AC, DC, Grounding FUNDAMENTALS

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6/20/2023

Disclaimer

- I am not an electrician

Safety

- Do not work on any open electrical. Notify your supervisor and reschedule the service call.
- Don't touch electrical connections with the palm of your hand. Only the back of the hand. This prevents locking the hand on live power.
- Do not work around electrical if the area is wet

9 Things You Should Never Do With Power Strips

- **Never Plug a Surge Strip Into Another Surge Strip or UPS**
- Never Plug a Power Strip Into Another Power Strip
- Never Use Indoor Power Strips Outdoors
- Never Overload a Power Strip
- Never Plug Tools, Heaters or Fans Into a Power Strip
- Never Use a Damaged Power Strip
- Never Get a Power Strip Wet

https://www.familyhandyman.com/article/things-you-should-never-do-with-power-strips/#:~:text=Never%20Plug%20a%20Power%20Strip%20Into%20Another%20Power%20Strip,-If%20your%20power&text=In%20a%20word%E2%80%94don't,fail%20or%20even%20catch%20fire.

Question

What Powers our Equipment?

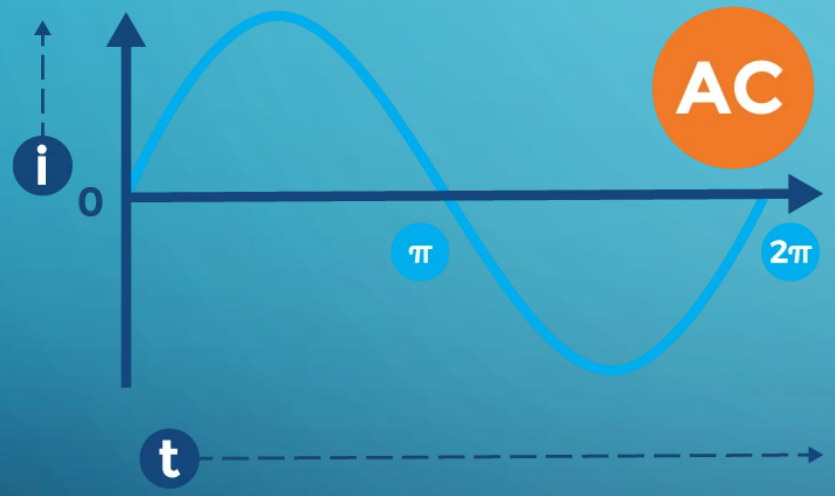
What Powers Chips?

- AC?
- DC?
- Battery?
- Solar?

Alternating Current (AC)

- AC Powers our equipment in most cases
  - Alternating Current
    - This powers most of our facilities.
      - Easier to Install
      - Less Equipment
      - Cost Effective
      - Goes Longer Distance

What is Alternating Current (AC)



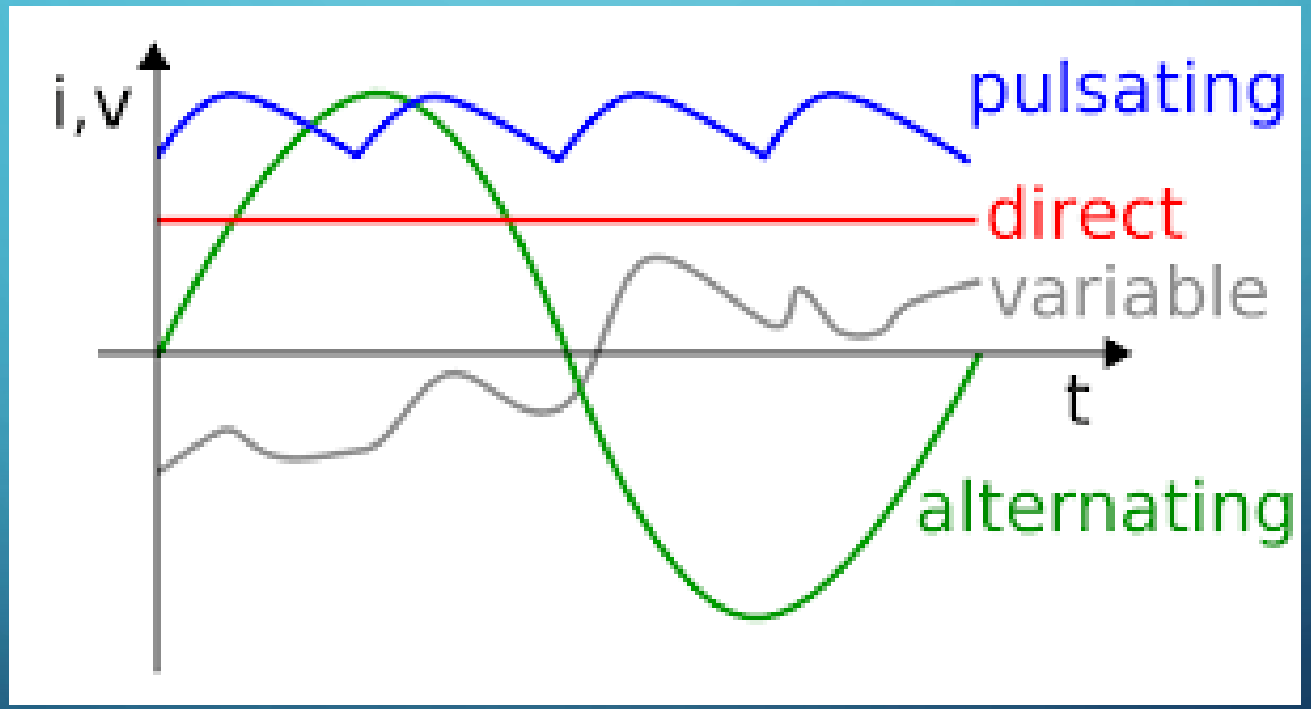
- An electrical current that is periodically reverses direction and whose instantaneous magnitude varies continuously over time.

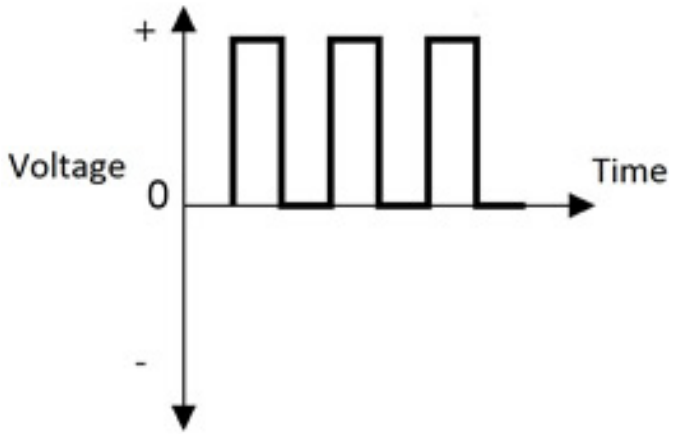
https://www.scte.org/information-page-index/back-to-basics/

