Capacitors

Session 2d of "Basic Electricity"
A Fairfield University E-Course
Powered by LearnLinc

Basic Electricity

Two Sections

- Electron Flow and Resistance
  - 5 on-line sessions
  - Lab
- Inductance and Capacitance
  - 5 on-line sessions
  - Lab

Mastery Test, Part 1

Basic Electricity (Continued)

- Text: "Electricity One-Seven," Harry Mileaf, Prentice-Hall, 1996, ISBN 0-13-889585-6 (Covers several Modules and more)
- References:
  - "Digital Mini Test: Principles of Electricity Lessons One and Two," SNET Home Study Coordinator, (203) 771-5400
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
  - Basic Math Tutorial (Thanks to George Mason University)
  - Vector Math Tutorial (Thanks to California Polytec at atom.physics.calpoly.edu)

Section 2: AC, Inductors and Capacitors

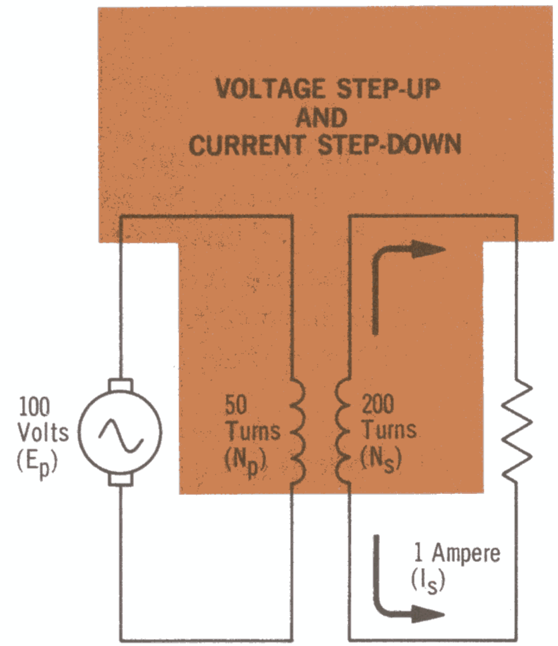
- 0BJECTIVES: This section introduces AC voltage / current and additional circuit components (inductors, transformers and capacitors).

Section 2 Schedule:

Session 2a – 03/27	Alternating Current & Sine Waves	Text 3.1 – 3.41
Vector Math – 04/01	Sine Waves, Magnitude, Phase and Vectors	Text 4.1 – 4.24
Session 2b – 04/03 (Fri. Q&A session)	Inductors and Circuits	Text 3.42 – 3.73
Session 2c – 04/08	Transformers	Text 3.74 – 3.100
Session 2d – 04/10 (lab - 04/13, Sat.)	**Capacitors**	**Text 3.101 – 3.135**
Session 2e – 04/15	More Capacitors	Text 3.135 – 3.148
Session 2f – 04/22	Review (Discuss Quiz_2)	

Transformer Session Review

- Two or more "Mutually Coupled" coils
- Coupling Coefficient (k)
  - Perfect Coupling k=1 - $M = k * \sqrt{L_p * L_s}$
  - Read world k < 1
- Power is Conserved (Losses?) $M = k * \sqrt{L_p * L_s}$
- Turns Ratio
- Purpose
  - Change voltage /current ratios
  - Adjust "Impedances"

