Basics

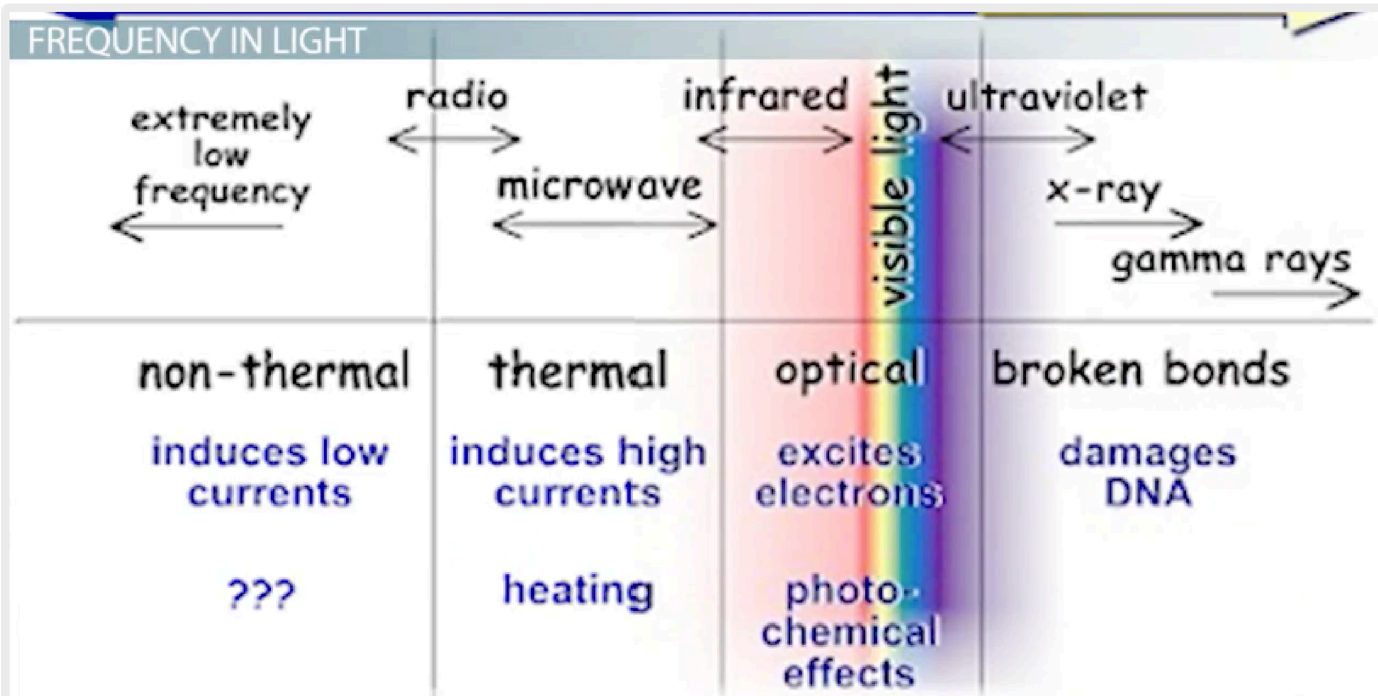
Wave

a vibration that carries energy with it

Frequency

frequency, in physics, **the number of waves that pass a fixed point in unit time**; also, the number of cycles or vibrations undergone during one unit of time by a body in periodic motion. Frequency is **the rate at which current changes direction per second**. Measured in hertz or cycles per a second.

Angular frequency is measured in rads per a second



Current - rate of flow of charge.

Voltage - work done per a coulomb of charge.

Resistors

A resistor is **a passive two-terminal electrical component that implements electrical resistance as a circuit element**. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

Capacitors

component which has the ability or “capacity” to store energy in the form of an electrical charge producing a potential difference (*Static Voltage*) across its plates, much like a small rechargeable battery.

Insulators

Materials that do not allow electricity to pass through them are called electrical insulators. Examples of these materials include plastic, rubber, wood, and glass. Air is also an insulator. Most electrical objects are made using insulators to keep them safe. Plugs, for example, have plastic cases.

