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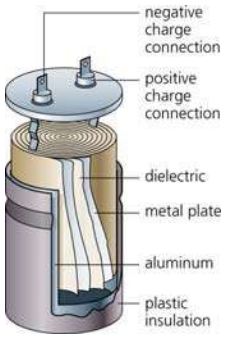
MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

Class 13
Reactive Components II
Capacitors



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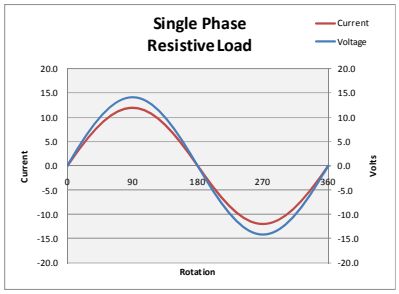
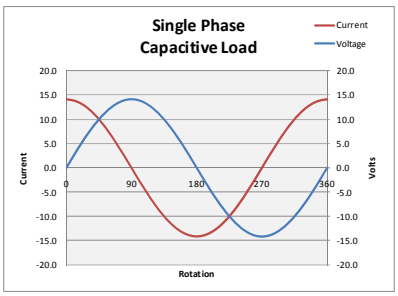
- Reactive Components
  - An electronic component that causes a phase shift between current and voltage



Current & Voltage in sync

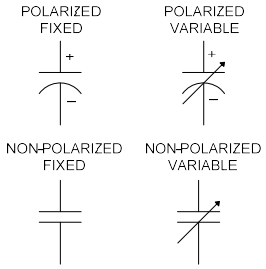


Current Leads Voltage

- Reactive Components
  - **Capacitor** – two conducting plates that store energy in their electrostatic field
  - **Capacitance** – the ability to store an electric charge
    - UOM – Farad (F) – one coulomb per volt

$$C = \frac{Q}{V}$$

Where;
$C = capaci\tan ce(farads)$
$Q = ch\arg e(coulombs)$
$V = voltage(volts)$

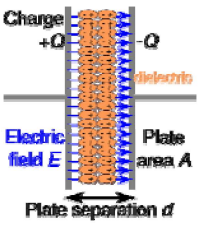


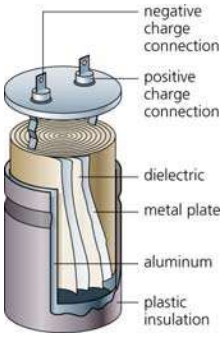
- Capacitance
  - Capacitance is directly related to
    - Plate area (charge)
    - Dielectric material (electric field permittivity)
  - Capacitance is indirectly related to
    - Plate separation distance
    - Voltage

$$C = \varepsilon_T \varepsilon_o \frac{A}{d}$$

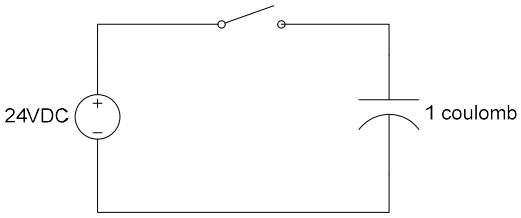
$$C = \frac{Q}{V}$$

Where;
$A = plate\_area$
$\varepsilon_T = dielectric\_const$
$d = plate\_dist$





- Capacitance
  - Capacitance example
    - A circuit has a source voltage of 24vdc and stores one coulomb of charge
      - Find the circuit capacitance in milli-farads



$$C = \frac{Q}{V}$$

$$C = \frac{1coulomb}{24V}$$

$$C = ??\,mF$$

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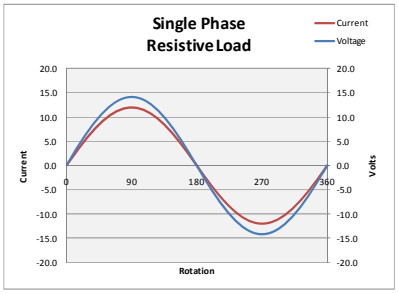
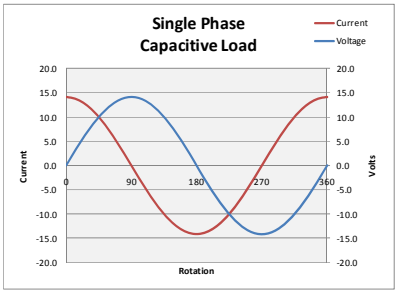
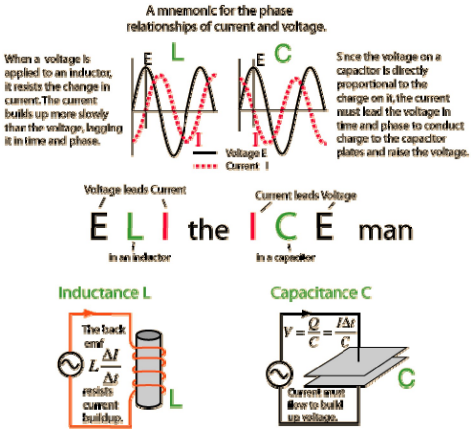
- Capacitance
  - Capacitive phase shift
    - ICE – current leads voltage
    - 90° for a perfect capacitor

