

Electronics for artists

induction, capacitance, resistance

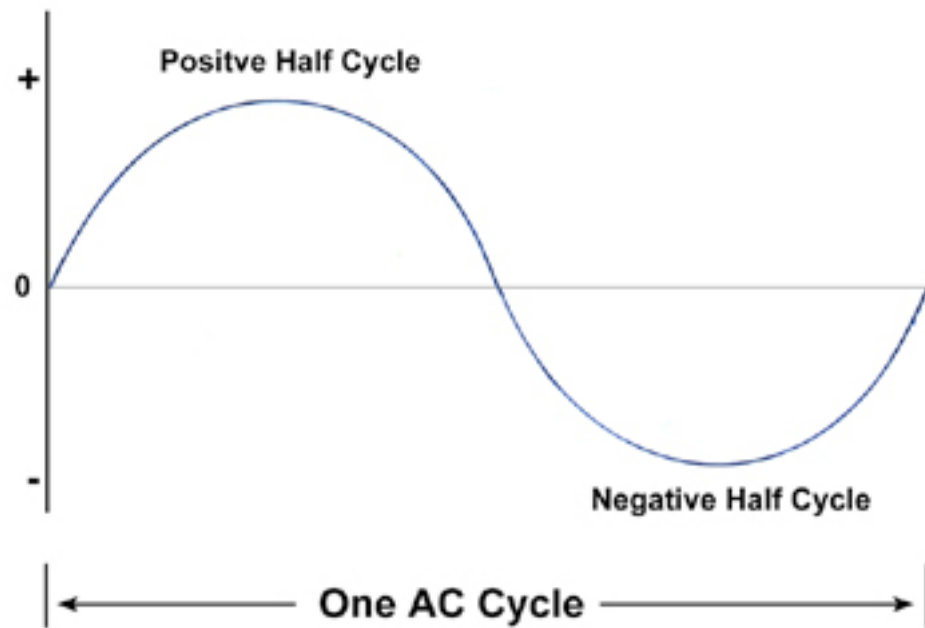
Goals

- AC
- electromagnetism
- induction
- capacitance

Transformations

- we can use current to create magnetic fields, and magnetic fields to create current
- capacitor turns electrical energy into a charge field
- inductors turn electrical energy into a magnetic field
- resistors turn electrical energy into heat

