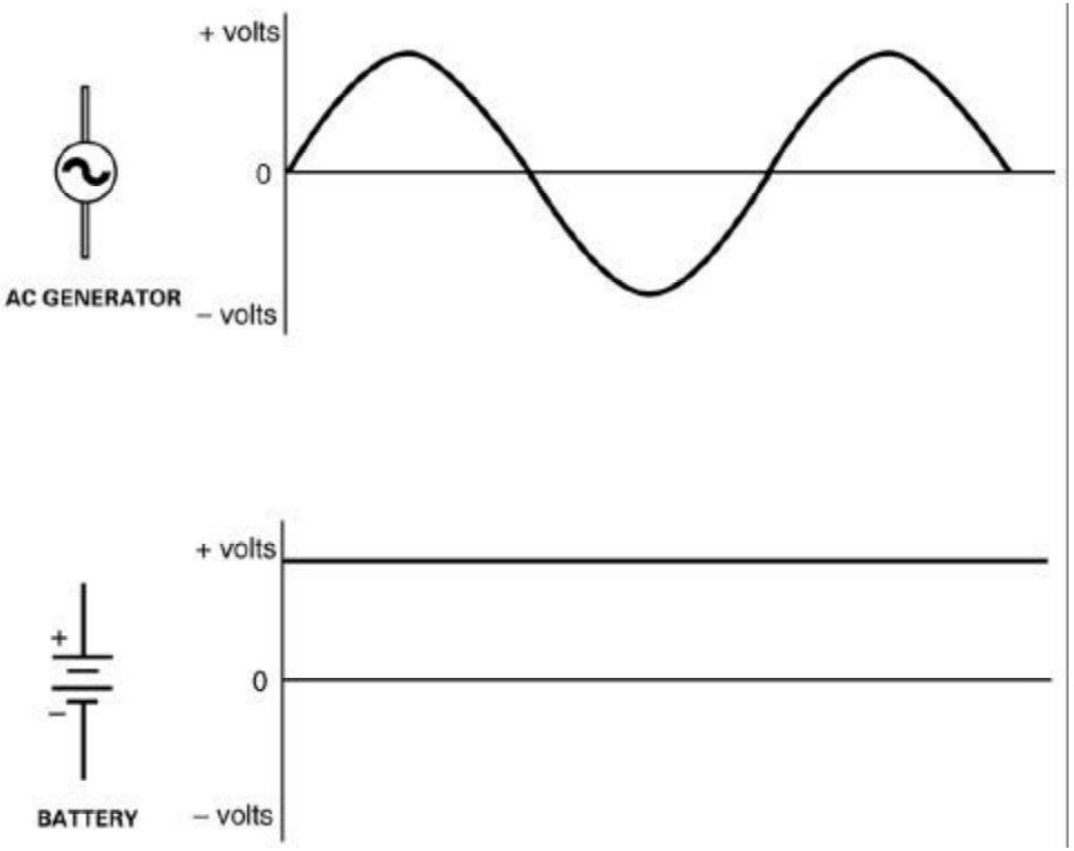
After viewing this document, the student should be able to:

1. Explain the basic difference between DC and AC electricity.
2. Identify the electrical print symbols for a DC and AC power source
3. Explain what devices create DC power, and how AC power is generated.
4. Explain what an AC cycle is, and how it was generated.
5. Explain the AC terms of frequency, period and hertz.
6. Explain the AC terms of voltage RMS, voltage peak, and voltage peak-to-peak.
7. Calculate the peak voltage from a measured RMS voltage.
8. Calculate the RMS voltage given the peak voltage
9. Explain the purpose of a transformer, and which type of electricity can be transformed

Please Read This

This document was created to give a focused explanation about AC electricity terminology, concepts and quantities. This material is based on what a Maintenance Technician would need to know about AC basics in order to understand and troubleshoot equipment in an industrial workplace.

AC power versus DC power:



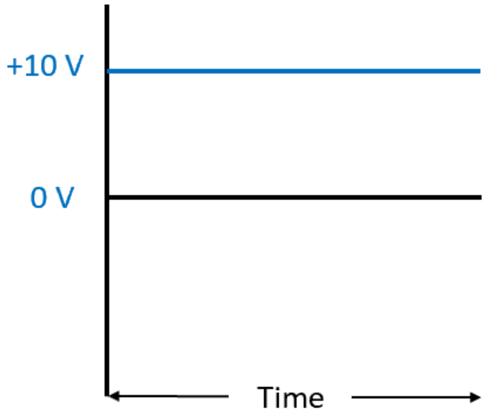
This slide compares the waveforms for both AC and DC power waveforms.

The top graphic is an AC (Alternating Current) waveform, that is many times called a Sine Wave. Notice that it alternates from positive to negative continuously (thus called alternating). AC power is predominately used in residential, commercial and industrial environments.