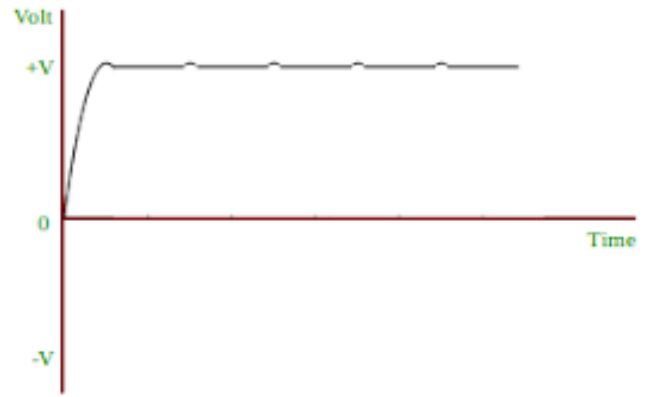
Direct Current (DC)

- DC powers our chips and some of the electronics out in the field
  - Direct Current (like a battery)
    - More Efficient no conversion
    - Longer run times (just add battery strings)
    - Runs cooler less loss
    - Can be stored in batteries

What is DC







DIRECT CURRENT (DC)

- -48v Telco / Service Provider
- +48v Power over Ethernet POE
- 24v Military Vehicles (some proprietary Wireless)
- 12v (13.8) Electronics, Communications Equipment and Cars
- 5 v Electronics and Computers
- Benefits
  - More stable
  - Efficient
  - Longer Run Times

DC Connectors

Anderson

Lug

Ring

RJ45

Power Over Ethernet
POE

- 48 to 58 volts DC over 2 pair
- (24v Proprietary)
- Switch (end-span)
- Injector (mid-span)
- Hi power of 60 and 100w over 4 pairs

RJ45 Ethernet Cable Pinout for PoE

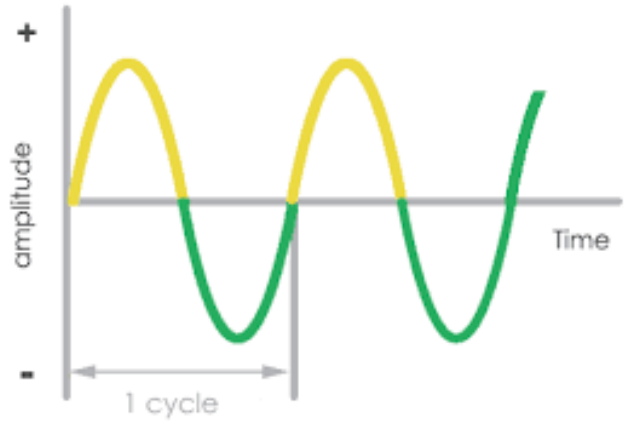
RJ45 Pin	Function	Colour T-568A	Colour T-568B
1	Tx +	White/Green	White/Orange
2	Tx -	Green	Orange
3	Rx +	White/Orange	White/Green
4	DC + PoE	Blue	Blue
5	DC + PoE	White/Blue	White/Blue
6	Rx -	Orange	Green
7	DC - PoE	White/Brown	White/Brown
8	DC - PoE	Brown	Brown

Satoms.com

Name	IEEE Standard	Power to Powered Device (PD)	Max. Power per Port	Energized Pairs	Supported Devices
PoE	IEEE 802.3af	12.95 W	15.4 W	2-pair	Static surveillance cameras, VoIP phones, wireless access points
PoE+	IEEE 802.3at	25.5 W	30 W	2-pair	PTZ cameras, video IP phones, alarm systems
PoE++	IEEE 802.3bt (Type 3)	51 W	60 W	4-pair	Video conferencing equipment, multi-radio wireless access points
PoE++	IEEE 802.3bt (Type 4)	71.3 W	100 W	4-pair	Laptops, flat screens

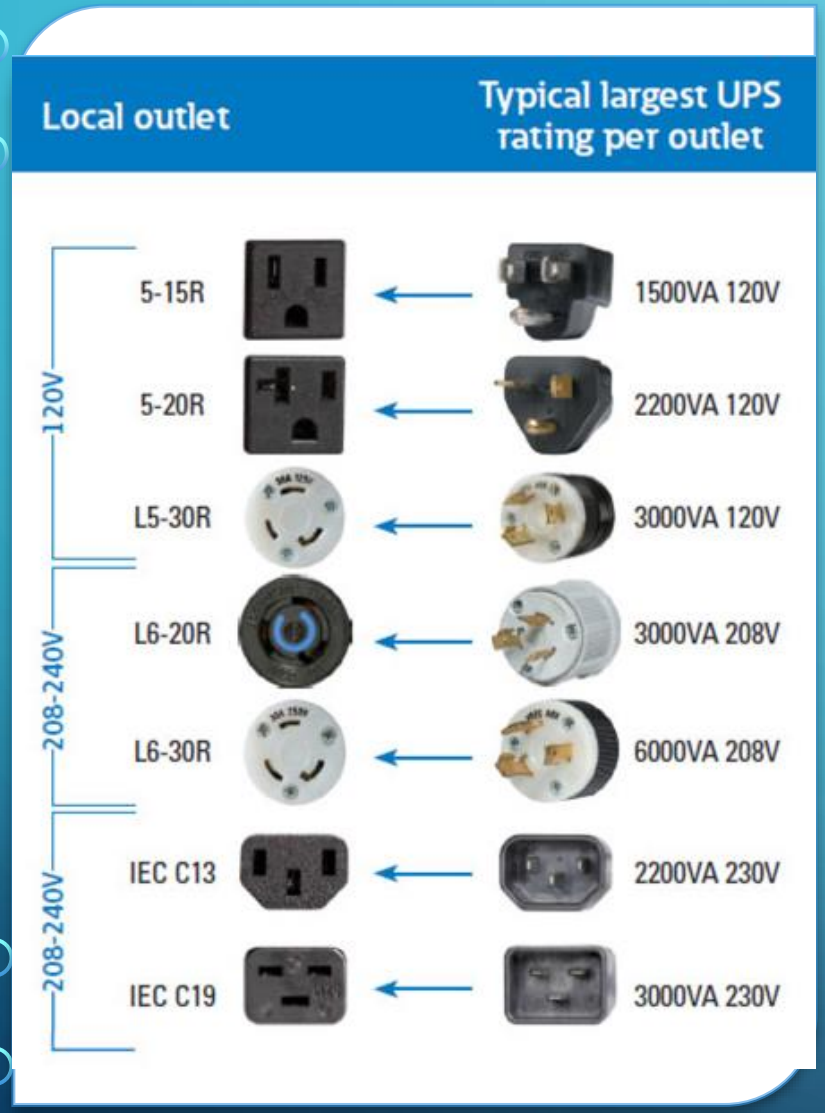
AC Power Sources

- Comercial Power Grid
- UPS
  - Converts AC commercial power to DC for Battery storage and then back to AC with and Inverter.
- Generator
- Solar with an Inverter (offgrid)



ALTERNATING CURRENT (AC)