AC



AC

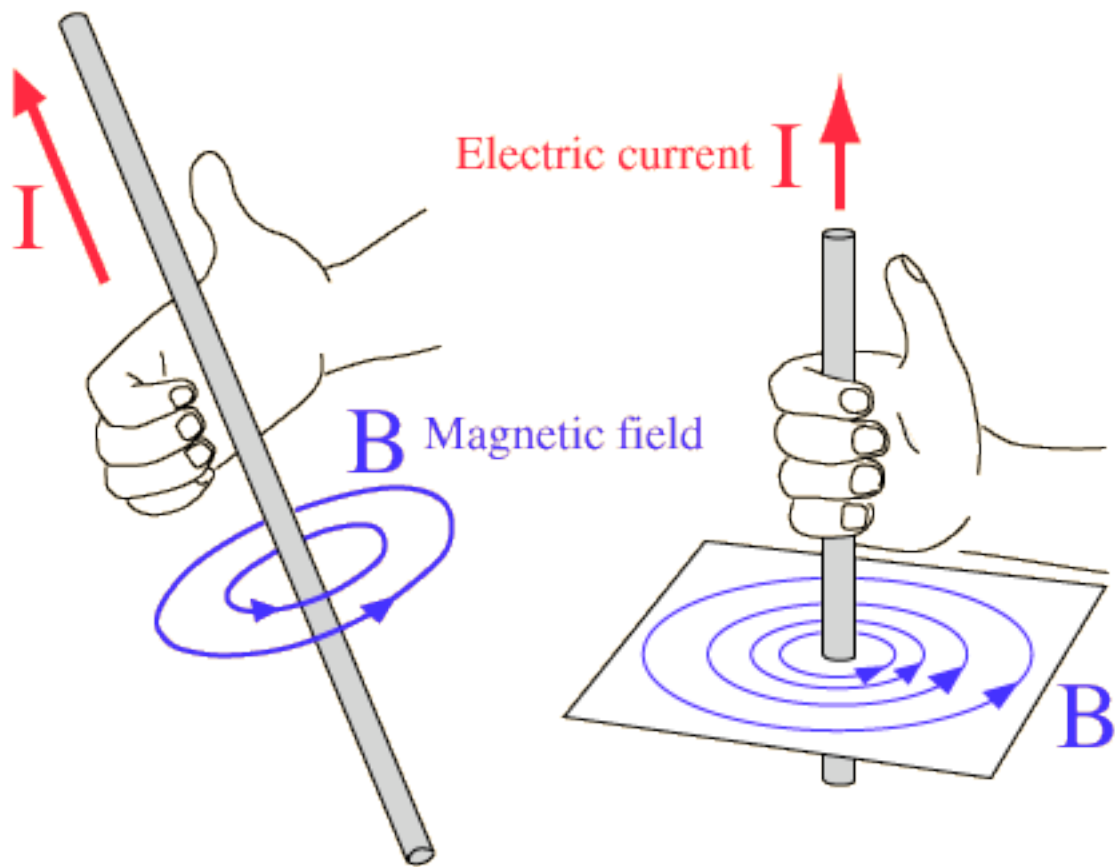
- AC Voltage alternates from positive to negative. Sinusoidally!
- AC Voltages are specified with a value equal to the DC voltage capable of doing the same work.
- The specified voltage ends up being about 0.707 the peak voltage
- Household voltage is specified at 120 VAC, meaning peak voltage is about 168v

AC and filtering

- An AC voltage can have a DC component and vice versa. Usually we try and void this or filter it out.
- How do we filter AC from DC? Stay tuned to find out!

electromagnetism

- magnetic field exists whenever current is flowing
- magnetic field is at a right angle to current flow
- magnetic field strength is proportional to current
- moving a conductor through a magnetic field generates a current flow



Demonstration

- which has little pedagogical value
- totally awesome

Inductors

- By coiling wire we increase the strength of the magnetic field induced by current
- A large inductor functions like an electromagnet
- The strength of the magnetic field depends on number of coil turns, coil size, coil spacing, winding arrangement, core material and shape of inductor.
- Induction is measured in Henrys

Inductor



Inductor

- Converts electrical energy into a magnetic field
- Unlike a resistor which dissipates energy, inductors store energy
- Resists change in current flow - why?
- likes to pass dc, doesnt like to pass ac

how do inductors work

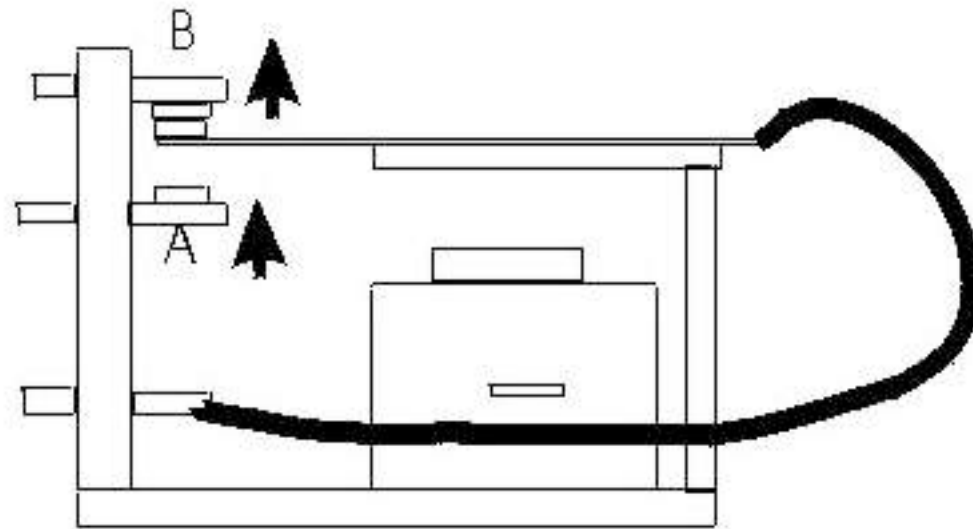
- current begins to flow into inductor - electrical energy turns into magnetic field
- as current increases field increases pulling energy away from the circuit
- as current stabilizes, field stabilizes - no more effect on current
- as current decreases, energy in field is released