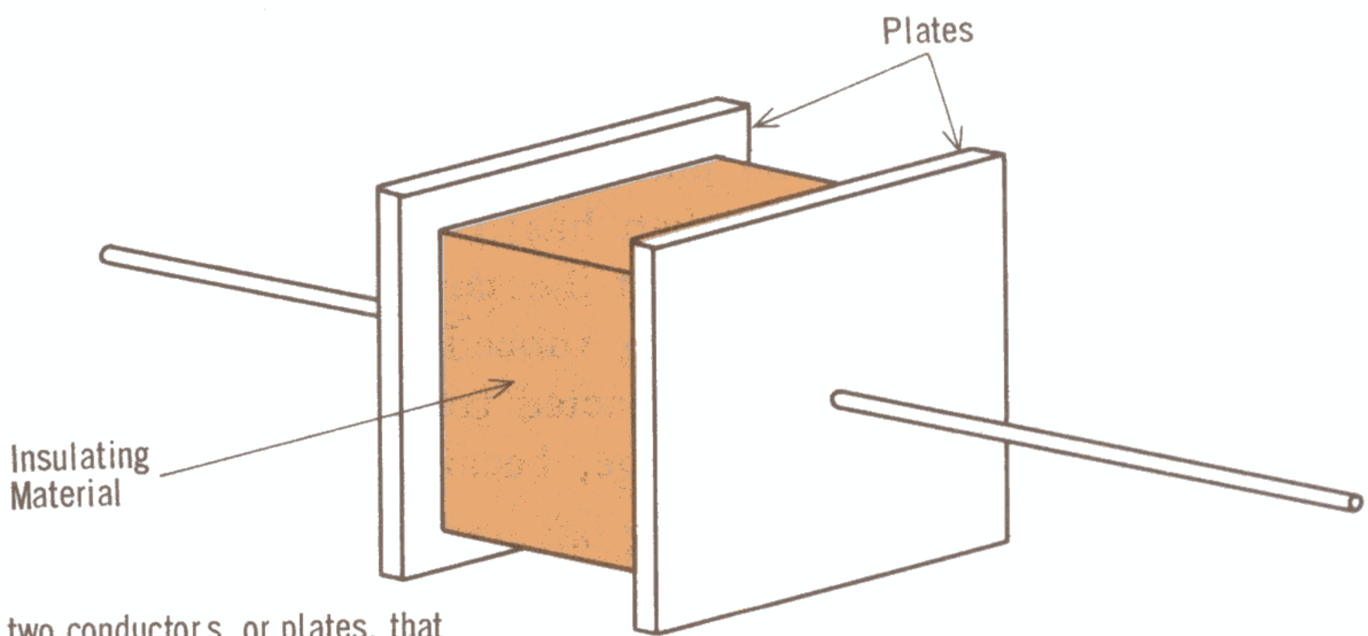


Capacitor Symbol

CAPACITORS can alternately STORE and RELEASE electrical energy by means of an ELECTROSTATIC FIELD