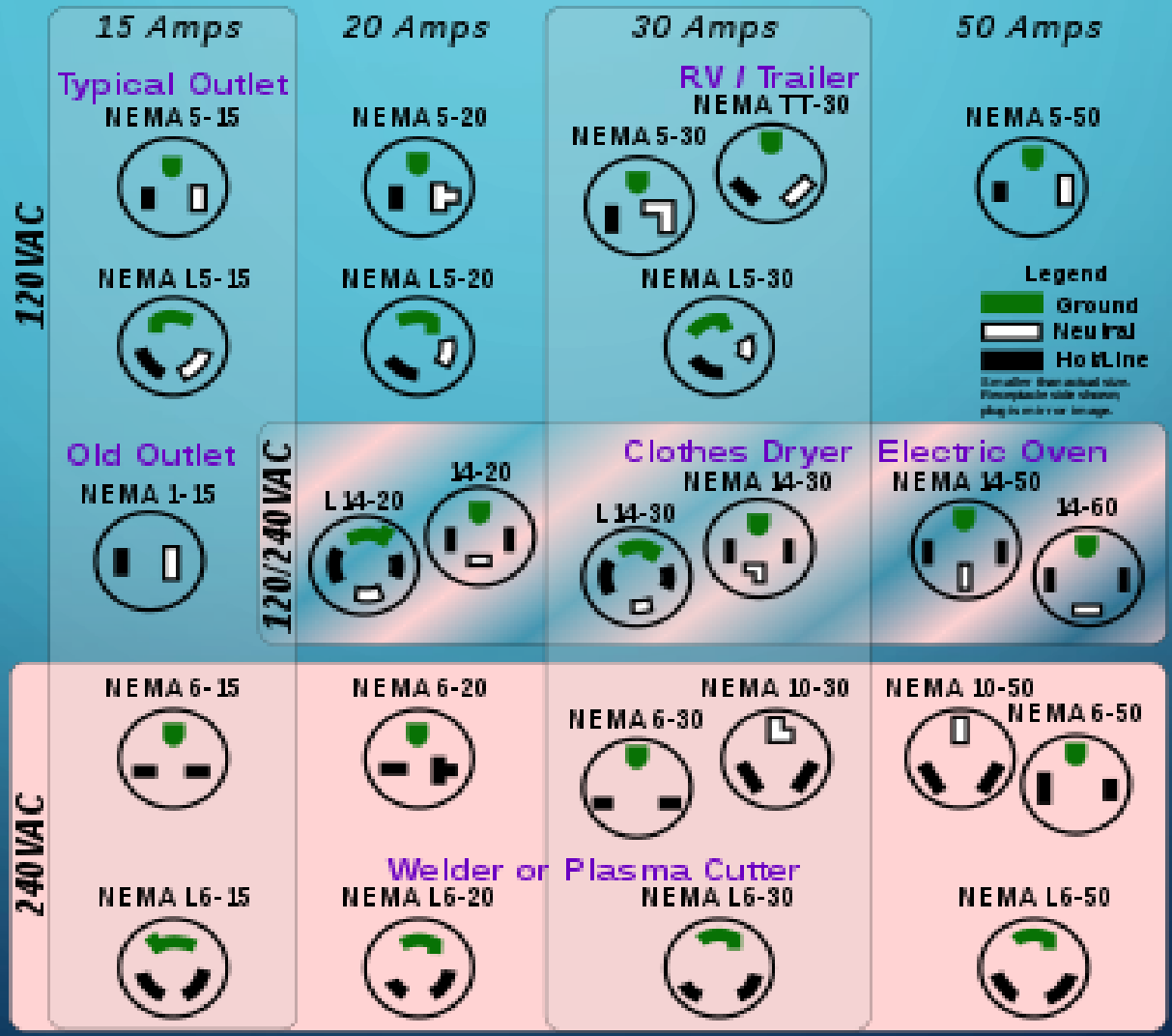
- Single Phase 60 Hz
  - 120v Residential / IDF
  - 208 Computer Power
  - 240v Residential Power
  - 277 commercial lighting
- 3 Phase
  - 208v
  - 417v
- Benefits
  - Easier to Install and Maintain
  - Less Expensive
  - More available
  - Higher voltage the more efficient