Some uses for inductors

- solenoid
- electromagnet
- relay
- filters

Relay

- 1) Switch operated by an electromagnet.
- 2) Control signal is electrically isolated from switched current.
- 3) Relatively slow and electrically noisy.
- 4) Can pass oodles of AC or DC current.
- 5) Generates unfriendly voltage spike when magnetic field in coil collapses.

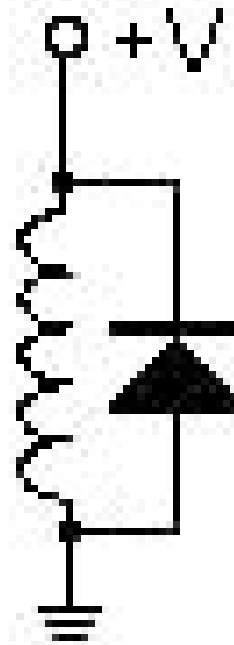


Relay Sequencing open frame relay

Relay and Solenoid Demo

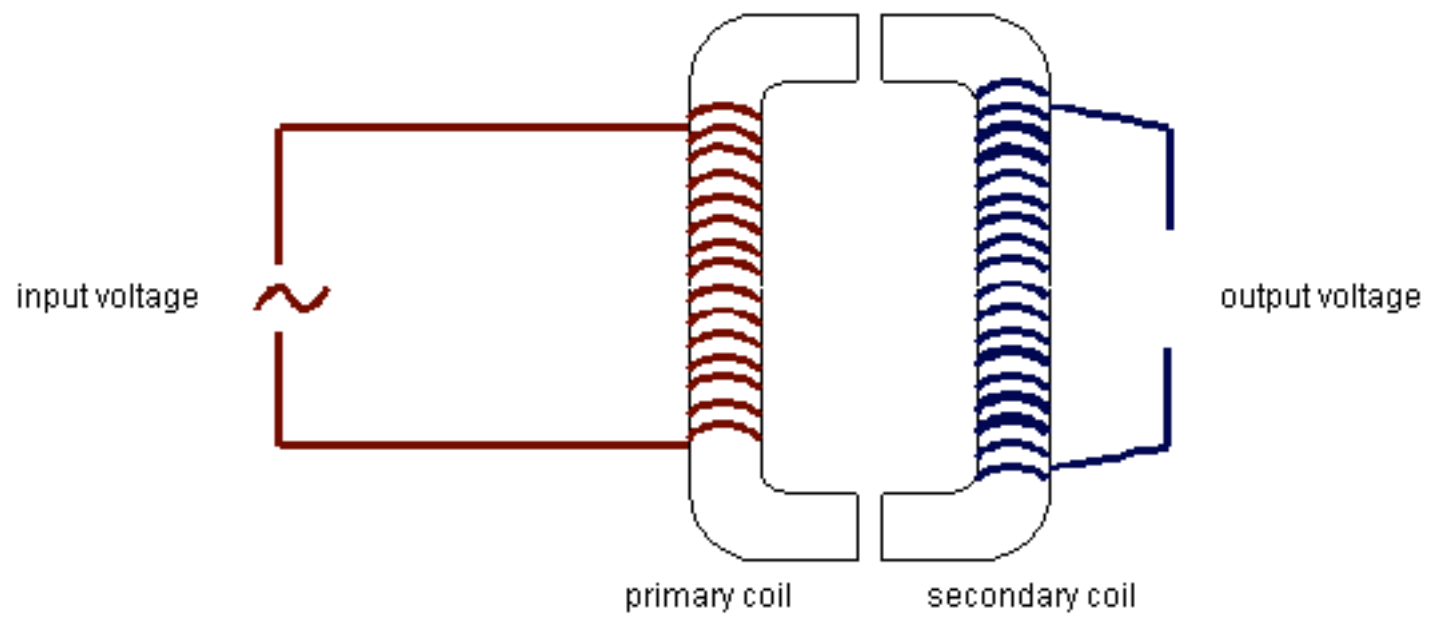
snubbing spikes

Relay
Coil



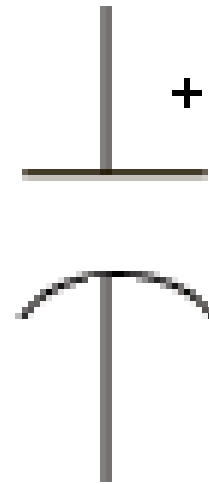
