Basic Talk about Electricity

What is Electricity?

- Matter is made of particles called electrons and protons
- They both have a property called "charge"
- Protons are positively charged (+)
- Electrons are negatively charged (-)
- "Like charges repel // unlike charges attract"

Conductors and Insulators

A **conductor** is a material that has very low resistance to electricity. Copper and gold are good conductors. The cables in your studio are made of a mixture of metals, including copper. The more copper there is, the better the cable. But copper is expensive, so the more copper, the more costly the cable. Gold is often used on the ends of cables, where one cable is attached to another. The advantage of gold is that it is not only a good conductor, but that it also resists corrosion. So the contact between a gold-plated plug and the device it's connected to is a good one. Of course, gold is *very* expensive, so you'll never find gold cables, but you might find gold-plated plugs.

An **insulator** is a material that has very high resistance to electricity. Rubber and ceramic are good insulators. Insulators are used to protect you (the rubber sleeve around an extension cord) and to keep electronic components working properly (the ceramic shell around a transistor).

Most metals are good electrical conductors. Metals are also good conductors of heat. That's why we cook with metal pots, not wooden ones.

Electrical Current; Amperage; (Amps) I or A

Current is the flow of electrical energy through a circuit. You measure current in **Amperes (A or I)** and usually just call them Amps. It's about how much electricity is available. If you want to power a whole bunch of studio gear, you'll need lots of electricity.

Imagine a water hose. The wider the hose, the more water can run through it. A fire hose lets more water through than a garden hose. It's a question of how much water there is.

Electrical Pressure; Voltage; (Volts) V

Voltage is the pressure of electricity in a circuit. This pressure is measured in **Volts (V)**. The higher the voltage, the harder the electrons push through the circuit.

Voltage is like the water *pressure* through the garden hose. By increasing the pressure, you can turn a gentle stream of water into an intense spray. Even with very little water (current), you can still create a lot of pressure (voltage).

Electrical Power; (Watts) W

Power is the amount of work that can be done with the electricity. When we measure power, we use **Watts (W)**. Watts are the *rate* at which energy is converted from the electrical energy to some other form. For example, the conversion of electricity to heat energy (a stove), mechanical energy (a lawnmower blade), or sound energy (a guitar amp).

Calculating Electrical Power Requirements

If you know the amperage and voltage, you can calculate how many watts are generated. Or, if you know the wattage and the voltage, you can calculate how many amps are needed.

Amps x Volts = Watts (A x V = W)

Or you can also say

Watts ÷ Volts = Amps (W ÷ V = W)

Amps Volts	5A	10A	12A
1v	5w	10w	12w
50v	250w	500w	600w
120v	600w	1200w	1440w

Suppose that you want to know how much current a blow dryer needs. You know that the blow dryer is rated at 1200 watts. In a typical house, the AC outlets provide 120 volts. So a 1200 watt blow dryer needs 10 amps.

Watts ÷ Volts = Amps : 1200 watt ÷ 120 volts = ***10 amps***

Or if you don't like division, you can use multiplication:

Amp x Volts = Watts : ***10 amps*** *x 120 volts = 1200 watts*

Now, a typical circuit in your house is rated at 15 amps. If you run two hair dryers in at the same time, the total current needed would be 20 amps. You would blow the fuse,

Electrical Resistance; (Ohms) Ω

In electrical systems, the tendency to fight the flow of electricity is called **resistance**. Resistance is measured in **Ohms (R)**. The symbol for ohms is the last letter of the Greek alphabet, *omega*, or **Ω.**

It's a little like friction. It's harder to push a heavy box across a rough concrete floor than to slide it across a smooth vinyl floor. The burners of an electric stove are made from a resistant material. When you apply an electric current to the burner, it gets red hot.

Ohm's Law

Georg Ohm figured out that the current and the voltage in a circuit are related to its resistance. Just like with A x V = W, if you know two of the values, you can figure out the third one.

$$\mathbf{I = V \div R}$$

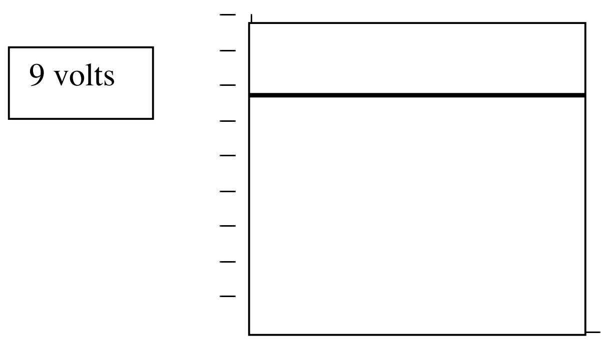
Normally, the resistance doesn't change. So if you increase the current, you'll increase the voltage by the same amount. If you double the current, you'll double the voltage. If you triple the current, you'll triple the voltage. This is a *proportional relationship*.