Common AC PLUGS

- Single Phase Plugs
- These are the most common plug types

PLUGS BY AMP RATING

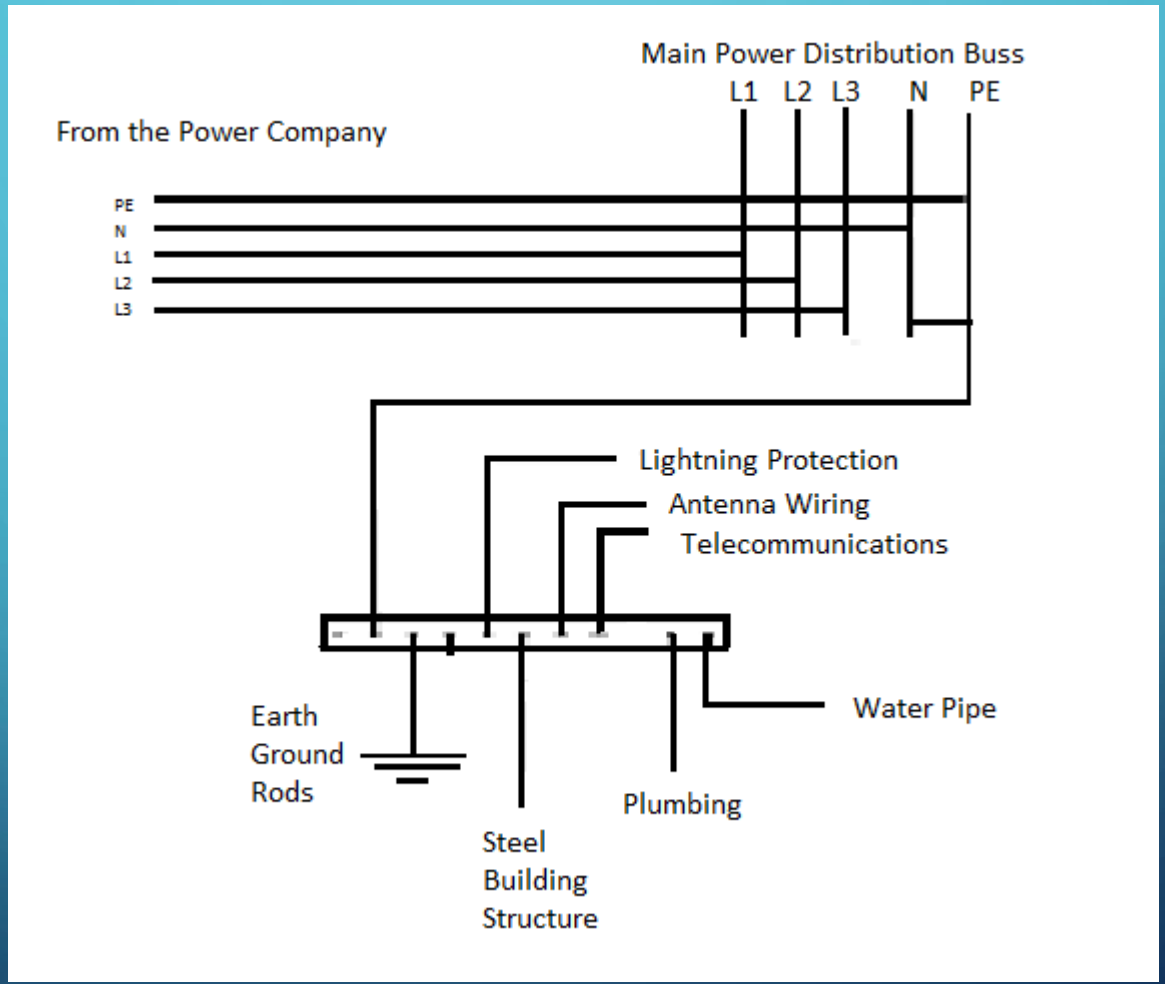


2-Pole 2-Wire	125V	ML1	ML-1R	ML-1P				
	125V	L1	L1-15R②	L1-15P				
	250V	L2			L2-20R	L2-20P		
2-Pole 3-Wire Grounding	125V	ML2	ML-2R	ML-2P				
	125V	L5	L5-15R	L5-15P	L5-20R	L5-20P	L5-30R	L5-30P
	250V	L6	L6-15R	L6-15P	L6-20R	L6-20P	L6-30R	L6-30P
	277V AC	L7	L7-15R	L7-15P	L7-20R	L7-20P	L7-30R	L7-30P
	480V AC	L8			L8-20R	L8-20P	L8-30R	L8-30P
	600V AC	L9			L9-20R	L9-20P	L9-30R	L9-30P
3-Pole 3-Wire	125/250V	ML3	ML-3R	ML-3P				
	125/250V	L10			L10-20R	L10-20P	L10-30R	L10-30P
	3Ø 250V	L11	L11-15R	L11-15P	L11-20R	L11-20P	L11-30R	L11-30P
	3Ø 480V	L12			L12-20R	L12-20P	L12-30R	L12-30P
	3Ø 600V	L13					L13-30R	L13-30P
3-Pole 4-Wire	125/250V	L14			L14-20R	L14-20P	L14-30R	L14-30P
	3Ø 250V	L15			L15-20R	L15-20P	L15-30R	L15-30P
	3Ø 480V	L16			L16-20R	L16-20P	L16-30R	L16-30P
	3Ø 600V	L17					L17-30R	L17-30P
	400Hz 3Ø Δ 120V	FSL3					FSL3	FSL3
4-Pole 4-Wire	3ØY 120/208V	L18			L18-20R	L18-20P	L18-30R	L18-30P
	3ØY 277/480V	L19			L19-20R	L19-20P	L19-30R	L19-30P
	3ØY 347/600V	L20			L20-20R	L20-20P	L20-30R	L20-30P
4-Pole 5-Wire	3ØY 120/208V	L21			L21-20R	L21-20P	L21-30R	L21-30P
	3ØY 277/480V	L22			L22-20R	L22-20P	L22-30R	L22-30P
	3ØY 347/600V	L23			L23-20R	L23-20P	L23-30R	L23-30P
	400Hz 3ØY 120/208V	FSL4					FSL4	FSL4

3 PHASE AC PLUGS

- 3 phase
  - 3 Hot legs
    - A B C
  - 1 Neutral
  - 1 Ground (4 Plug has no ground)