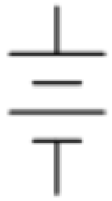
The lower graphic is DC (Direct Current), which does not alternate, it stays a steady voltage. A flashlight or smoke alarm battery is DC. In an industrial environment, DC will be used to power the control systems of a machine, and will also be used within a variable frequency drive.

We will cover and compare the basics on both DC and AC electricity in the following slides.

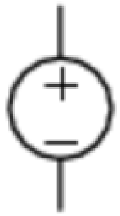
DC Basics:



DC stays at a consistent voltage over time, and does not alternate or change direction



Symbol for a DC Power Source, 2 batteries in series



Symbol for a DC Power Source

24 Vdc Power Supply found in most electrical panels

DC stands for Direct Current, which is typically low voltage type of electricity. The most basic form of DC is a battery.

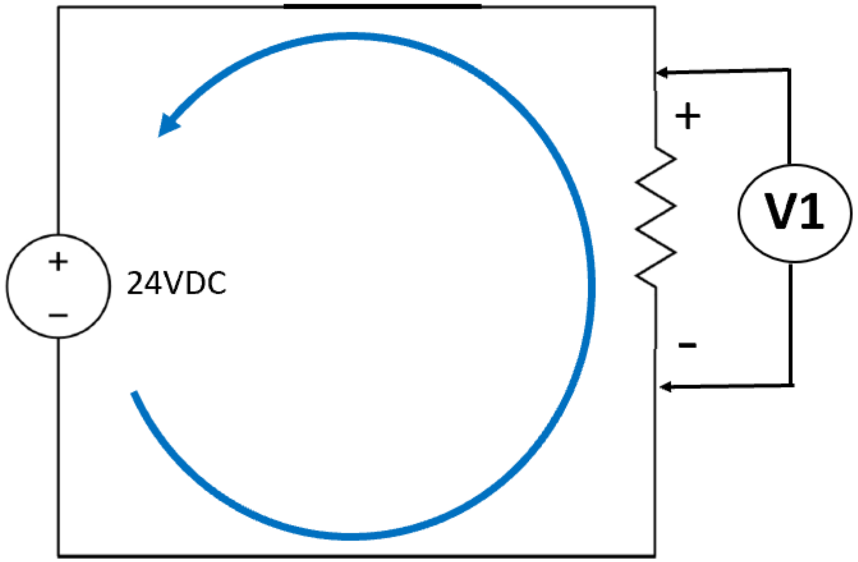
An important characteristic of DC power is that current only flows in one direction, and it is constant with time, as shown in the top graphic. The primary sources for DC power is batteries and DC power supplies.

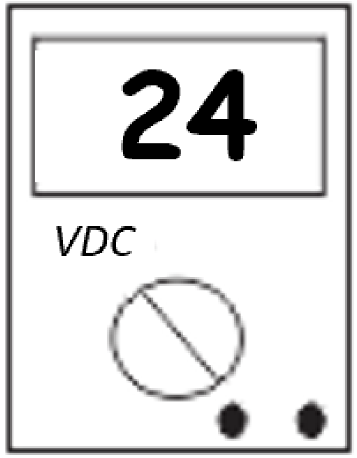
Another important characteristic of DC is that I cannot transform it through a transformer. In the following slides, we will discuss AC power, and its advantage of being able to transform to different voltage level.

There are a number of applications for DC power in an industrial environment. Tow motors (lift trucks) is one of our more common applications. The track has a bank of batteries that will run a DC motor. DC is very common on industrial machinery to power the control circuit of a production machine. The most common control voltage is 24 Vdc, which will come from a DC power supply, as shown in the lower graphic.

DC Basics cont.:

DC Power Source





In this DC circuit, 24 Vdc is applied to a resistor. The important thing to understand is that current travels in only one direction. In DC circuits you may hear someone use the term electronic flow, which means that the current flows from the negative side of the DC power source to the positive side. Conventional current flow is positive to negative. This really doesn't matter. The important thing is that current is flowing in the circuit.

If current is flowing (power source is good, and the resistor is good) then there will be voltage drop across the resistor.

The DC voltmeter will be used to measure the voltage. Notice that the meter dial must be set for Vdc in order to measure DC volts.

If the DC voltage reads a negative value, just reverse the leads of the meter.

Practice Question #1

What are the two power sources for DC voltage?