This is the symbol and letter designation for capacitors

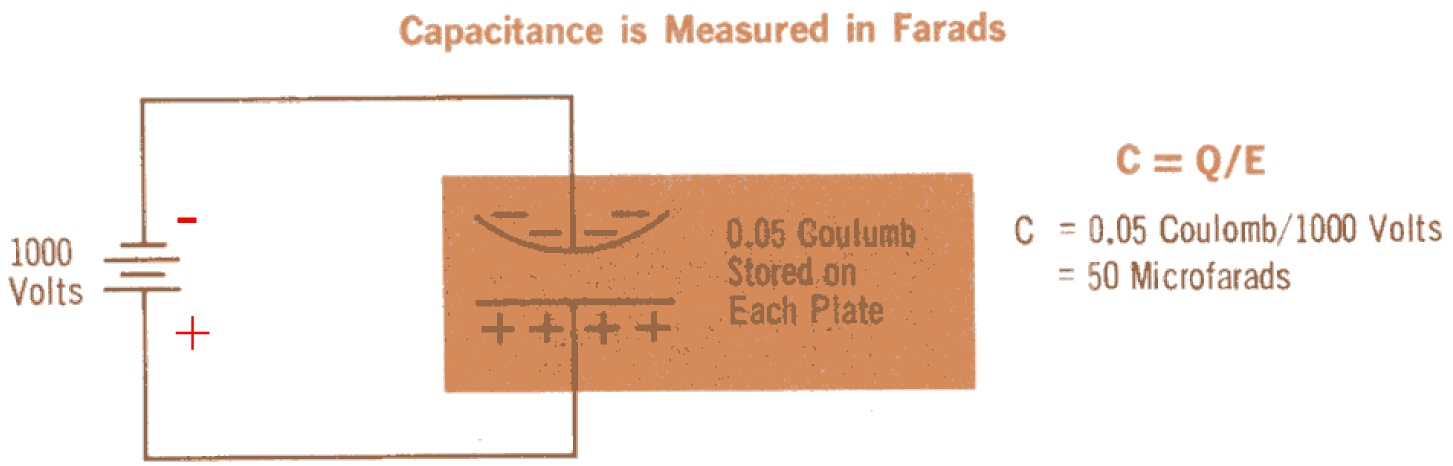
Parallel Plate Capacitor



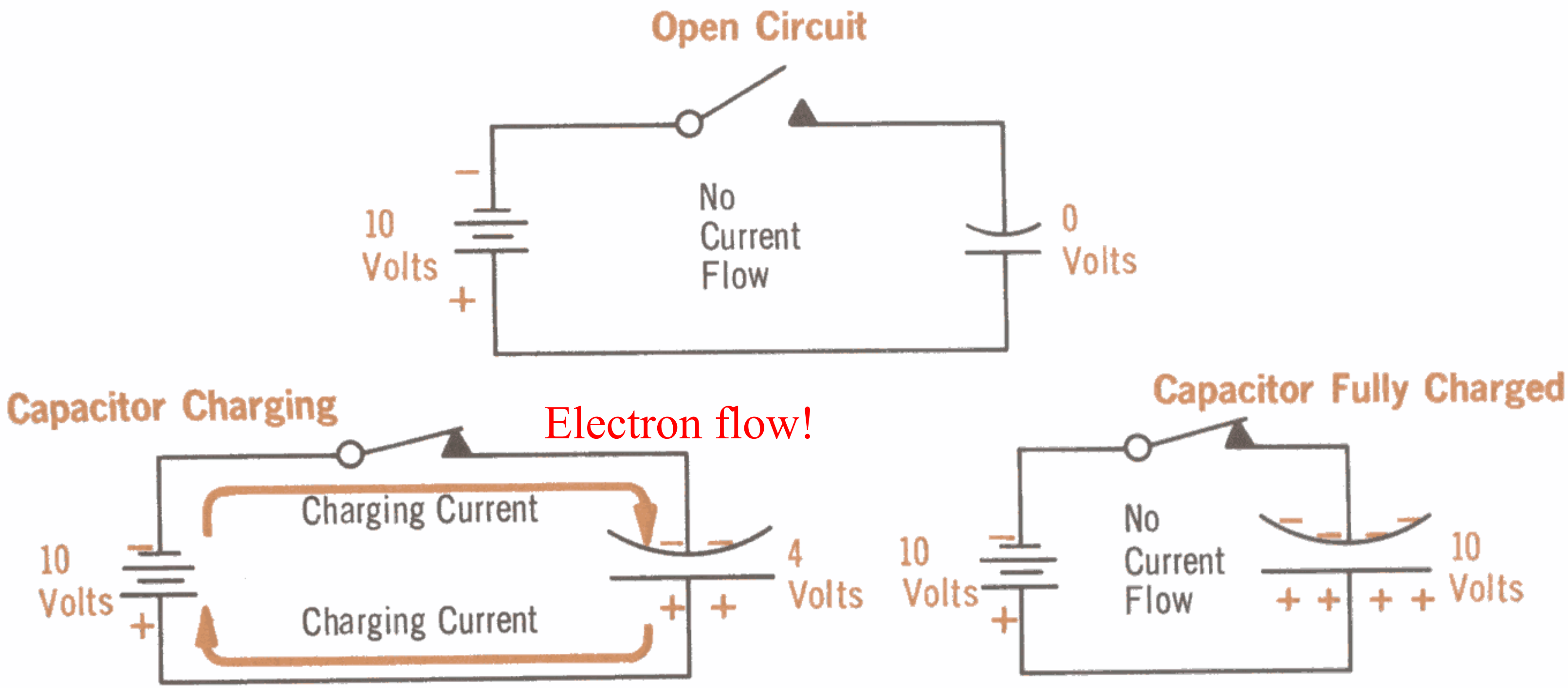
Any two conductors, or plates, that are separated by an insulating material can form a capacitor