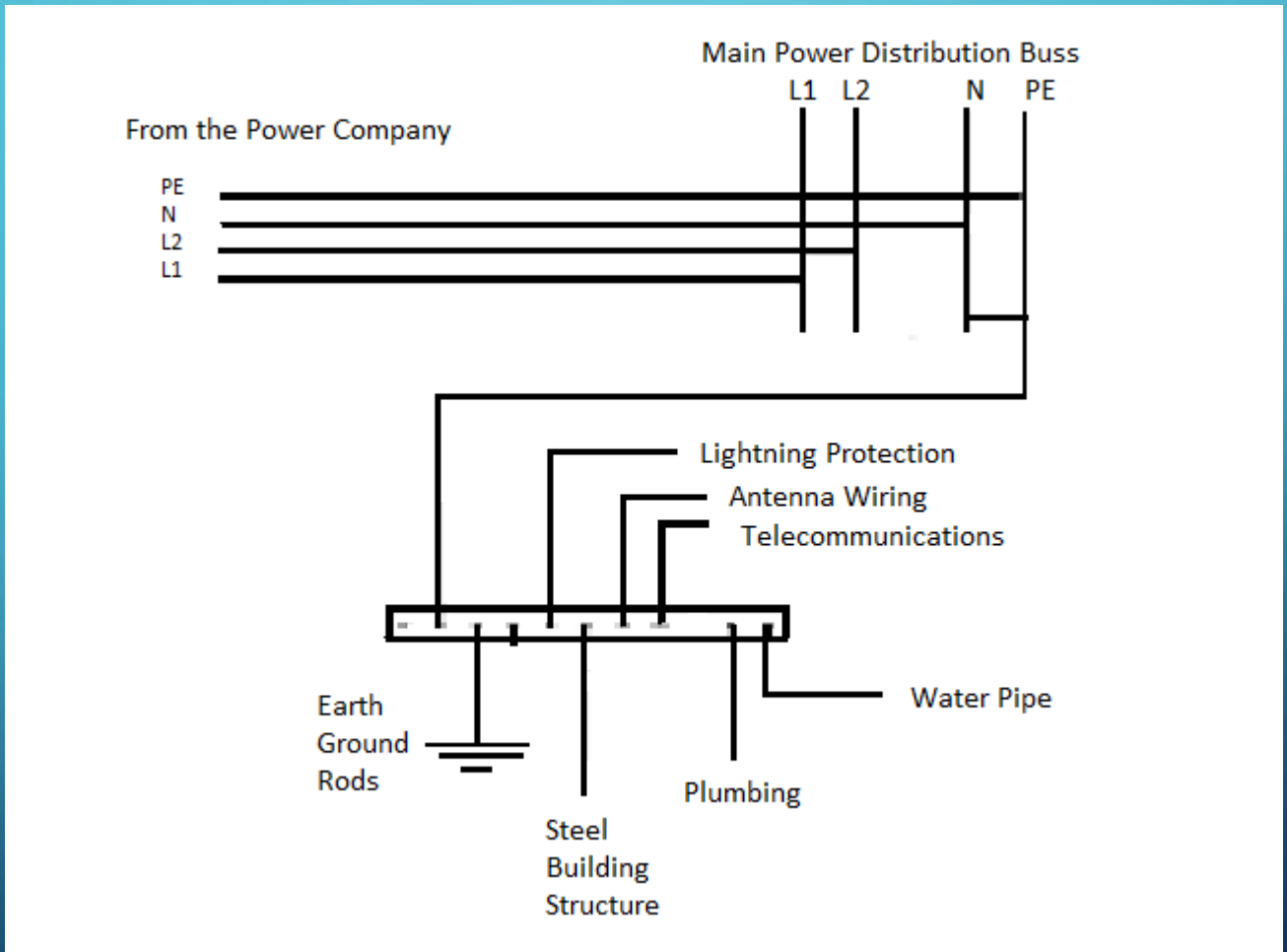
3 PHASE WIRING



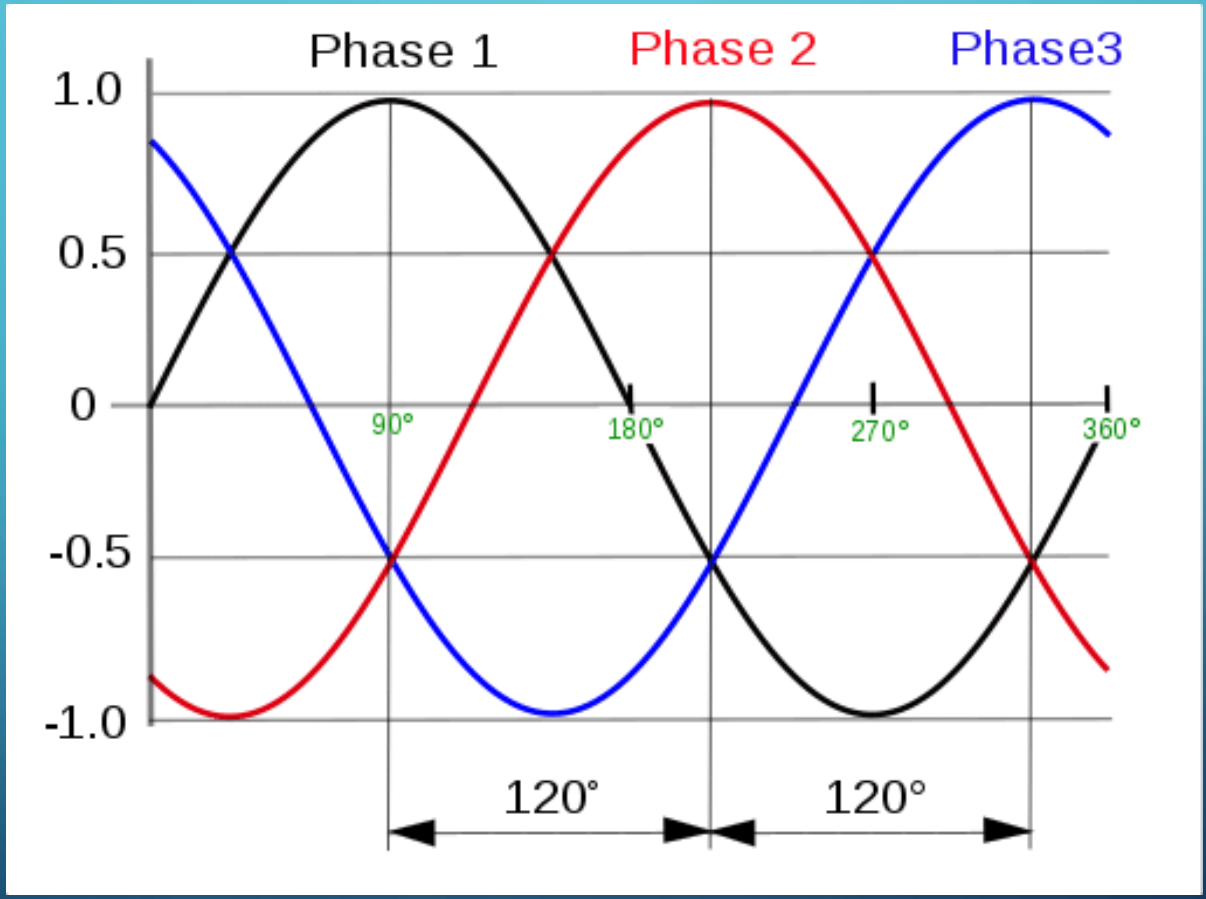
SINGLE PHASE AC PLUGS

- Single phase
  - 2 Hot legs
    - L1 L2
    - 1 Neutral
  - 1 Ground (3 Pin Plug has no ground)

Single PHASE WIRING



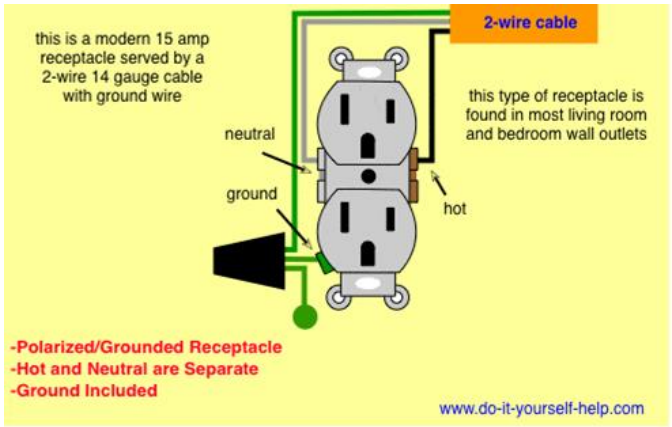
3 PHASE SIGNWAVE



AC SINGLE PHASE CONNECTORS

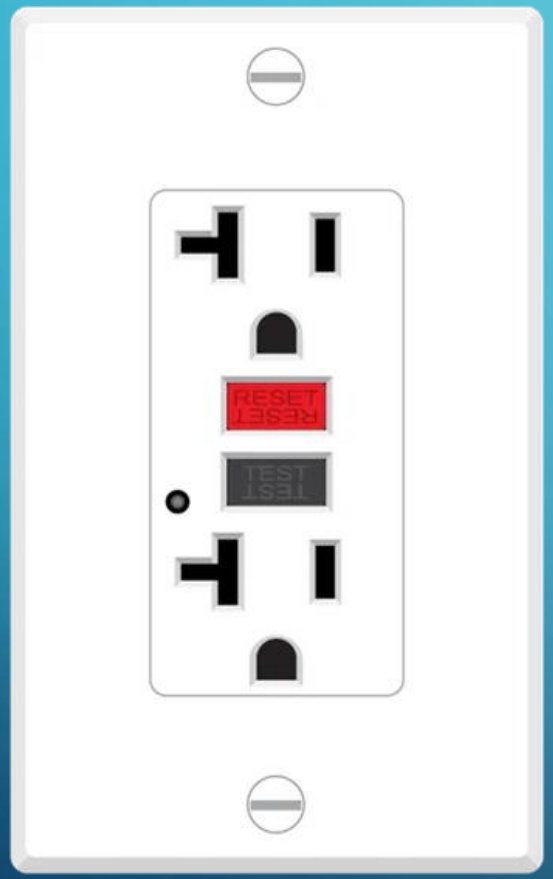
- Common 120v Connectors
  - Residential / IDF
    - Nema 5-15
    - Nema 5-20
    - L5-20
    - L5-30
- Common 208v Connectors
  - L6-20
  - L6-30