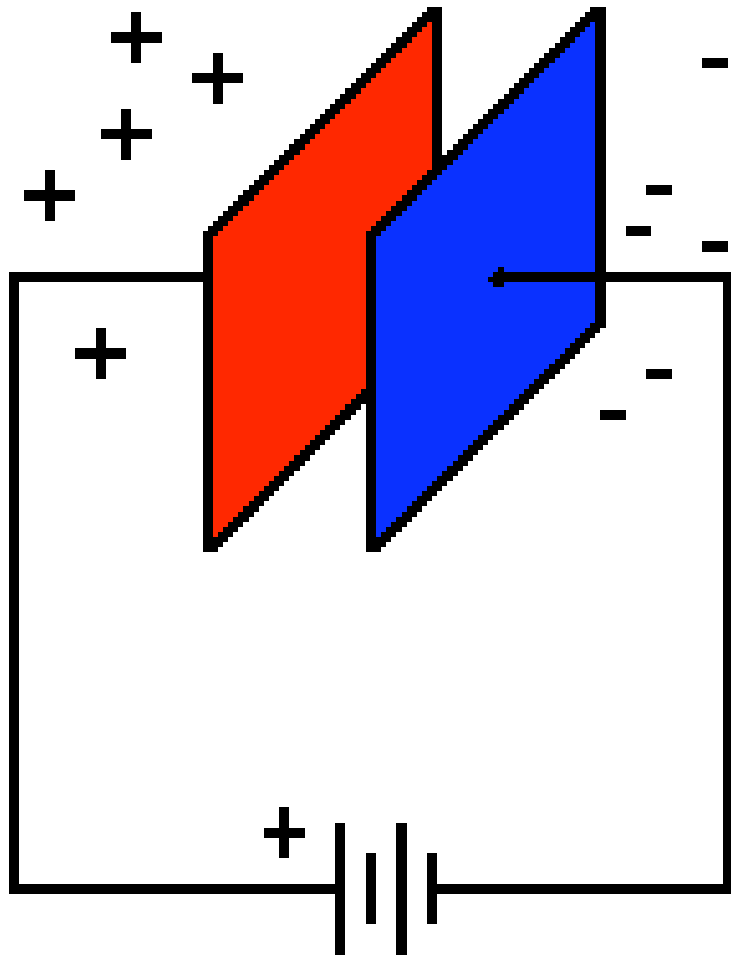
transformer

- 1) Four terminal device which turns ac input voltage into a higher or lower output voltage.
- 2) Transformers consist of two coils called primary and secondary sharing a common iron core.
- 3) Ratio of turns between primary and secondary coil determines step up/step down value.
- 4) Power ($V \cdot I$) is the same in the primary and secondary coil.
- 5) Stepping down voltage increasing current. Stepping up voltage decreases current.
- 5) Uses - Isolation, Power Conversion, Impedance Matching.