Charge and Capacitance

- Capacitance – C = Charge / Voltage



Current Flow

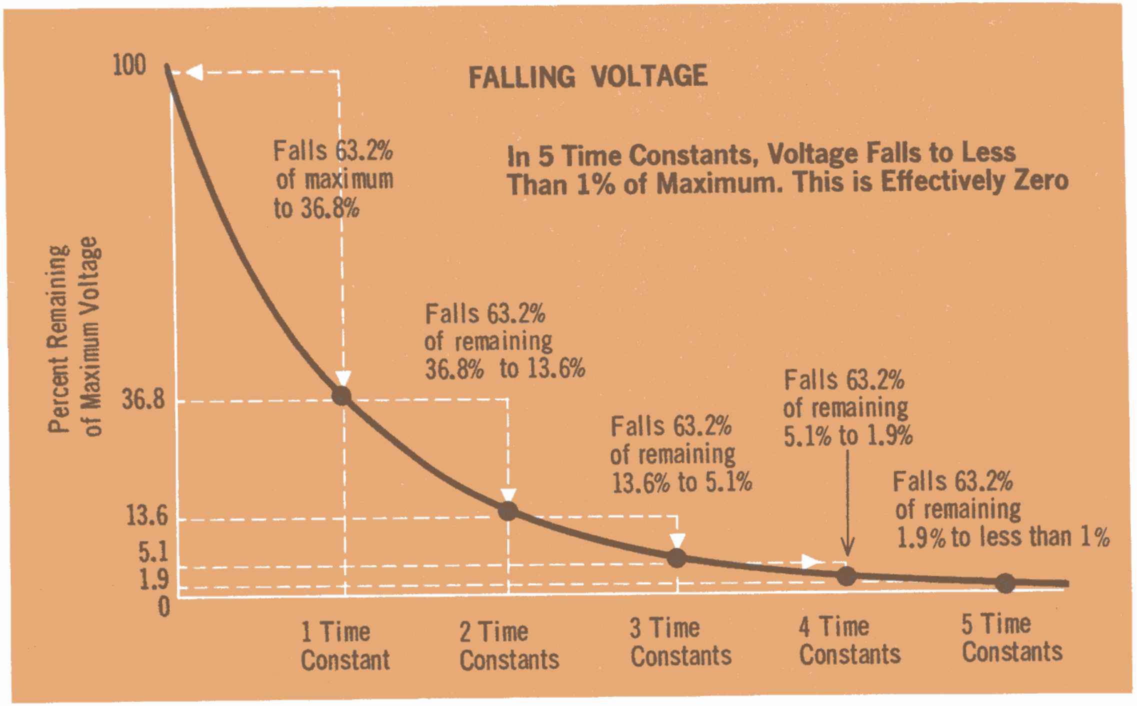


A capacitor charges until the voltage built up across it equals the applied voltage. When the two voltages are equal, the capacitor is fully charged, and current stops

For this reason, a capacitor can never be charged to a higher voltage than the source supplying the charging current

RC Time Constant

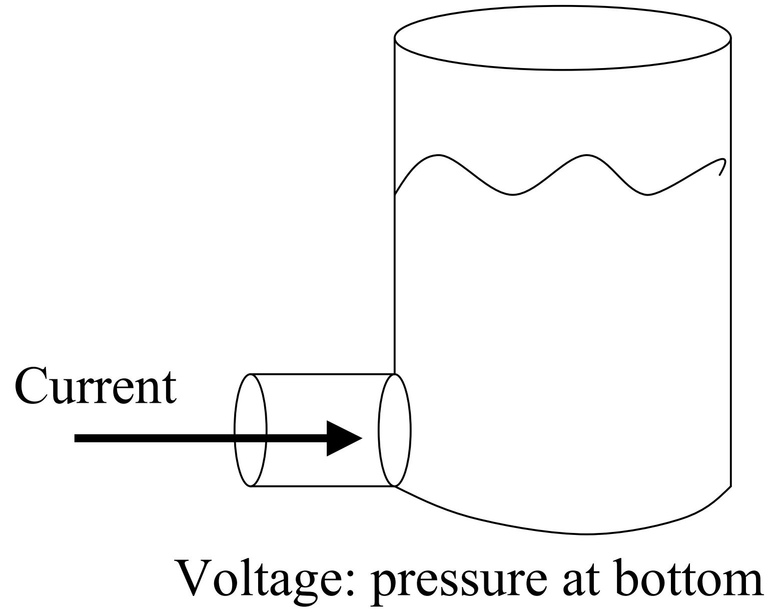
- $\tau = R * C$
- Similar to Inductance
- role of voltage and current reversed
- Inductor and Capacitor are "Duals"