- a. Wall outlet
- b. DC Power Supplies
- c. Batteries
- d. All of the above

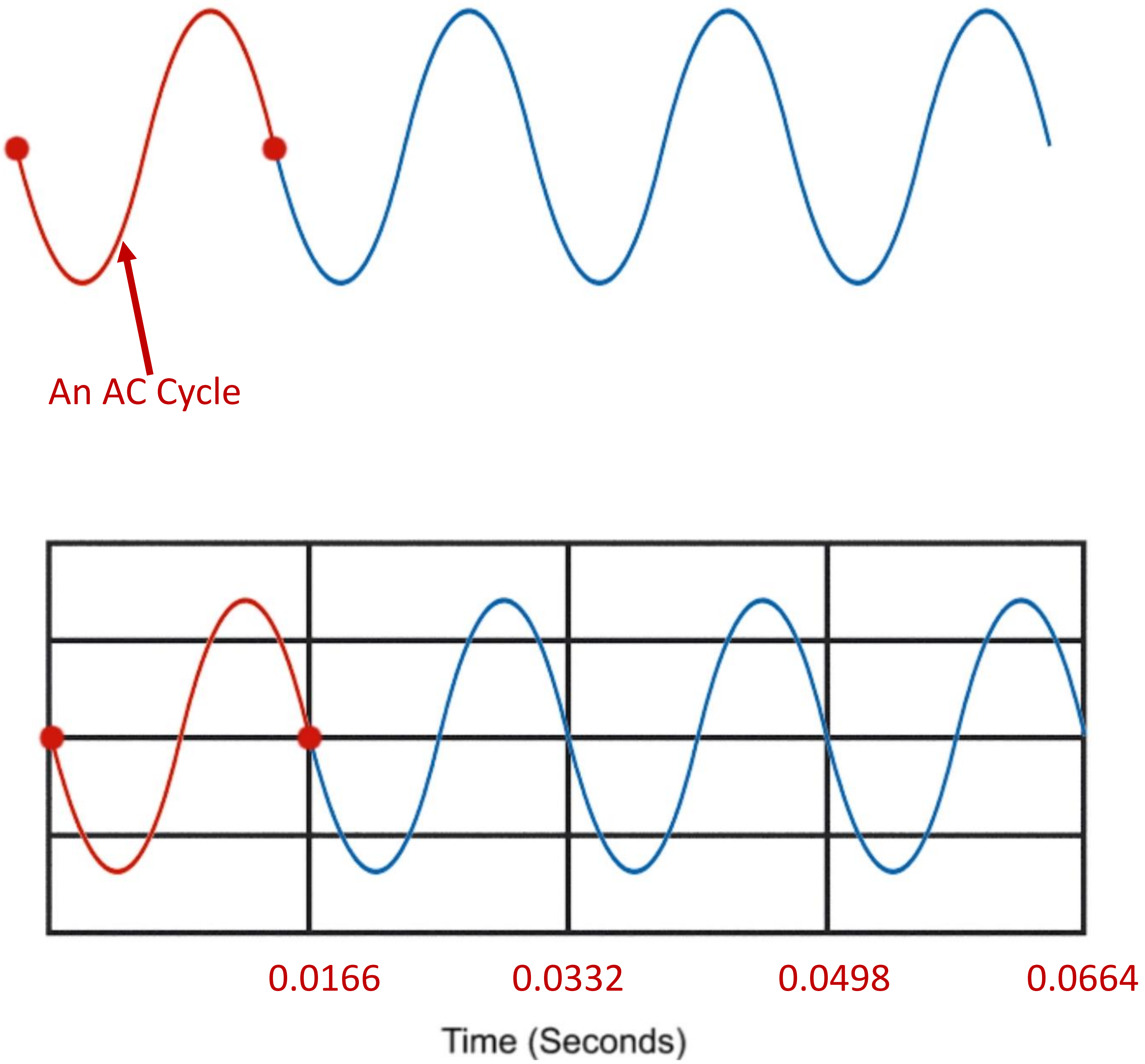
The Answer to Practice Question #1

What are the two power sources for DC voltage?

- a. Wall outlet
- b. **DC Power Supplies**
- c. **Batteries**
- d. All of the above

Explanation: The two sources for DC power is batteries and power supplies. Many devices have their own internal power supplies such as variable frequency drives. Incoming AC power is converted to DC power within a VFD. Batteries are used in many industrial applications.

Alternating Current:



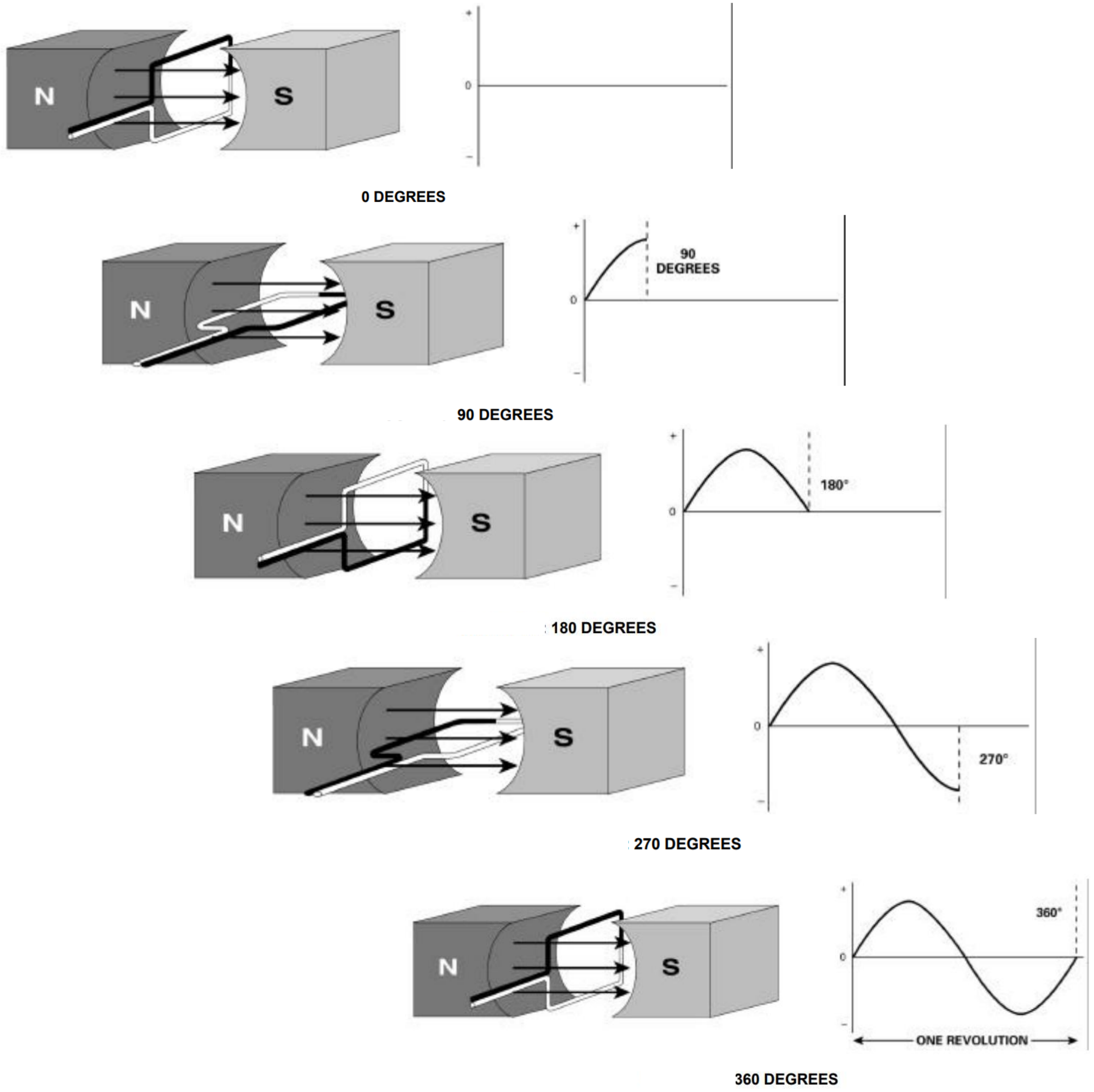
In the top graphic the sine wave in red is called one cycle. This cycle will occur in a specific time. Frequency of a sine wave defines the number of times that a sine wave repeats per second.

Frequency is measured in Hertz (Hz). All of our AC power in the U.S. is standardized at 60 Hz. This means that there are 60 sine wave cycles that occur every second.

The lower graphic shows what is termed a Period. A period is the amount of time it takes for one cycle. The period is calculated as 1/frequency, so 1/60 will equal 0.0166 seconds. This is how long it will take to complete 1 cycle.

Frequency has become important in the industrial maintenance world, with the advancement of variable frequency drives. The speed of an AC motor is proportional to the frequency. Reduce the frequency and the motor speed reduces.

How AC is generated:

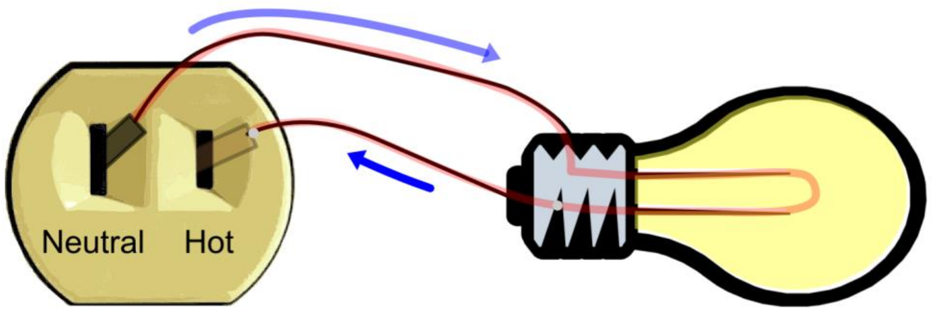


This slide shows how AC is generated, and the different quadrants of the sine wave.