NEMA 15



- Standard house plug

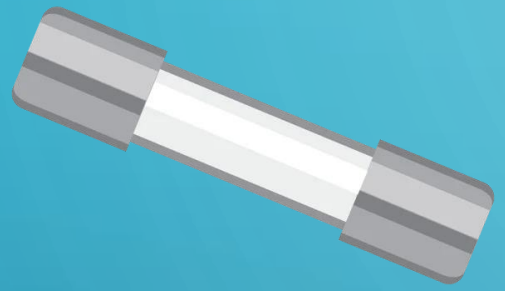
What is a GFCI

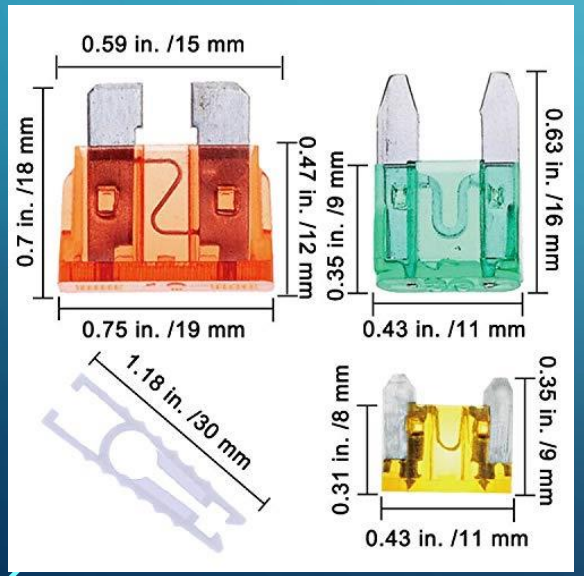


- A ground fault circuit interrupter (GFCI) is type of electrical circuit breaker designed to protect people from electrical shock.
- A GFCI quickly shuts off the circuit if any electrical current flows to any path other than the intended return conductor.

SCTE https://www.scte.org/information-page-index/back-to-basics/

What is a Fuse ?





- Fuses opens an electrical circuit when the electrical current exceeds a predetermined level.
- Fuses are used to protect electrical components from overheating
- Equipment potentially being destroyed or starting fires.
- “Burned out” fuses cannot be reset or repaired; they must be replaced.

https://www.scte.org/information-page-index/back-to-basics/

What is a Circuit Breaker ?

- A Circuit Breaker is similar to a Fuse
- It is an automatic electrical switch that disconnects power when the electrical current exceeds the specified value.
- It prevents electrical components from overheating due to excessive current.
- It is used to protect electrical components from overheating and potentially being destroyed or starting fires.
- Tripped Breakers can be reset.

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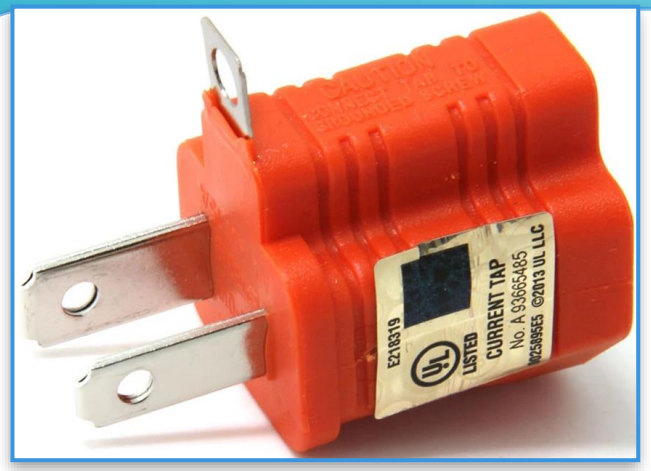


3 to 2 PRONG PLUG ADAPTER

Do not uses these for installation as these are not safe as there is no electrical ground connection at the outlet.

Note: can be used to troubleshoot ground loops

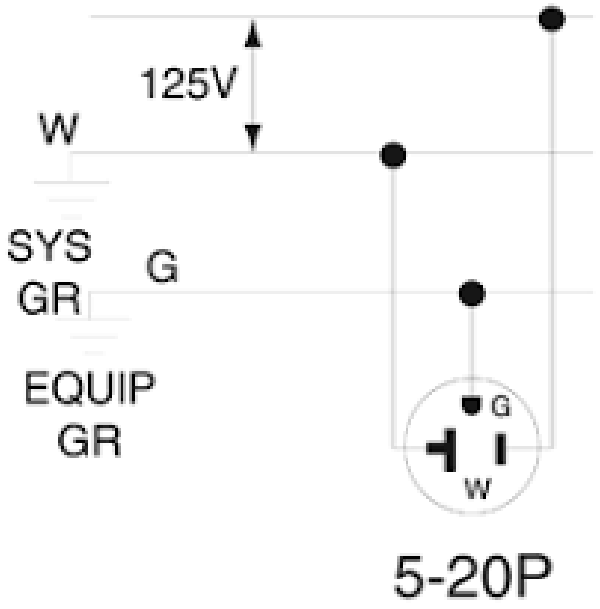
Tools

These are tools everyone should have in their kit

- Outlet checkers to verify the outlet is wired correctly
- MultiMeter to verify AC and DC voltage and ground on an outlet.
- Clamp Volt and Amp meter

POLARITY CHECKER

- You should have a polarity checker in you tool kit for safety reasons
- **Note they are usually only good for 120v**