Power

Power (P) is measured in **watts (W).** Power is the rate at which energy is transferred. One watt is equal to one joule per second. A source of energy such as a voltage will produce or deliver power while the connected load absorbs it. Light bulbs and heaters for example, absorb electrical power and convert it into either heat, or light, or both. The higher their value or rating in watts the more electrical power they are likely to consume. P=IV.

Ohms Law

Ohm's law states that **the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperature, remain constant**.
V=IR

Series Circuit

The total resistance of any series circuit is equal to the sum of the individual resistances. This should make intuitive sense: the more resistors in series that the current must flow through, the more difficult it will be for the current to flow. The current through the resistors are the same. Increase the total resistance by connecting in series. The total voltage in a series circuit is **equal to the sum of all the individual voltage drops in the circuit**. Increase the voltage by adding batteries in series.

Parallel Circuit

Each parallel resistor added to a circuit reduces the total equivalent resistance.

Rtotal $= \frac{1}{R_1^{-1}+R_2^{-1}+R_3^{-1}}$. Decrease the total resistance by connecting in parallel.

The voltage through the resistors are the same. Identical batteries in a parallel circuit will not affect the voltage. However the current will increase.

Incandescent

An object that glowed at a high temperature (such as a piece of coal) was incandescent. By the mid-1800s, the incandescent lamp—aka the lightbulb—had been invented; it contains a filament which gives off light when heated by an electric current.

LED

a semiconductor device that emits light when an electric current flows through it. LED lamps are significantly more **energy-efficient (https://en.wikipedia.org/wiki/Electrical_efficiency)** than equivalent **incandescent lamps (https://en.wikipedia.org/wiki/Incandescent_light_bulb)**. If put too much current through an LED, can burn out.

Potentiometer

A potentiometer is **a manually adjustable variable resistor with 3 terminals**.

Conventional Current

Flows from high potential to low potential. Current is **the rate at which charge crosses a point on a circuit**. A high current is the result of several coulombs of charge crossing over a cross section of a wire on a circuit.

Electron Current

Flows from low potential to high potential.

Resistance

Resists the flow of current e.g a long wire or a thin wire has high resistance.

Direct Current

"unidirectional" flow of current; current only flows in one direction. Voltage and current can vary over time so long as the direction of flow does not change. To simplify things, we will assume that voltage is a constant. For example, we assume that a AA battery provides 1.5V. DC has a constant voltage over time.

Alternating Current

describes the flow of charge that changes direction periodically. As a result, the voltage level also reverses along with the current. AC is used to deliver power to houses, office buildings, etc. A loop of wire is spun inside of a magnetic field, which induces a current along the wire. The rotation of the wire can come from any number of means: a wind turbine, a steam turbine, flowing water, and so on.

Opened Circuit

a circuit where the path has been interrupted or "opened" at some point so that current will not flow.

Short Circuit

electrical circuit that allows a current to travel along an unintended path with no or very low electrical impedance. The voltage is zero in short circuits.

Reactance in an Inductor of a coil

depends on the frequency of the applied voltage as reactance is directly proportional to frequency $X_L=2\pi fL$. f is frequency, L is the inductance. X_L is the reactance.

Reactance in a Capacitor

X_C =. $\frac{1}{2\pi f C}$

LCR circuits

A circuit containing L,C and R at a certain frequency can make L and C (or at least their electrical effects) completely disappear! The LCR circuit can appear to be just a capacitor, just an inductor, or solely a resistor! Not only that, the series LCR circuit can magnify voltage, so the voltages across individual components within the circuit, can actually be much larger than the external voltage supplying the circuit.

Active filters

contain amplifying devices to increase signal strength while passive do not contain amplifying devices to strengthen the signal.

Passive Filter

In low frequency applications (up to 100kHz), passive filters are generally constructed using simple RC (Resistor-Capacitor) networks, while higher frequency filters (above 100kHz) are usually made from RLC (Resistor-Inductor-Capacitor) components.