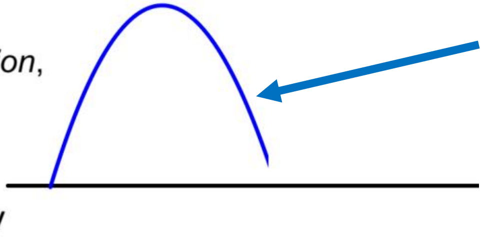
AC voltage is initially generated in an alternator (which is an AC generator) that is found in a power plant that generates electricity. Voltage is generated in windings that go through a magnetic field. The position of the winding within the magnetic field generates a sine wave. The figures on this slide shows the steps the alternator goes through to generate a sine wave voltage at 60 Hz.

Through a series of transformers, distribution lines and substations, the voltage ends up at your home and at an industrial plant, to run equipment.

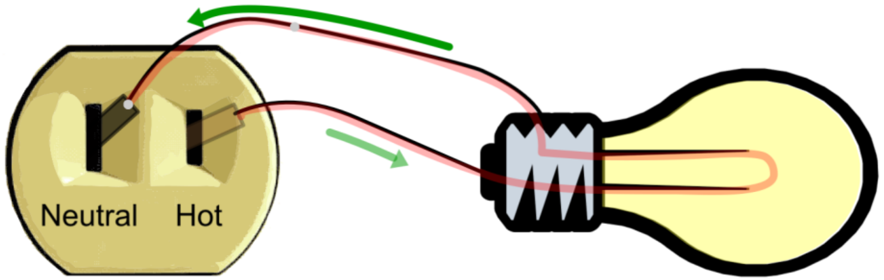
Alternating current flow:



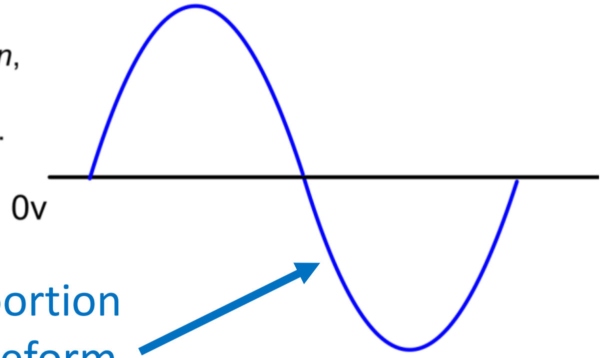
This is called the *positive alternation*, and the hot wire is positive with respect to the neutral terminal.



Positive portion of the waveform



This is called the *negative alternation*, and the hot socket is negative with respect to the 0-volt neutral terminal.



Negative portion of the waveform

This slide shows the a light bulb that is powered with AC (120 VAC) power from a standard residential power outlet.

The current flows in one direction during the positive portion of the AC sine wave. Notice that it flows from the Neutral portion of the plug, through the light, then back to the hot side of the outlet.

The current flows in the other direction on the negative portion of the AC sine wave, thus in the lower portion of the graphic, current flows from the Hot portion of the outlet, through the light, then back to the Neutral side of the outlet.

Realize that this is why they term “Alternating Current” (AC) is used, the current changes direction every half cycle.

Practice Question #2

Which type of electricity has current flowing in only one direction is a circuit?

- a. DC electricity
- b. AC electricity
- c. Both DC and AC electricity

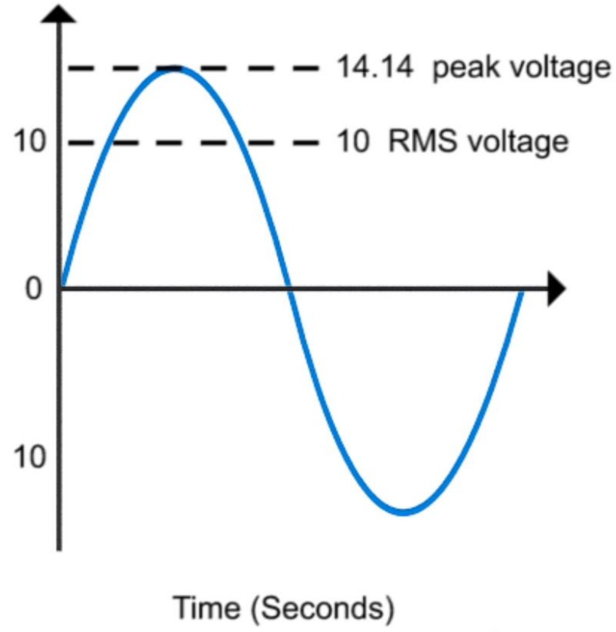
The Answer to Practice Question #2

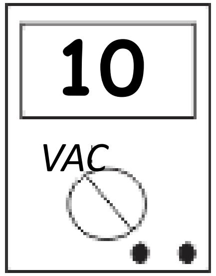
Which type of electricity has current flowing in only one direction is a circuit?