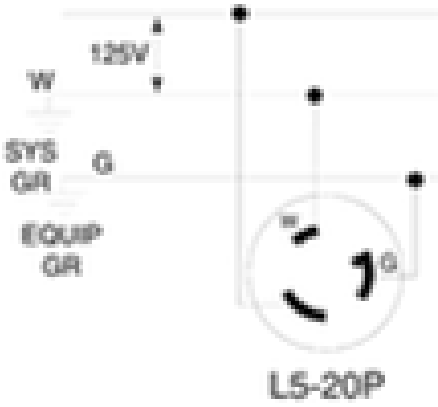


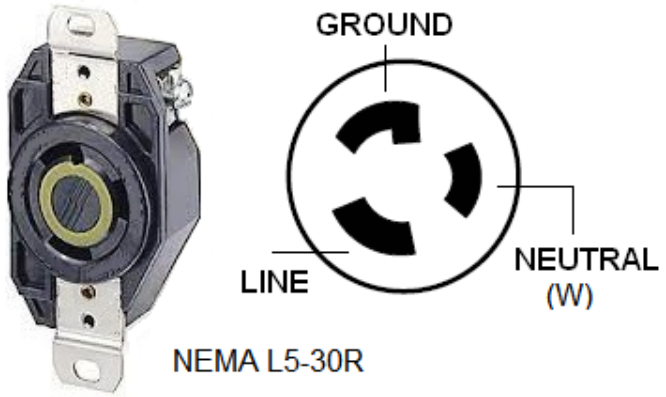
5-20P

NEMA 5-20R2P

- Standard 20 amp socket Wiring

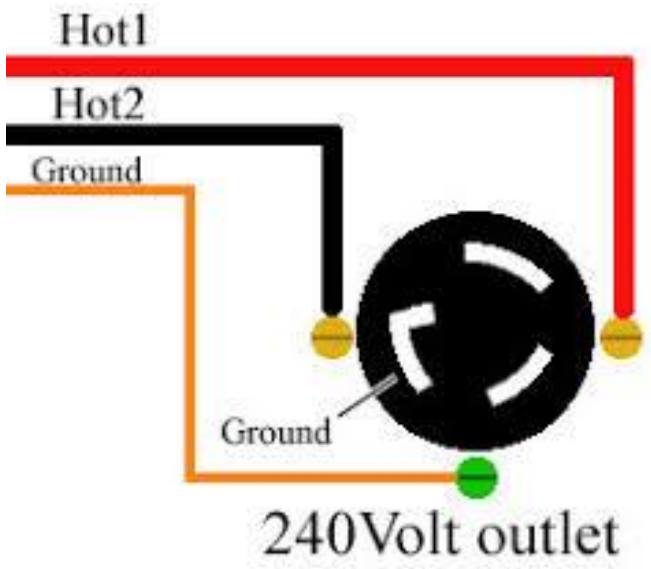
L5-20 AND L5-30





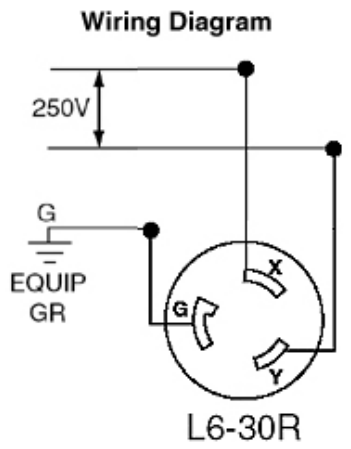
- **L5 is for 120v L6 is 208**
  - Used on Generators
  - Data Closets (IDF)
  - Power Distribution Unit (PDU)

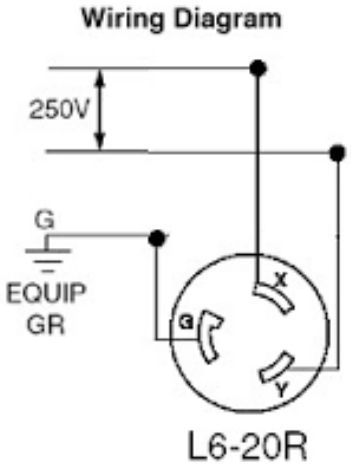
208 V L6-20 L6-30



- Hot
- Hot
- Ground

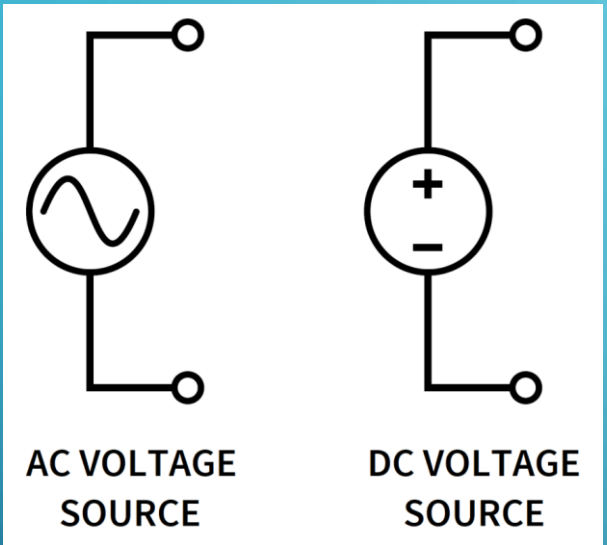
208 TWIST LOCK





- L6-20
- L6-30

What is a Volt



- AC or DC is the potential
- The pressure in a hose
- Measured in parallel with the source

- Hot and Neutral in AC
- + and - in DC

https://www.circuitbread.com/tutorials/voltage-and-current-sources

What is Amperage (AMP)

- The ampere (A), often referred to as an "amp," is the unit of electric current
- Named after French mathematician and physicist André-Marie Ampère.
- It can be thought of as the amount of **flow through a circuit**.
- Think of it as water flowing through a pipe
- Is measured in serial (inline)with the power source

https://www.scte.org/information-page-index/back-to-basics/

What is a Battery

- It stores DC power
- It provides power in portable situations
- Stabilizes the input power to a device.

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What is Amp-Hour

- An ampere-hour (or amp-hour) is a measure of electric charge and is often noted as A-h or Ah.
- It is measured by multiplying electrical current (amps) and time (hours).
- It is commonly used to specify the capacity of a battery by defining how much current the battery can deliver for how much time.
- The power capacity of a battery, measured in watt-hours (Wh), is determined by multiplying the amp-hour rating and the voltage of the battery.

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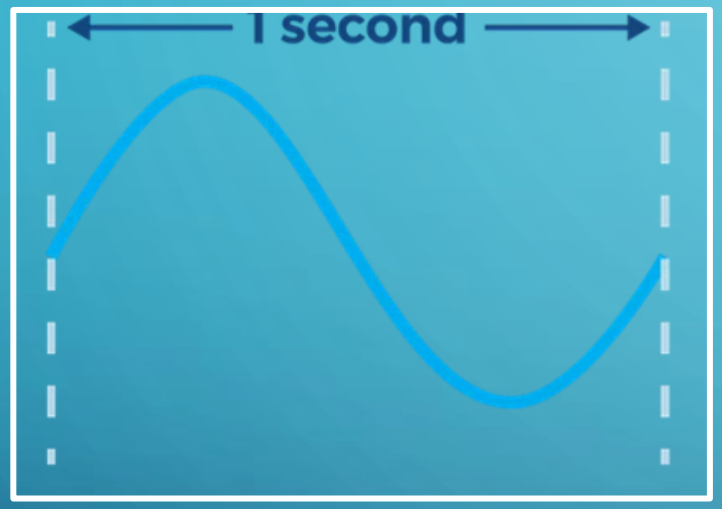
What is Frequency



- The number of times, typically per second, that a repetitive event happens.
- For an electromagnetic wave, frequency is the wave's rate of oscillation.
- Commonly measured or stated in units of hertz (Hz), which is the number of cycles per second.

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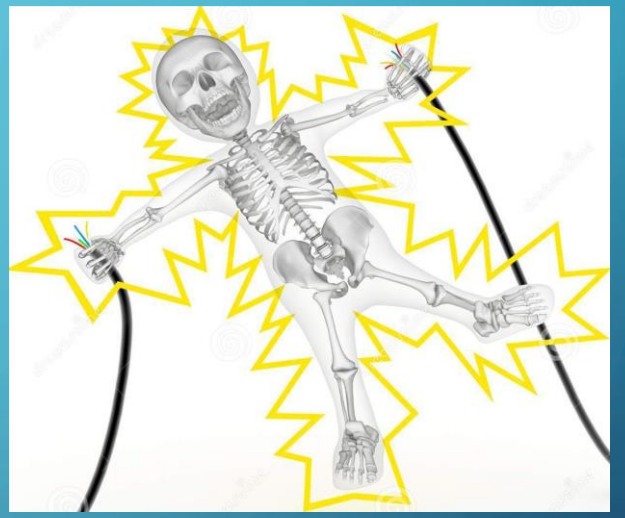
Grounding

- Why do we need a ground?
- Aren’t all grounds the same?

