Georg Simon Ohm

16 Mar 1789 – 6 July 1854

$V = IR$

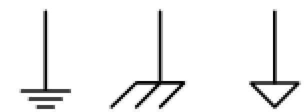
$I = V / R$

$R = V / I$

Dictionary

- V = Potential Difference (Volts) – electromotive force (analogous to pressure in a mechanical system)
- “Ground” is for Potatoes and Carrots

  Circuits have References



- I = Current (Amps) – 1 Amp = 6.24 x 10^18 charge carriers past a fixed point each second (analogous to flow volume)
- R = Resistance (Ohms Ω) – Ratio of voltage to current (no energy storage)
- Z = Impedance (Ohms Ω) – Ratio of voltage to current (includes energy storage, superset of R, Z = R + jX)
- P = Power (Watts) = V * I = I^2 * R

  (746 Watts = 1 Horsepower)

Building Blocks

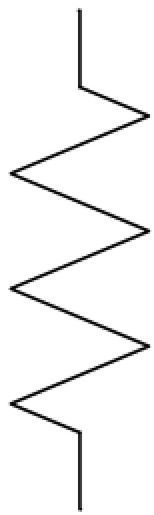
Passives

- Resistors (R ohms) – consume energy
- Capacitors (C Farads) – store energy as electric charge
- Inductors (L Henries) – store energy as magnetic fields
  - (transformers are magnetically linked inductors
  - ferrite bead is functionally an inductor & resistor)
- LED – Light Emitting Diode

Actives (everything else)

- Tubes, Transistors, SCR’s, Triacs, etc.

Ideal Resistor



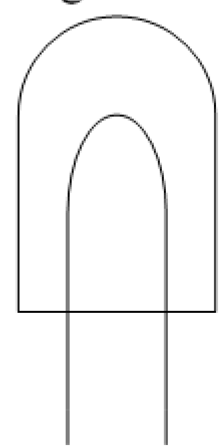
Value = mohms, ohms, kohms, Mohms, etc.
Power Handling = $^{1}/_{10}$ W, ¼ Watt, 1 Watt, 10 Watts, etc.
Package = Pin thru Hole (PTH), and Surface Mount (SMT) (0402, 0603, 0805, 1210, etc.)
Chemistry = carbon, metal film, etc.

10K Ω

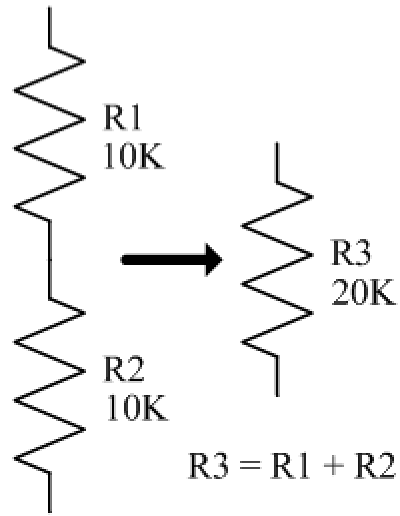
Ex.

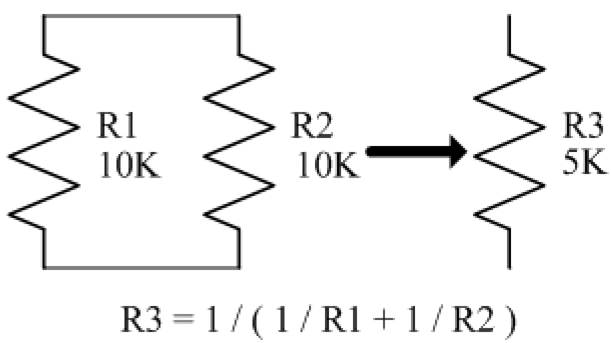
Given → V = 120 Vac
Given → P = 60 Watts
Calc → I = ½ Amp
Calc → R = 240 Ω