- a. **DC electricity**
- b. AC electricity
- c. Both DC and AC electricity

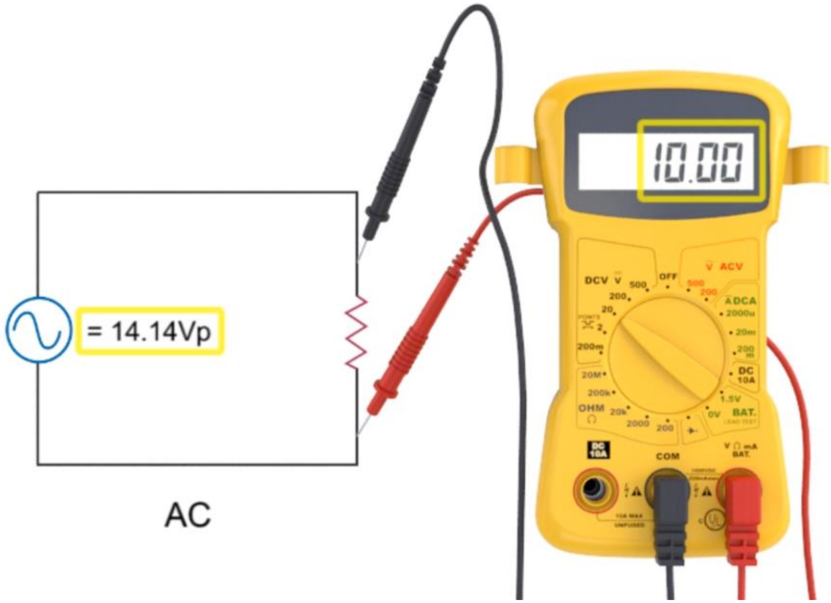
Explanation: DC electricity flows in only one direction. AC electricity flows in one direction for ½ of the AC cycle, and the other direction in the other ½ of the AC cycle.

AC Quantity Terms:





Vp = 1.414 x 10



Three important terms to know when working with AC systems is Peak Voltage, Peak to Peak Voltage, and RMS voltage.

First of all, RMS stands for Root Mean Square. RMS is roughly the equivalent of what the voltage would be in a DC circuit. In the lower graphic, notice that the AC voltage is 14.14 Vp (peak), which will be explained in future slides, but the meter reads 10V.

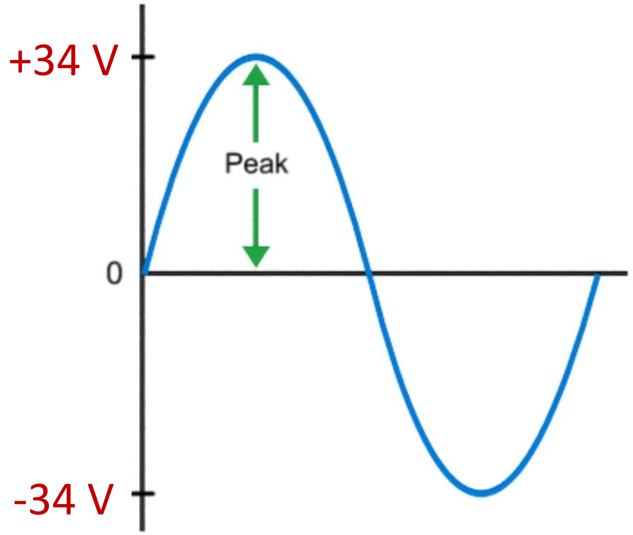
The AC voltages that a Technician reads on a voltmeter is in RMS. So in this example if a meter is on the VAC (voltage AC) scale, the meter would read 10 V (RMS).

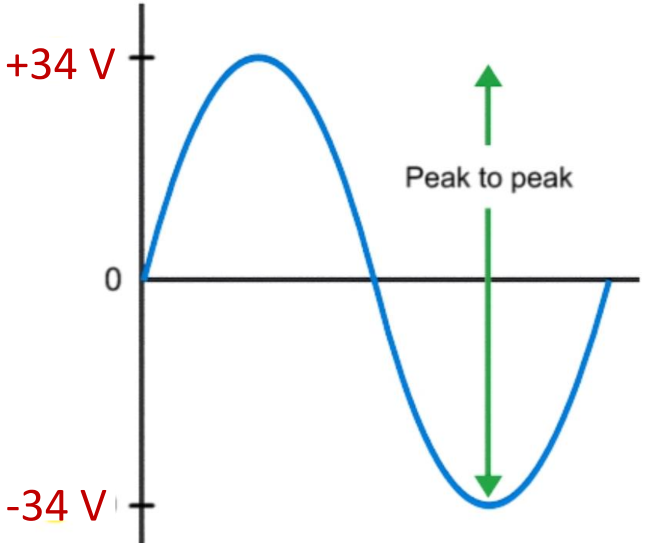
Make sure when you are using a digital voltmeter to measure AC voltage (such as the 120Vac on your outlets at home) that the dial on the meter is set for AC volts.

The peak voltage (Vp) is shown in the top graphic as the highest point on the AC sine wave.

Also notice at the top graphic, there is a formula that shows that show: Vp = 1.414 * Vrms.