In each time constant, the voltage decreases to a value 63.2% closer to zero

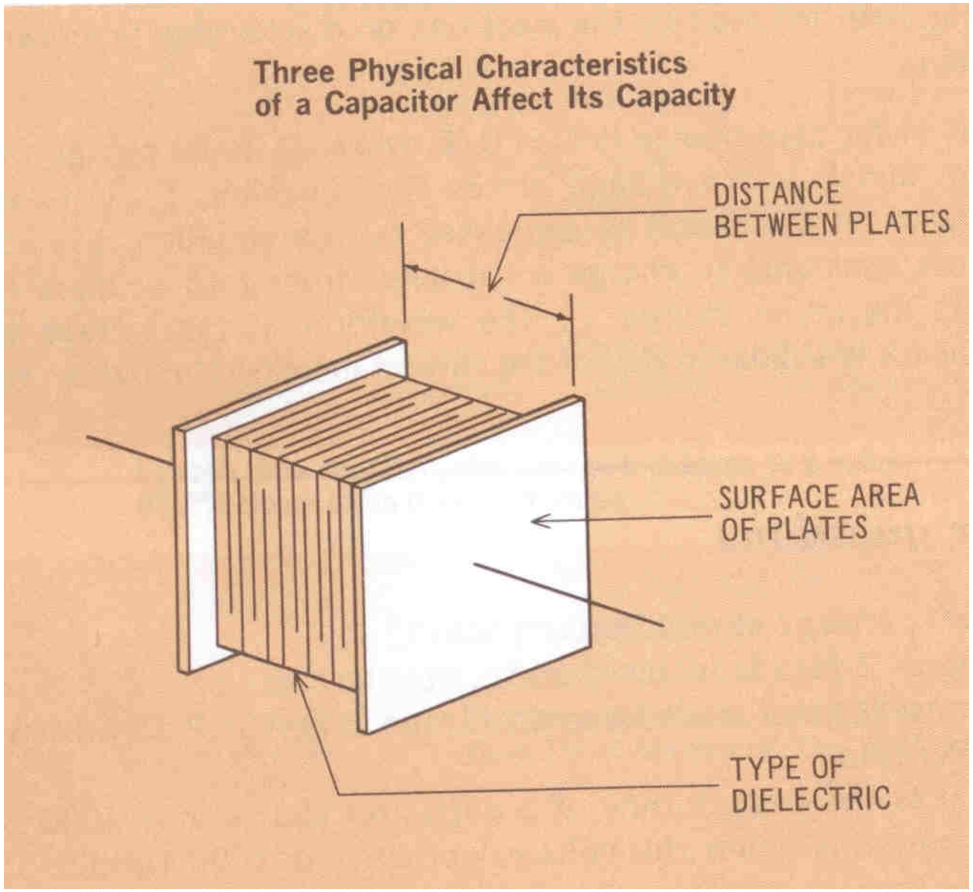
Capacitor: The Water Model

- Charge: fill the bucket (Q)
- Discharge: empty the bucket
- Voltage: pressure fighting the filling current
- Capacity: how much “Q” the bucket holds at a given voltage
- Breakdown: too much pressure for the bucket (it bursts)