Impedance

Impedance is a vector (two-dimensional)quantity consisting of two independent scalar (one-dimensional) phenomena: resistance and reactance. Z, is an expression of the opposition that an electronic component, circuit, or system offers to alternating and/or direct electric current

Capacitive reactance

the reactance of a capacitor varies inversely with frequency. At low frequencies the capacitive reactance, (X_C) of the capacitor will be very large compared to the resistive value of the resistor, R. This means that the voltage potential, V_C across the capacitor will be much larger than the voltage drop, V_R developed across the resistor. When Voltage is high the, current is zero- the capacitor is trying to drop the current to oppose the change in voltage. Current and voltage are out of phase by 90 degrees. Analogy - Force (sine curve) / Water flow (cosine curve)

Resistor reactance

value of the resistor remains constant as the frequency changes.

Complex Capacitor Impedance

Complex impedance exists because the electrons in the form of an electrical charge on the capacitor plates, appear to pass from one plate to the other more rapidly with respect to the varying frequency.

Charge

Number of electrons x charge of each electron (e)

Dielectric

used in capacitors to **influence the property of capacitance**. When voltage is applied across the capacitor plates, the dielectric material blocks the flow of current through the material.

Kirchhoff's voltage law

the voltage around a loop *equals the sum of every voltage drop in the same loop for any closed network and equals zero*.

Impedance

extends the concept of **resistance** (https://en.wikipedia.org/wiki/Electrical_resistance) to alternating current (AC) circuits, and possesses both magnitude and **phase**

(https://en.wikipedia.org/wiki/Phase_(waves)) , unlike resistance, which has only magnitude.
$Z = R + X_L + X_C$. Impedance is a combination of the resistance from the resistor, inductor and capacitor. This is resistance to electron flow. The impedance of inductors increases as frequency increases; $Z_L = j\omega L$, the impedance of capacitors decreases as frequency increases $Z_c = \frac{1}{j\omega C}$

Resistance

Opposite to the flow of current. Voltage and Current are in phase for AC circuits in a resistor.

Inductor- prohibit change in current. When current is at its peak, the inductor will drop the drop voltage. When current is zero, the voltage will be a maximum.

Analogy - Force (sine curve) / Water flow (negative cosine curve)

Amplifier

- increases the voltage of the imput signal without distorting it.

Op-Amplifier - *any circuit that puts out a higher voltage than the input voltage*. Op-amp can only amplify the voltage up to the level of its power supply. When reaches this level it is referred as saturation.

Can do calculations such as different between inputs, addition, also scalar multiply an input, find the derivative and the integral of the input.

db/decade

how far the amplitude drops when the frequency increases tenfold.

A voltage buffer amplifier

transform a voltage signal with high **output impedance** (https://en.wikipedia.org/wiki/Output_impedance) from a first circuit into an identical voltage with low impedance for a second circuit.

Unity gain amplifier

amplifier with a gain of 1. Even though a gain of 1 doesn't give any voltage amplification, a buffer is extremely useful because it prevents one stage's input impedance from loading the prior stage's output impedance, which causes undesirable loss of signal transfer.

Gain-dB

The power gain of an amplifier is the ratio of output power to input power. For example, if the output power is 1000000 watts and the input power is 100 watts, then the power gain A_p is 1000000/100= 10000.

Power Gain in DB = $10 \log_{10} \frac{P_{out}}{P_{in}}$

Power Gain in DB$= 10 log_{10} 10000$

Power Gain in DB $= 10 log_{10} 10^4$

Power Gain in DB $= 40$

Voltage Gain in DB

$$V = \frac{P}{I} = \frac{P}{\frac{V}{R}}$$

$$P = \frac{V^2}{R}$$

$$10 log_{10} \frac{\frac{V_{out}^2}{R_{out}}}{\frac{V_{in}^2}{R_{in}}}$$

$$R_{out} = R_{in}$$

$$10log_{10}\frac{V_{out}^2}{V_{in}^2}$$

$$20log_{10}\frac{V_{out}}{V_{in}}$$

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