Incandescent Light Bulb



Multiple Resistors

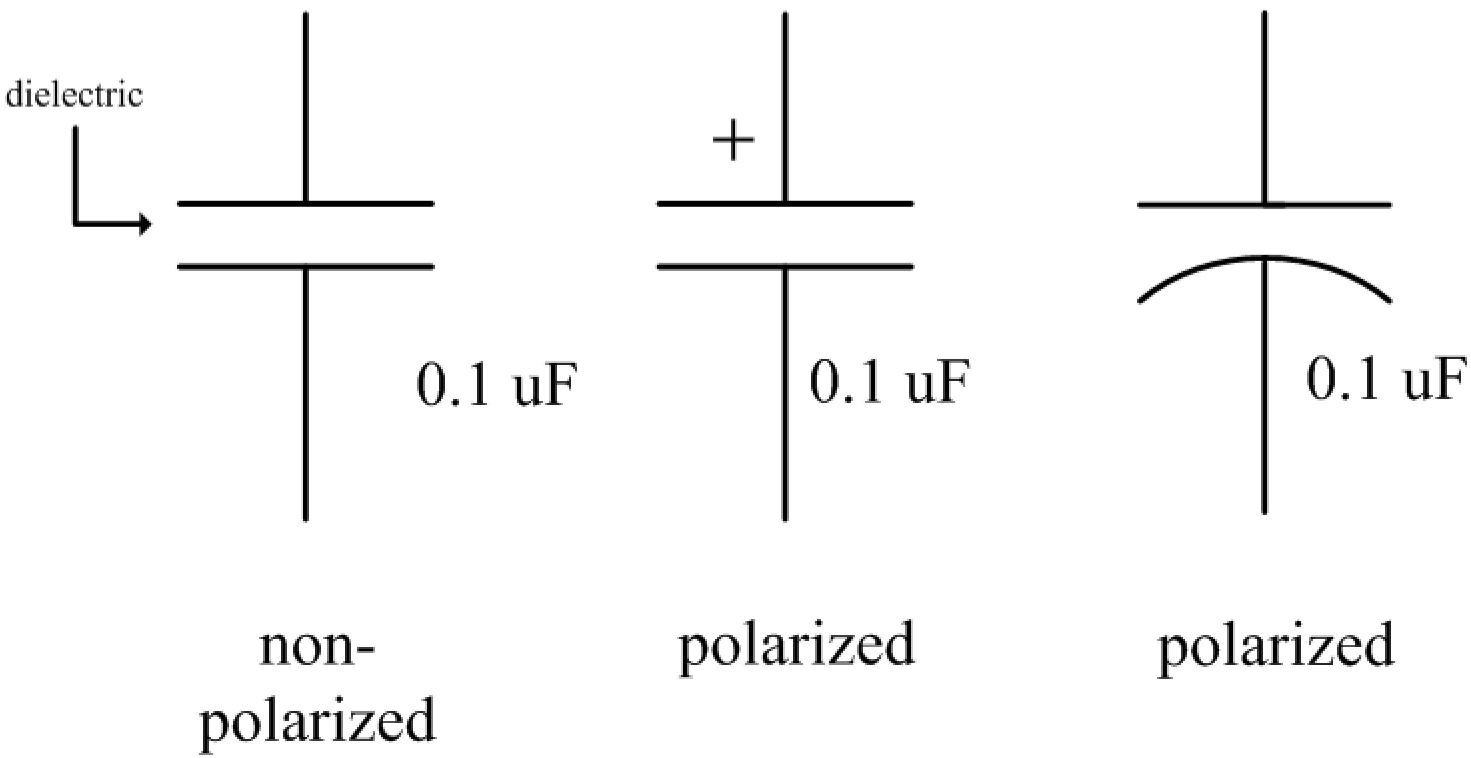




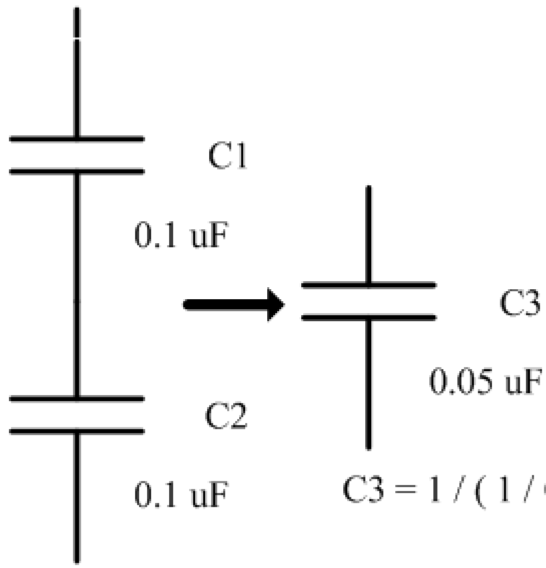
Ideal Capacitor

Value = ufarads, mfarads, farads, etc.
Voltage Rating
Package = Pin thru Hole (PTH) (radial, axial, disc, etc.)
and Surface Mount (SMT) (0402, 0603, 0805, 1210, etc.)