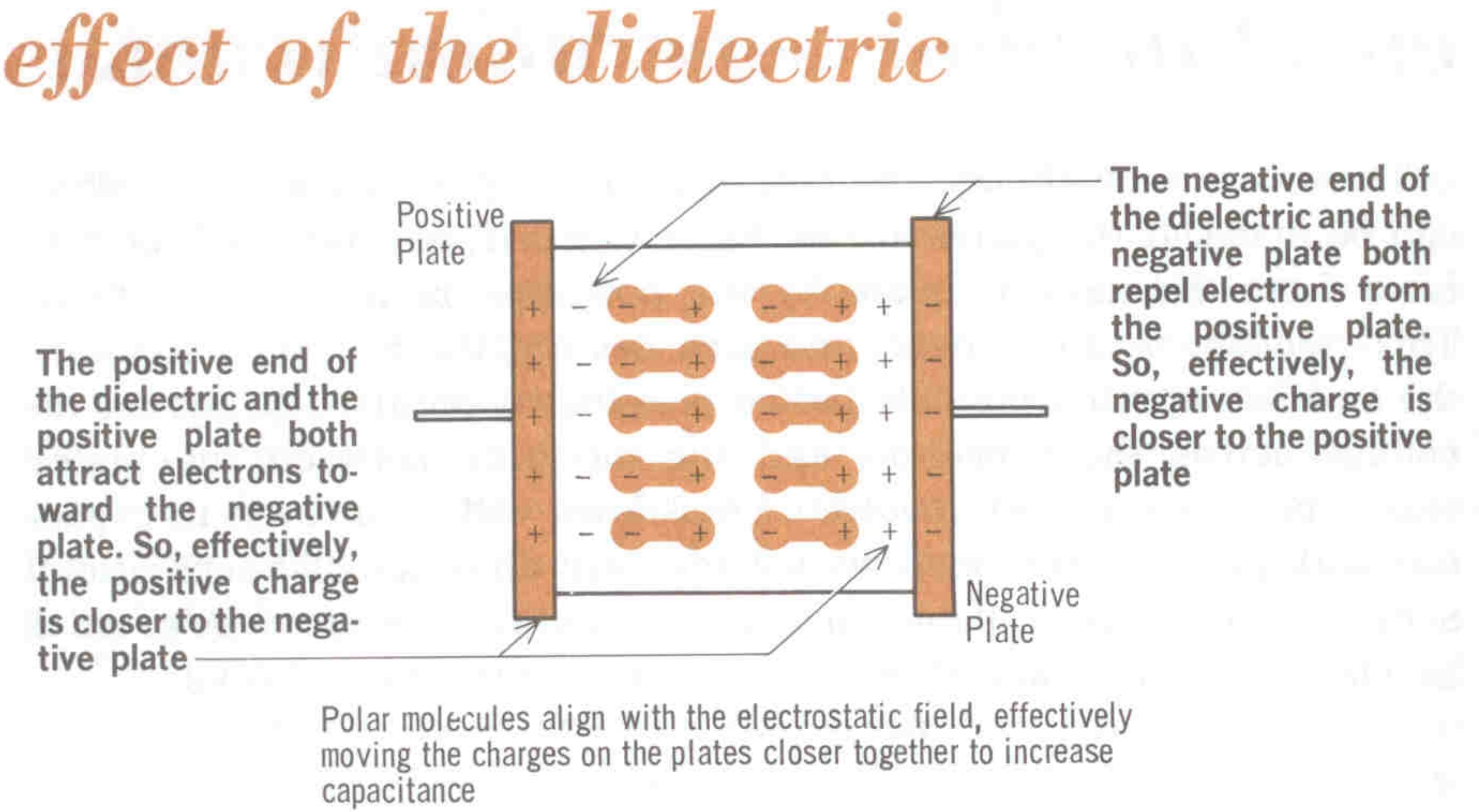


Capacitor Value

- Larger Area – Larger C
- Larger distance – Lower C
- Higher "Dielectric Constant" – Higher C



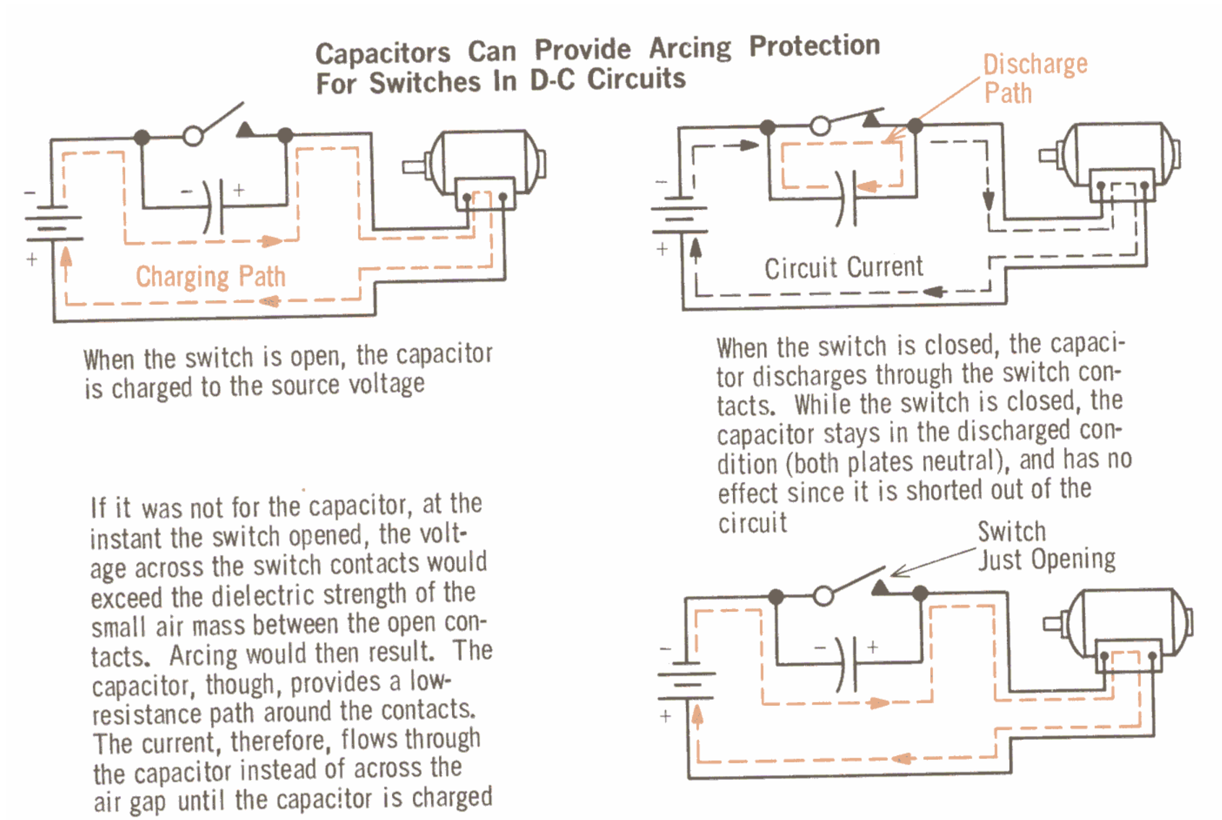
Dielectric Effect



Contact Protection:

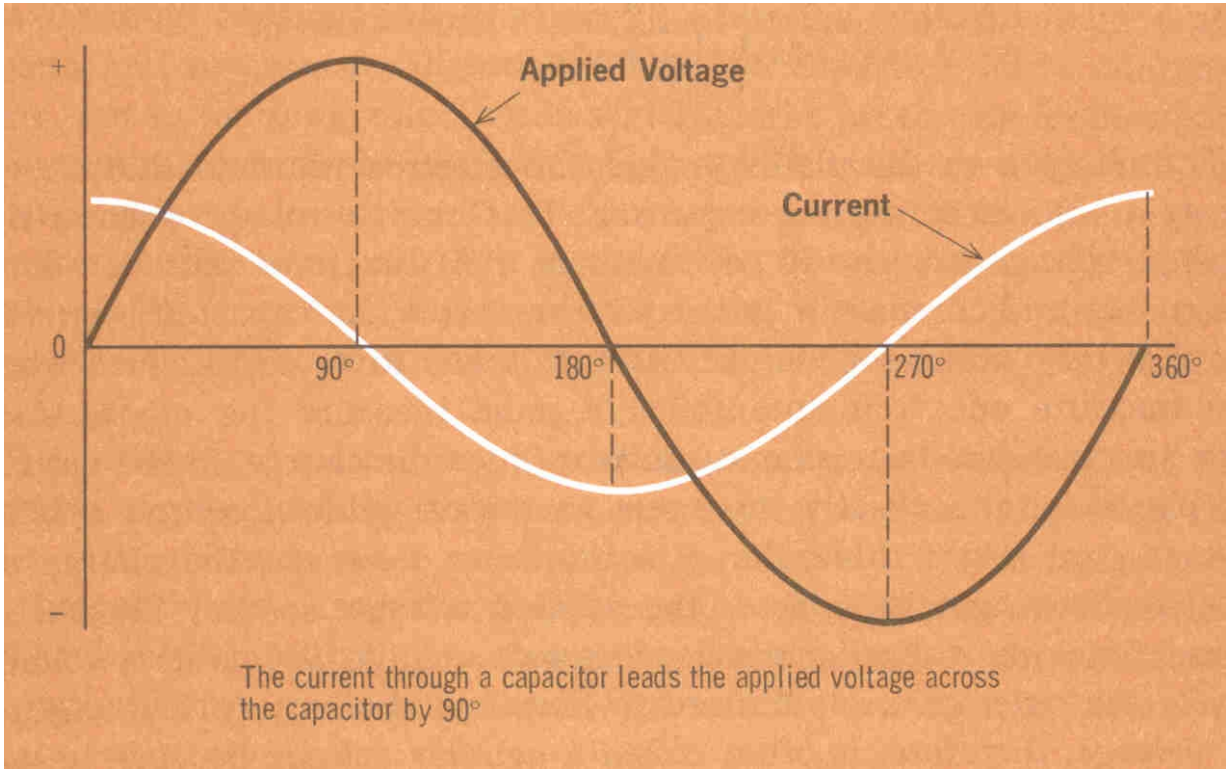
Inductive Load

- Current surge kills contacts
- Current in Inductor keeps going
- Capacitor allows continuation
- Need a resistance to avoid surge on contact closure



AC and Phase

- ELI the ICE man
- Current Leads Voltage



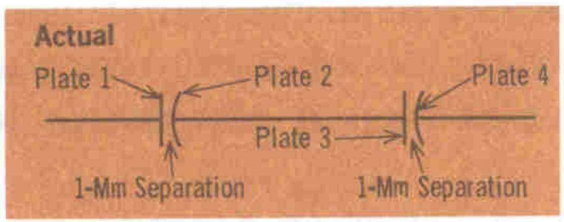
Capacitor Reactance

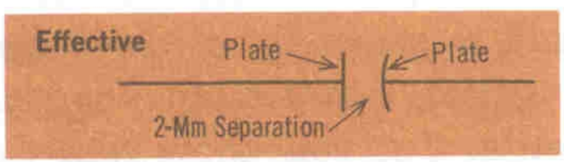
- Similar to Inductive Reactance: Voltage and current are 90° out of phase
- Now Frequency and Capacitance make for a lower reactance.
- $Xc = 1 / (2 * \pi * f * C)$
- Again the magnitude of the reactance determines the magnitude of the current that flows for a given AC voltage