AC Quantity Terms cont.:





Continuing the AC quantity explanation, peak voltage is the highest point that the sine wave will go to. This value can be measured using an oscilloscope, or calculated from the measurement of the RMS value with the digital voltmeter measurement.

The other term that is important is voltage peak-to-peak (Vp-p). This value is obtained by measuring the maximum positive voltage and the maximum negative voltage, then adding them together. In this example, the Vp is 34V. This means that the Vp-p is 64V.

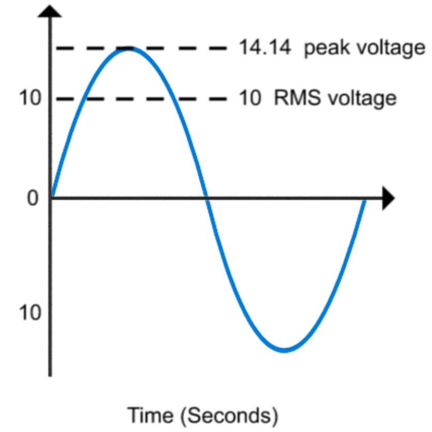
The RMS voltage can be calculated as: Vrms = Vp x 0.707.

So, in this application: 34V * 0.707 is equal to 24 V. This is what the meter will read

Oscilloscopes:

Old style Oscilloscopes used on a bench or cart

Handheld Oscilloscope, a more modern type of testing device



Vp = 1.414 x 10

This slide shows a piece of test equipment named an Oscilloscope. This is a device that can show the full waveform of the AC sine wave, so a Technician can see what is happening on an AC line.

From the aspect of the Maintenance Technician, this is not a device that they would carry to a job for troubleshooting, as they do a digital voltmeter.

Typically there may be one of these in a maintenance shop, and one or two people that would know how to use it.

A couple of applications for these devices is measuring the switching of an AC waveform on a welding unit used in a production process. Another application would be using this device on the output of a variable frequency drive to measure and test for harmonic activities that could create problems in the operation of the solid state drive.

Reason for introducing this: to know what it is, and what the purpose of it is.

Practice Question #3

What unit is used to measure frequency?

- a. Period
- b. Hertz
- c. Amps
- d. Seconds

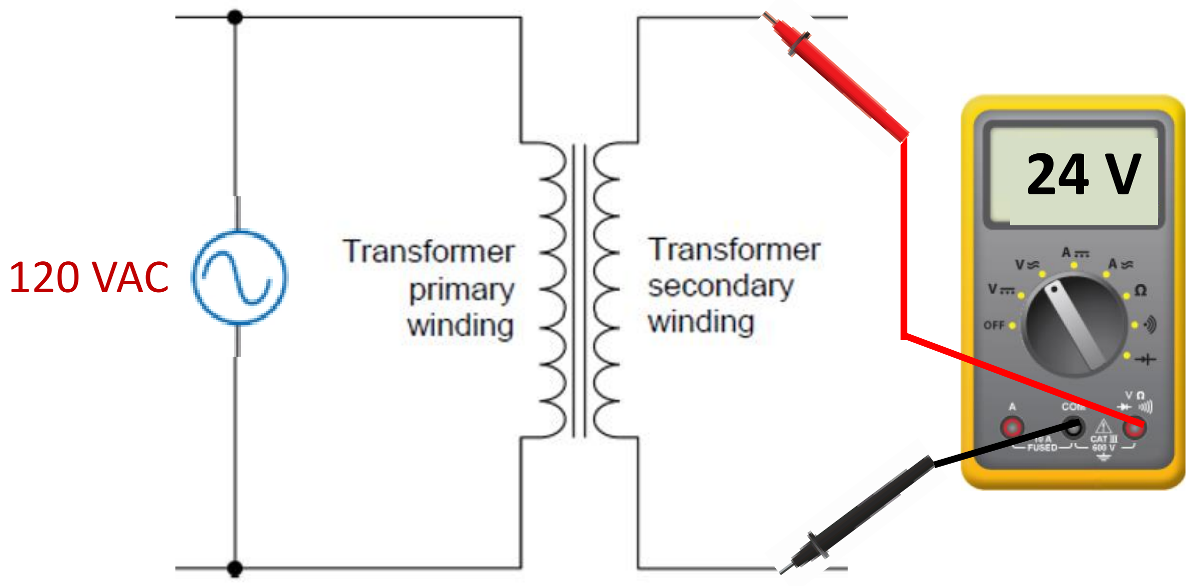
The Answer to Practice Question #3

What unit is used to measure frequency?

- a. Period
- b. **Hertz**
- c. Amps
- d. Seconds

Explanation: Hertz is the unit of measure for frequency. Period is the amount of time it takes to complete one cycle. Amps is used to measure current, and seconds is used to measure time.

AC can be Transformed:



This slide shows the concept of voltage transformation.
AC voltage can be transformed through a transformer.
DC voltage cannot be transformed through a transformer.