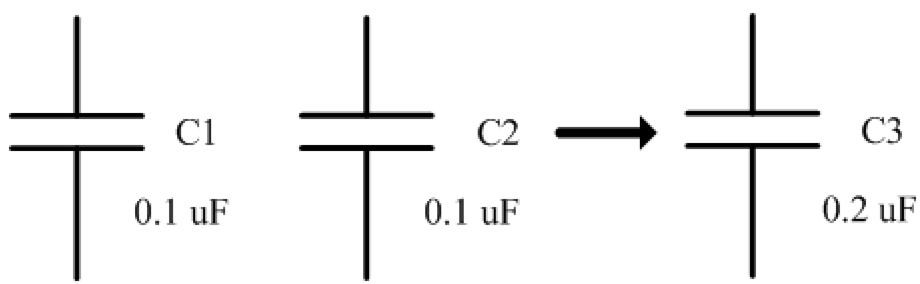
Chemistry = electrolytic, tantalum, ceramic, etc.



Multiple Capacitors

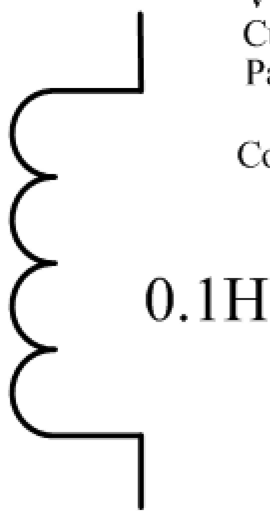


$C3 = 1 / (1 / C1 + 1 / C2)$



$C3 = C1 + C2$

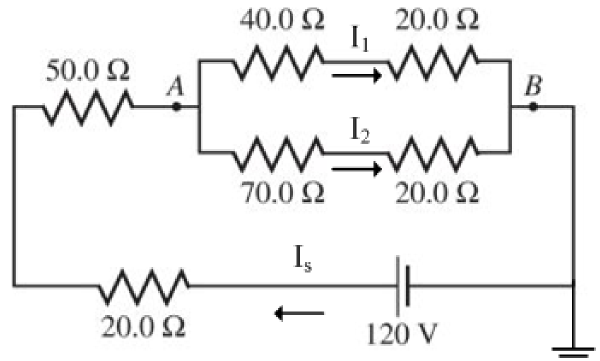
Ideal Inductor

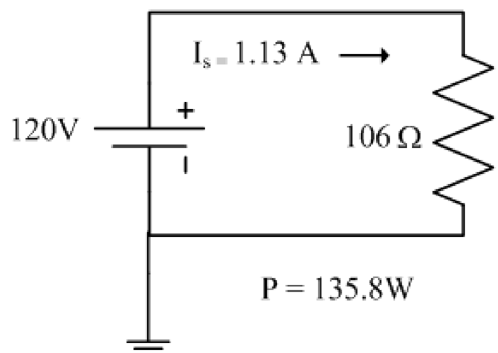


Value = mhenrys, uhenrys, etc.
Current Rating = 100 mA, 1A, etc.
Package = Pin thru Hole (PTH), and Surface Mount (SMT) (0402, 0603, 0805, 1210, etc.)
Core = air, iron, etc.

Inductors combine in same way as resistors:
Series add, parallel add as reciprocals

Resistive Circuit





$20 + 50 + (40 + 20) \| 70 + 20)$
$20 + 50 + 60 \| 90,\ 1 / (1 / 60 + 1 / 90) = 36$
$20 + 50 + 36$