Grounding

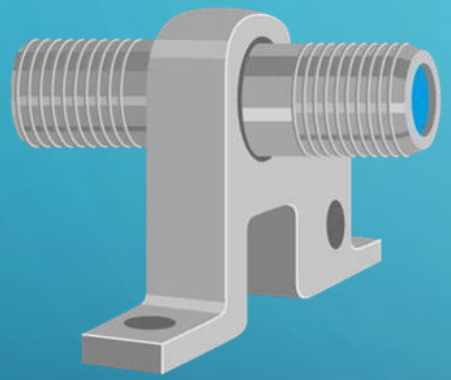


- Why do I need a ground?
  - For safety
- Are all grounds the same?
  - No
- What can or will happen if I don't have a ground?
  - electrical shock
  - overload and fires
  - communications errors
  - interference QRM
- Does this affect the operation of electronic equipment?
  - Yes, it can cause analog and digital communications errors
- What happened if there is no ground plug?
  - Notify customer they need to install the correct power
  - you can get shocked
  - communications errors as there is not a good ground reference

GROUNDING

- Types of Grounds
  - AC
    - Earth ground, chassis ground, or ground rod.
    - No more than .5v N-G NEC for clean power. Standard does go to 2 volts on 120v and 220v 4v . Any higher indicates an overloaded circuit.
  - DC
    - Often the black wire and negative lead on a battery. This is the other polarity of the power source. (-) -48 v is the opposite.
  - RF
    - Coax Shield
    - Ground plane or Counterpoise on an antenna
- All of these are different and behave differently

What is a Ground Block



- A ground block is the transition point between the network operator's service cable (the "drop") and the customer premises wiring
- It provides a connection point for a bonding conductor in accordance with requirements of the National Electrical Code or local building requirements.

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ttps://www.scte.org/information-page-index/back-to-basics/

DIFFERENCE AC, DC, AND RF GROUND

- The main difference between AC and DC ground is:
- **No current should flow into AC ground during normal operation**
- **While all current should flow into DC ground.**
- Current always needs a return path to its source. In a multiphase AC system (such as 3-phase supply used in industrial buildings), the current delivered by one phase returns through the other phases. In a single phase AC system (your 120V (in US) outlets), the current delivered by the hot conductor returns through neutral. It is important to note that AC ground and neutral are connected at your “Main” breaker box (and both to the earth), though only neutral should carry current.
- For DC systems, all current from supply rails returns to the source through DC ground.
- RF Ground is frequency dependent and is represented as low impedance (resistance) at the frequency of interest on the ground surface.

https://www.quora.com/

Power Strips

There are a few types of power strips

- Surge protectors
- Power Strips
- Power Distribution Unit (PDU)

What is the Difference??

Power Strips

There are a few types of power strips

- Surge protectors
- Power Strips
- Power Distribution Unit (PDU)

Warning:

Never plug surge strip into another surge strip

Do not use indoor power strips outdoors

Do not plug fans and heaters into power strips and surge protectors

This can damage sensitive electrical equipment.

Surge Strips

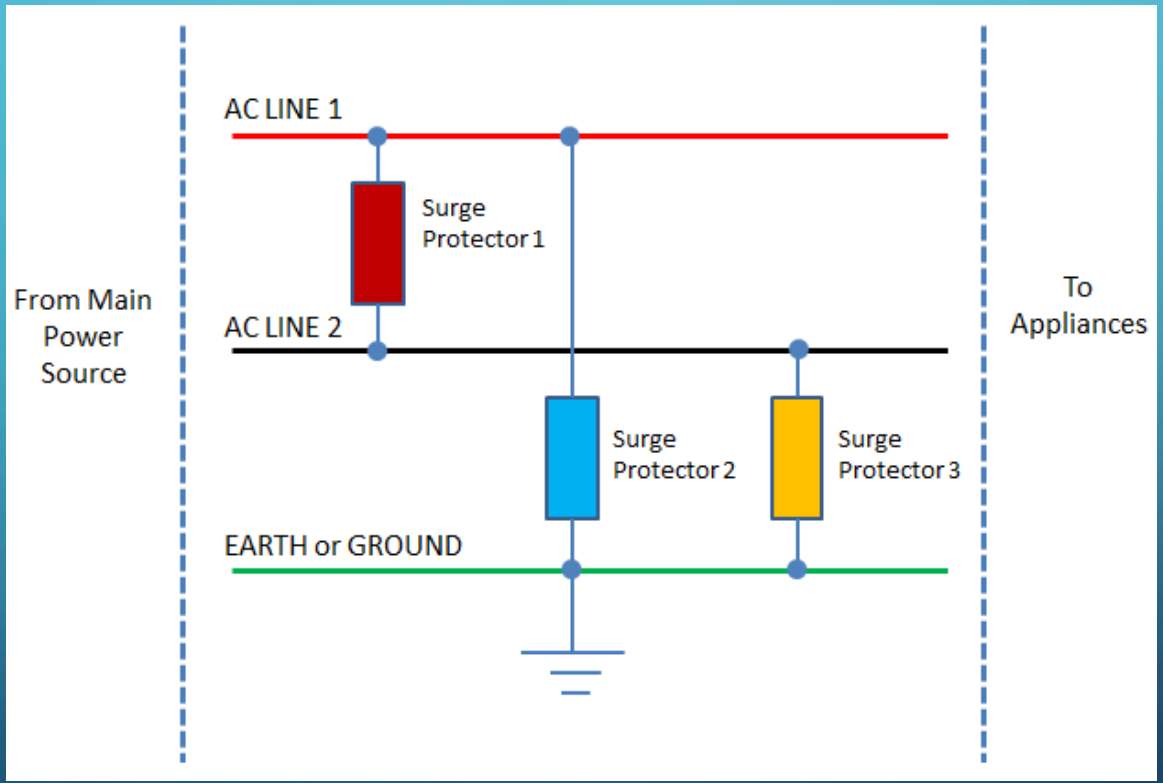
- Surge strips clamp the power spikes and dissipates the surge to Neutral and Ground

Caution: Do not plug power strips or other surge protectors into one surge protector and ensure the devices you have plugged in do not exceed the wattage capacity. An overloaded protector fails to stop a power surge that can ruin your electronics or even cause fires.

- Small UPS unit normally have built in Surge Protection.
- Only power strips should be plugged into a UPS for additional sockets

https://www.critterguard.org/blogs/articles/the-do-s-and-don-ts-of-using-surge-protectors

Diagram of a Surge Protector



What is a power inverter?

- A power inverter is an electronic circuit that converts direct current (DC) to alternating current (AC).
- Inexpensive power inverters create a square-wave AC voltage, which has high harmonic content and can overheat some electronic devices.
- Higher quality power inverters synthesize a sinewave AC voltage, which is very similar to the AC voltage provided by the electric utility.

https://www.scte.org/information-page-index/back-to-basics/

What is a power supply?

- A power supply provides electrical power to a device by converting incoming electricity to the voltage(s) required by that device.
- Power supplies must be carefully designed to provide the correct voltage(s) regardless of how much current is consumed by the device.
- They may supply AC or DC voltage.
- The power supply comes in different voltages and amperage.

Be careful to select the correct Voltage and Amp rating

https://www.scte.org/information-page-index/back-to-basics/

Part 2

UPS

DC Rectifies

Batteries

Battery Technology

QUESTIONS

Thank you for joining us

These slides are online in the Google Drive and on the Wiki page.