$$\mathbf{1 = 1 \div 1}$$
$$\mathbf{2 = 2 \div 1}$$
$$\mathbf{3 = 3 \div 1}$$

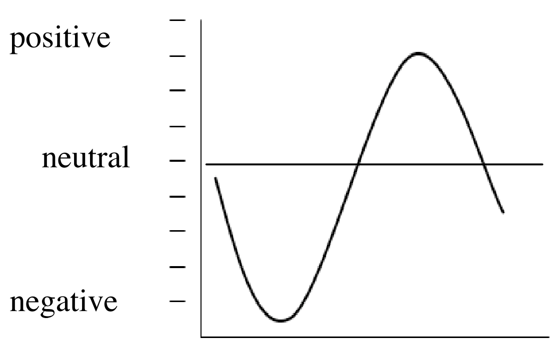
AC/DC

The difference between Direct Current (DC) and Alternating Current (AC) electricity is the way the energy travels in the wire.

- DC electricity is a unipolar flow of current through a wire. This flow of energy can be thought of as having a steady positive value. For example, a 9-volt battery produces a steady 9-volt current.



- AC electricity is a bipolar flow of current through a wire. The voltage flips back and forth from positive to negative to positive. This produces a waveform.



AC in North America runs at a frequency of 60 Hz. This means there are 60 complete cycles every second. Because AC is a bipolar waveform, it can actually be heard. If your stereo has a bad connection, you can sometimes hear that familiar deep hum. That's the sound of AC.

Circuits

In order to flow properly, electricity needs to complete a circuit. This means that it needs to start somewhere (perhaps at the outlet in the wall) and end up back at the same place.

If the electrical flow is complete, it is a **closed circuit**. For example, when you turn on a light switch you are closing the circuit.

If the electrical flow is broken, it is an **open circuit**. For example, when you turn off a light switch you are opening the circuit.

Series and Parallel

Imagine a guitar player who has a fuzz pedal and a wah-wah pedal. She plugs the guitar into the input of the fuzz pedal, the output of the fuzz into the input of the wah-wah pedal, and the output of the wah-wah into the input of her amplifier.

guitar ------ > fuzz ------> wah-wah ------> amplifier

We call this a **series circuit**. The word 'series' means that one thing follows another. A television series is a set of shows that are broadcast one after the other. In this case, her guitar sound will be fuzzed up first, then the fuzzy sound will be "wah-wah"ed.

Now, the guitar player is going to change her strategy. She splits the sound coming out of the guitar with some sort of 'Y' adaptor. One half of it goes to the fuzz, and the other half goes to the wah-wah. Then the fuzz and wah-wah are both connected to the amplifier.

guitar amplifier
----> fuzz ---->
----> wah-wah ---->

We call this a **parallel circuit**. In geometry, parallel lines are lines that travel in the same direction but are separate from each other. In this case, the guitarist really has two different sounds to work with, a pure fuzz sound, and a pure wah-wah sound.

Electromagnetic Fields

In a recording studio, there are transformers (the power supply in a computer) and AC power sources (like power bars). These things produce **electromagnetic fields** or **EMF**. It's like an invisible aura, floating around the object that produces it. EMF is a potential problem because they can cause hum and buzz. If you hold your electric guitar too close to a refrigerator, you might get a humming sound. Or if the instrument cables from your keyboard are too close to a power bar, you might hear a buzz.

The strength of the field is directly related to the strength of the electricity that's causing it. The stronger the current, the stronger the field. A 120V AC extension cord produces a much stronger field than an audio cable, which might be carrying just a volt or two.

The field strength is also related to the distance from the electrical source. As you move away from the source, the field gets weaker.

RF Interference

The air is filled with electromagnetic waves, from radio stations, TV stations, cell phones, etc. Audio equipment, especially cables, can behave like an antenna, picking up the radio waves or microwaves, and polluting your sound with them.

The way to deal with this is to have **shielding** in your equipment (lots of equipment already does), and to use **balanced** cables. Balanced cables use a special design to eliminate the RF interference that they accumulate.

Passive or Active

- Electric devices are grouped into *Passive* devices or *Active* devices.
- A Passive Device **does not** control the flow of electricity. Examples are a light bulb, a dynamic microphone, or a passive guitar pickup.
- An Active Device **does** control the flow of electricity. Examples are a synthesizer, a condenser microphone, or a Mixer.