This example shows a transformer with a primary and secondary winding. 120Vac is applied to the transformer primary winding. The Vac measured on the secondary is 24 Vac.

Not to get into too much transformer theory, but this is a 5:1 ratio, which means that the secondary voltage will be five times less than the primary voltage.

Practice Question #4

What is the peak voltage for a 120 V RMS voltage, as found on the outlet in a home?

- a. 120 V
- b. 150 V
- c. 170 V
- d. 240 V

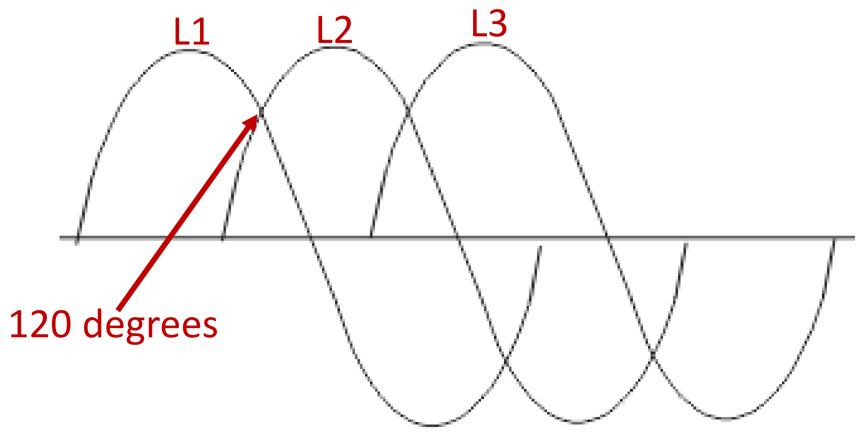
The Answer to Practice Question #4

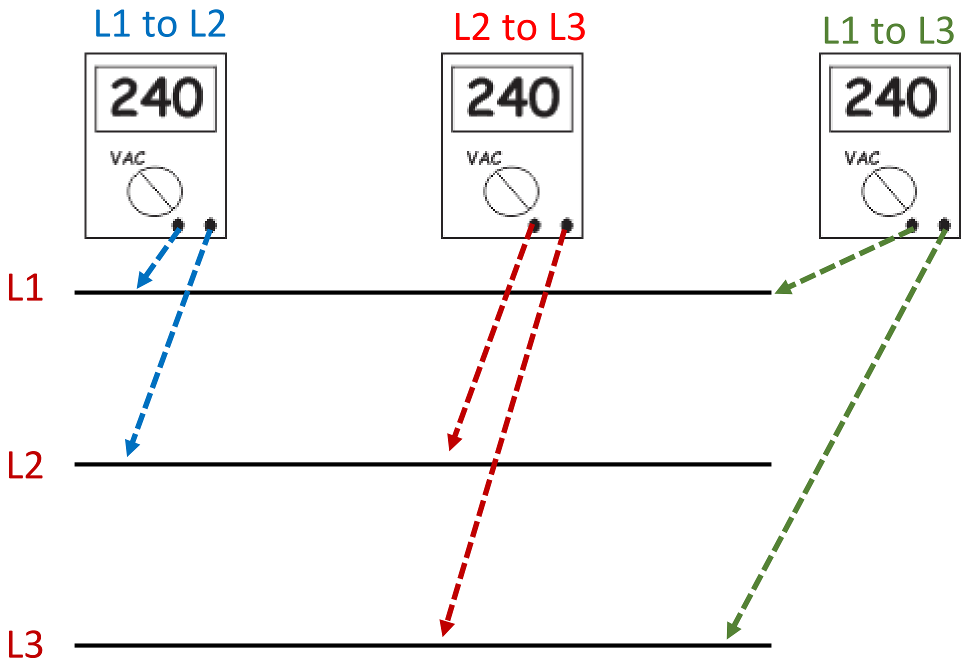
What is the approximate peak voltage for a 120 V RMS voltage, as found on the outlet in a home?

- a. 120 V
- b. 150 V
- c. **170 V**
- d. 240 V

Explanation: The calculation for Vp = Vrms x 1.414, So 120 * 1.414 = 169 V, or approximately 170 V. Since the peak voltage is 170V, the peak-to-peak voltage will be 340 V.

Three Phase Power





A three phase power waveform would look like this graphic. Notice that this is made up of three single phase waveforms. There is a 120 degrees phase shift with three phase. This means that 120 degrees into the first sine wave, the next single phase sine wave starts. Then 120 degrees later, the next sine wave starts.

Three phase is more powerful than single phase. This is why most industrial motors are three phase. The three phase motors are smaller than the same horsepower single phase motor.

This example is a 240V, three phase system. L1, L2 and L3 are the three power lines. This is a delta voltage (will be explained later), but the most important thing to remember is that there is 240Vrms measured between any two wires.

240V three phase is a common motor voltage.

This completes this Instructional Document