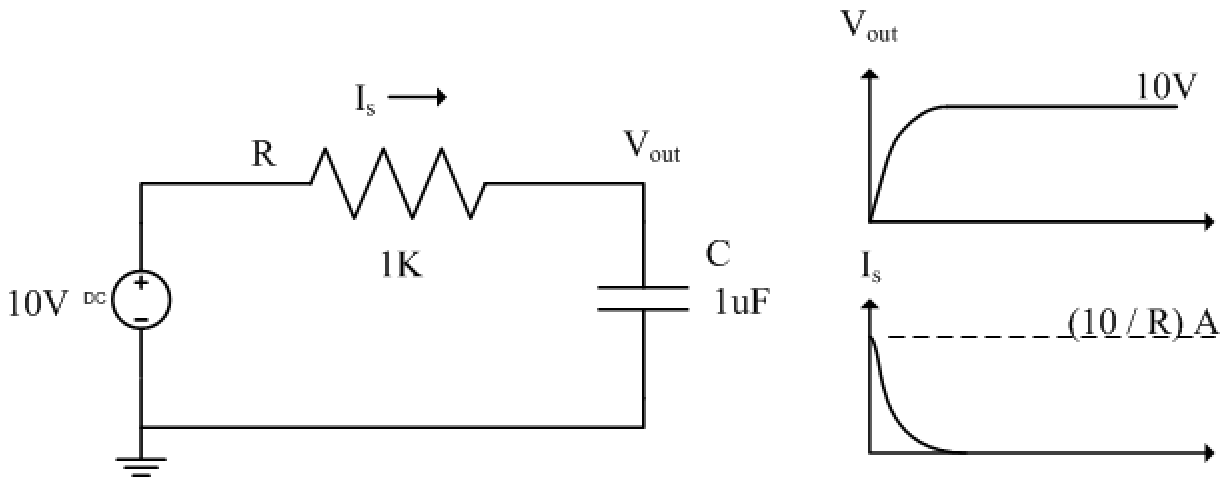
P = 135.8W

$I_s = I_1 + I_2 = 1.13$ A
$V_{AB} = I_1 * 60 = I_2 * 90,\ I_1 = 1.5 * I_2$
$I_s = 1.5 * I_2 + I_2 = 1.13$ A

$I_2 = 0.452$ A = 452 mA
$I_1 = 0.678$ A = 678 mA

$V_{AB} = I_S * 36 = 40.68$V

Capacitive Circuit - Transient

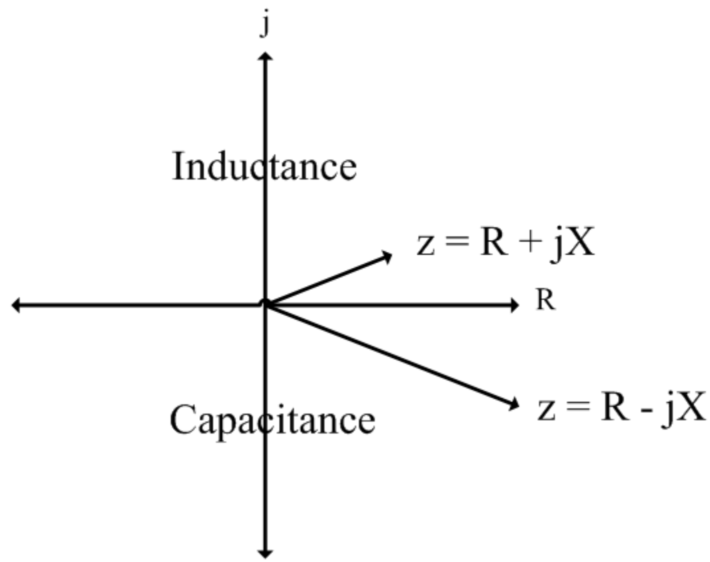


Time Constant = R * C = 1000 * .000001 = 1 msec

@ 0.7T = ½ * 10V = 5V
@ 1T = 0.63 * 10V = 6.3V
@ 5T = 10V

V_{out}

Impedance



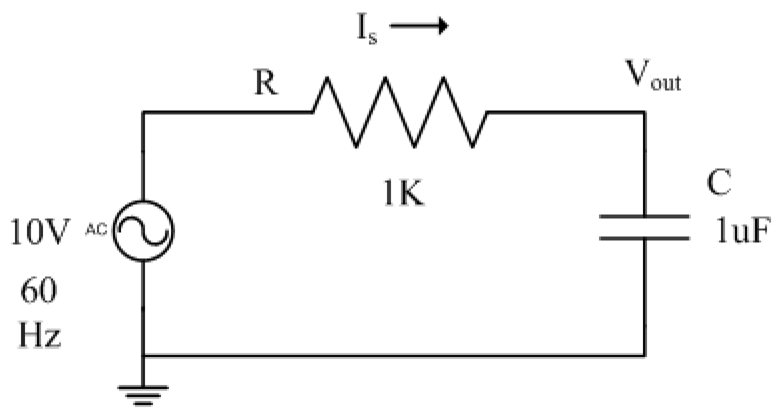
Resistor: $Z_R = R + j\ (0 * X) = R$

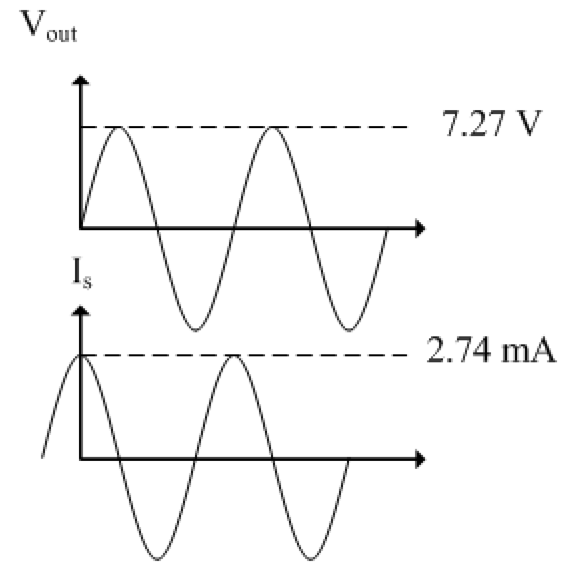
Capacitor: $Z_C = 0 - j(1/wC)$, $w = 2 * \Pi * f$

Inductor: $Z_L = 0 + jwL$, $w = 2 * \Pi * f$