Capacitors

- two metal plates separated by a nonconductive material (dielectric)
- when voltage potential is connected to plates, positive charge is “pulled” to one plate and “pushed” from the other
- dielectric keeps charge from jumping from one plate to another.
- can store and release electric charge
- charge is held when disconnected from power supply



Capacitance

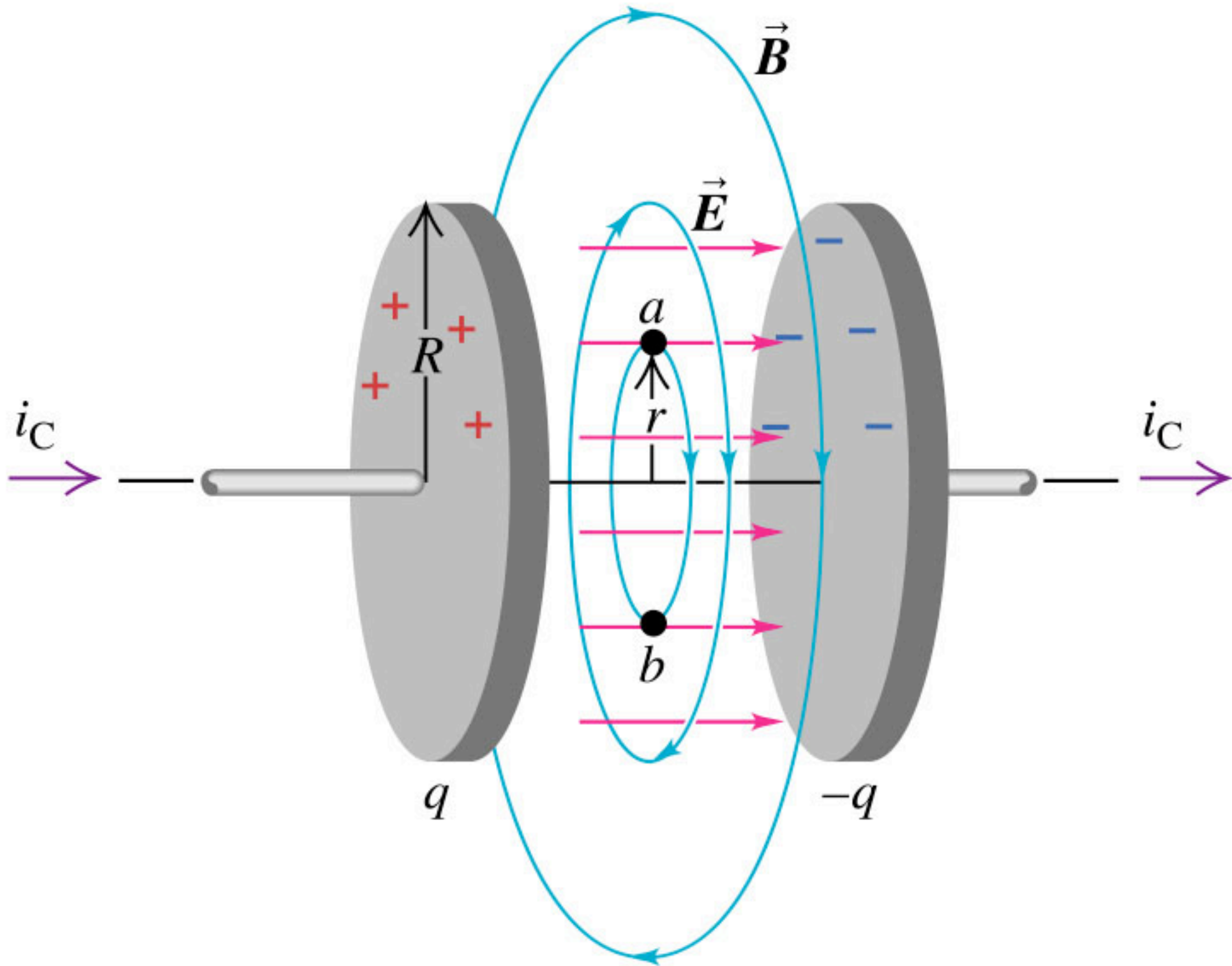
- Converts electrical energy into a charge field
- Resists static current flow.
- likes to pass ac, doesn't like to pass dc

displacement current

Changing magnetic field across plates induces a current across terminals of capacitor.