Capacitors in Series

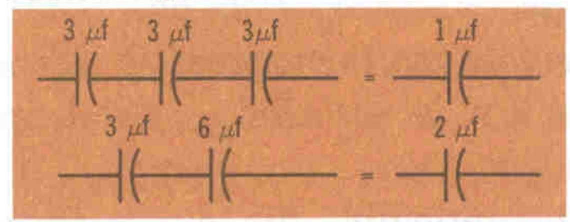
series capacitors

Putting Capacitors In Series Decreases Capacitance





Series capacitors act as a single capacitor with a separation between their plates equal to the sum of the separations of the individual capacitors. The total capacitance is, therefore, less than that of any of the individual capacitors



The total capacitance of series capacitors is calculated the same as the total resistance of parallel resistors. The reciprocal method:

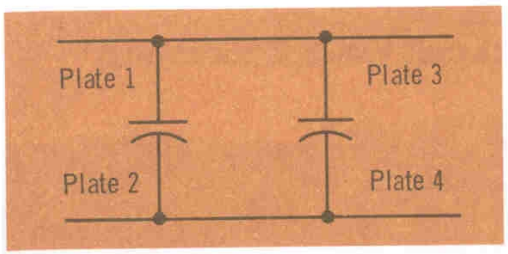
$$C_{TOT} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \text{etc.}},$$

or any of the shorter, special methods can be used. The total capacitive reactance, though, is simply the sum of the individual reactances:

$$X_{C\,TOT} = X_{C1} + X_{C2} + X_{C3} + \ldots + \text{etc.}$$

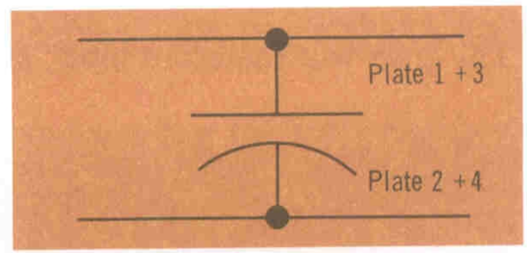
Capacitors in Parallel

Actual

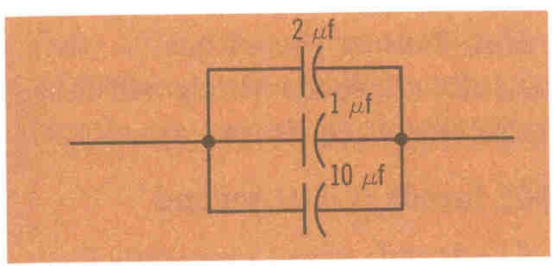


Parallel capacitors act as a single capacitor with a plate area equal to the sum of the plate areas of the individual capacitors

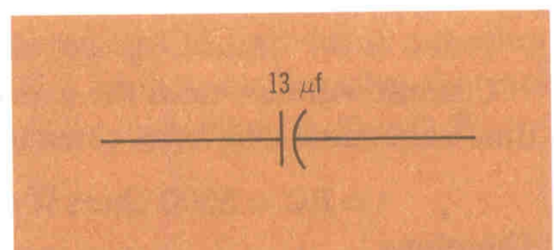
Effective



The total capacitance is, therefore, more than that of any of the individual capacitors



=



The total capacitance of parallel capacitors is equal to the sum of the capacitances of the individual capacitors:

$$C_{TOT} = C_1 + C_2 + C_3 + \ldots + \text{etc.}$$

The total capacitive reactance, though, is found by treating the individual reactances as parallel resistances:

$$X_{C\,TOT} = \frac{1}{\frac{1}{X_{C1}} + \frac{1}{X_{C2}} + \frac{1}{X_{C3}} + \ldots + \text{etc.}}$$

Section 2 Schedule:

Session 2a – 03/27	Alternating Current & Sine Waves	Text 3.1 – 3.41
Vector Math – 04/01	Sine Waves, Magnitude, Phase and Vectors	Text 4.1 – 4.24
Session 2b – 04/03 (Fri. Q&A session)	Inductors and Circuits	Text 3.42 – 3.73
Session 2c – 04/08	Transformers	Text 3.74 – 3.100
Session 2d – 04/10 **(lab - 04/13, Sat.)**	Capacitors	Text 3.101 – 3.135
Session 2e – 04/15 (Quiz, no Wed. session)	**More Capacitors**	**Text 3.135 – 3.148**
Session 2f – 04/22	Review (Discuss Quiz_2)	