Top Half Plane = Inductance (Positive Reactance)
Voltage leads Current, Current lags Voltage
Bottom Half Plane = Capacitance (Negative Reactance)
Voltage lags Current, Current leads Voltage
Resonance = coefficient of j is zero

Capacitive Circuit – Steady State





$V_{out} = I_s * Z_c$

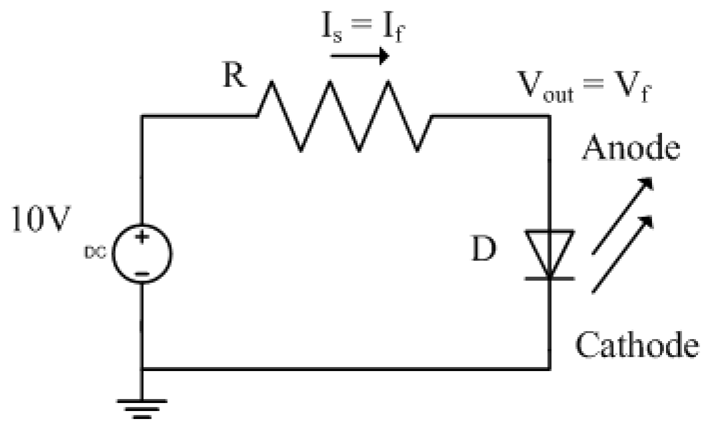
$Z_C = 1/jwC$, mag $(1/jwC) = 1/(2 * \Pi * 60 * .000001) = 2653\ \Omega$

$I_s = 10 / (1000 + 2653) = 2.74$ mA

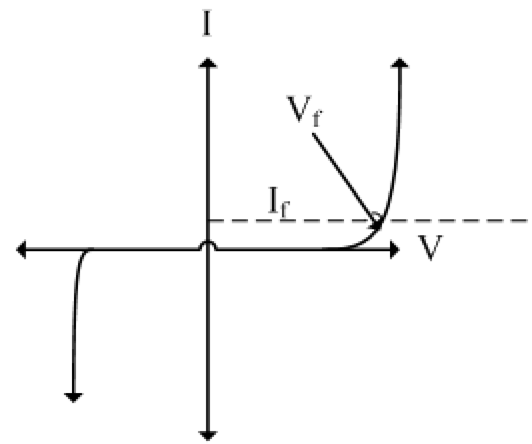
$V_{out} = 2.74$ mA $* 2653 = 7.27$ V

$V_{out} = (2653 / (2653 + 1000)) * 10 = 7.27$ V

LED
Choosing Current Limit Resistor



Given V_f and I_f



V_f & I_f depend on construction

$(10 - V_f) / R = I_f$

$R = (10 - V_f) / I_f$