Capacitors can pass decreasing amounts of DC while charging. Once charged they block DC.

Opposite to inductors, capacitors like to pass AC (displacement current) and don't like to pass DC.



Farads

- amount of capacitive charge is measured in Farads
- 1 Farad is equal to 1 amp of current at 1 volt for 1 second
- 1 Farad is a lot of charge. Capacitors we work with are typically measured in Micro Farads (μF)

Lightening is a giant capacitive charge discharging.

Examples - camera flash, lasers.

Common uses - decoupling noise, smoothing power supplies, timing.

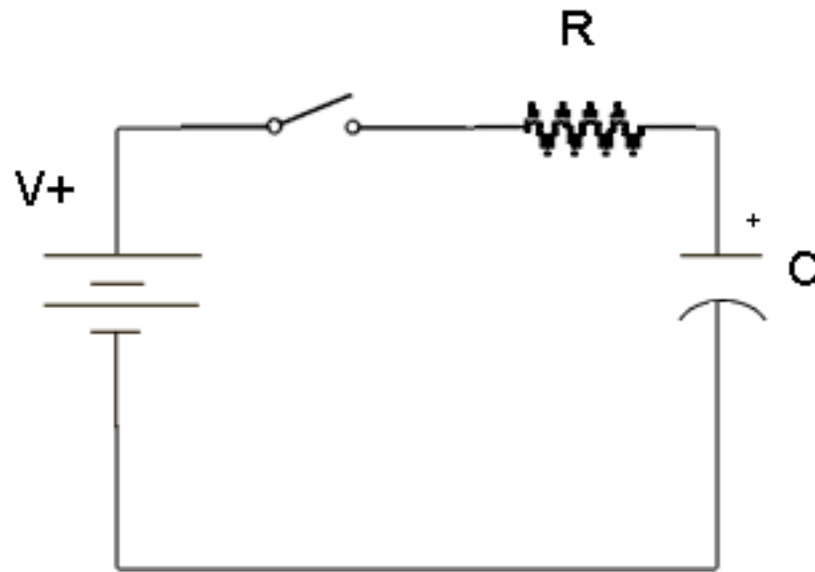
Capacitor Applications

- lasers
- camera flash
- timing
- decoupling noise
- smoothing power supplies

RC Time

- 1) Capacitors take time to charge and discharge, according to the amount of current.
- 2) We can control the charge/discharge time of capacitors using resistors.
- 3) Charge time (to 63.2% of supply voltage) and discharge time (to 36.8% of supply voltage) is nicely equal to $R \cdot C$. Time is in seconds.
- 4) RC Time allows us to control the rate that things happen in circuits, which turns out to be very useful.

RC Time



Capacitor types

1) Capacitors can be used to control timing, filtering, and smoothing out power supplies.

2) Three major types of capacitors are ceramic, electrolytic, and tantalum

Ceramic

Ceramic capacitors are small in size and value, ranging from a few Pico Farads to 1 μF .

Not polarized, so either end can go to ground. Value is given by a mystical code somewhat like that of resistors.



Electrolytic

Electrolytic capacitors look like small cylinders and range in value from 1 μF to several Farads.

Very inaccurate and change in value as the electrolytic ages. Polarized, cathode must go to ground. Cathode is marked with a minus sign on case. Value is usually written on case.



Tantalum

Tantalum capacitors are similar in size to ceramic but can hold more charge, up to several hundred μF .

Accurate and stable, but relatively expensive.

Usually Polarized, anode is marked with a plus sign.



Capacitor Demo

Capacitor lab