Capacitors resist changes in their applied voltage by converting electrostatic field strength into CEMF

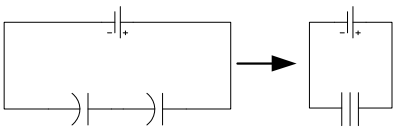




- Inductance & Capacitance
  - ELI the ICE man



- Capacitance
  - Series Capacitance
    - Plate area same
    - Dielectric thicker
    - Capacitance reduced



$$C_T = \frac{C}{N}$$

Equal value capacitors

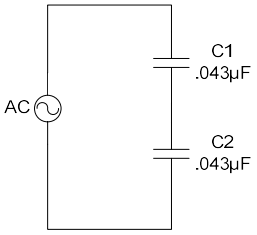
$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

Two capacitor circuits

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \frac{1}{C_n}}$$

General formula

- Capacitance
  - Series Capacitance Example
    - A circuit has two 0.043μF capacitors in series
    - Find the total circuit capacitance



$$C_T = \frac{C}{N}$$

Equal value capacitors

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

Two capacitor circuits

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \frac{1}{C_n}}$$

General formula

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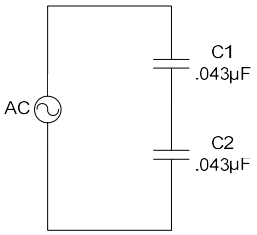
- Capacitance
  - Series Capacitance Example
    - A circuit has two 0.043μF capacitors in series
    - Find the total circuit capacitance



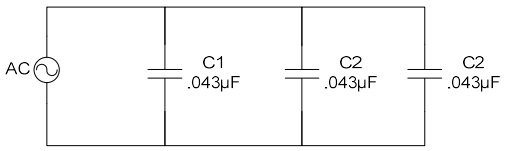
Equal value capacitors

$$C_T = \frac{C}{N}$$

$$C_T = \frac{0.0430\,\mu F}{2}$$

$$C_T = 0.????\,\mu F$$

- Capacitance
  - Parallel Capacitance
    - Plate area increased
    - Dielectric same
    - Capacitance additive



$$C_T = C_1 + C_2 + C_3 + ...C_n$$

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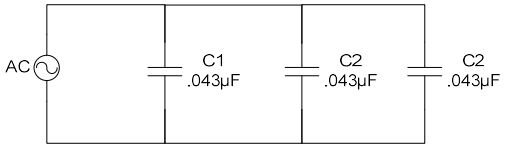
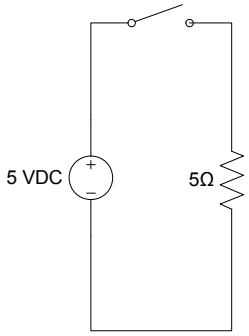
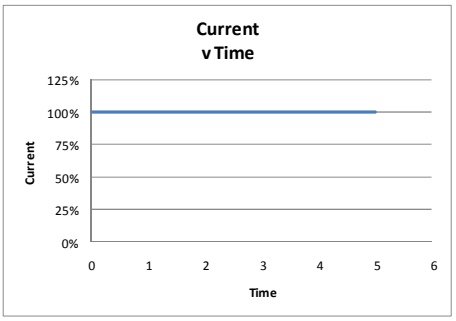
- Capacitance
  - Parallel Capacitance Example
    - A circuit has 3 – 0.043µF capacitors in parallel
    - Find total capacitance



$$C_T = C_1 + C_2 + C_3 + ...C_n$$
$$C_T = 0.043\mu F + 0.043\mu F 0.043\mu F$$
$$C_T = 0.???\mu F$$

- Capacitance
  - RC Time Constant
    - The time required to charge or discharge an capacitive circuit to full source voltage or to no voltage





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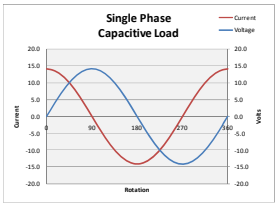
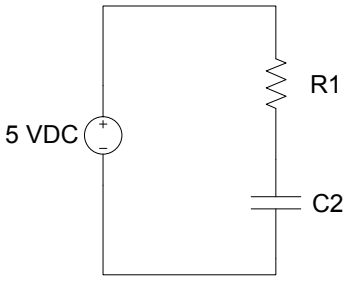
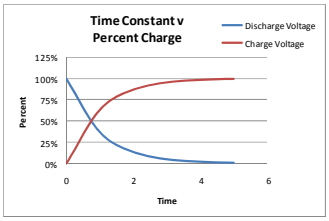


- Capacitance
  - RC Time Constant (τ)
    - The time required to charge or discharge an capacitive circuit to full source voltage or to no voltage





Lab 13 – RC Time Constants

Learning Objectives

- Characterize the output of an RC time constant circuit
- Calculate RC time constants for specified components
- Calculate and measure frequency and period

		Points Possible
Documentation	Quality of documentation (neatness, clarity, spelling, grammar), Expected and measured values recorded on schematic diagram	**10**
RC Time Constant	Resistance and capacitance values recorded	**5**
	Scatter plot drawn accurately with time constants shown	**5**
Astable Multivibrator	Scatter plot drawn, accurate with annotations	**5**
	Expected charge and discharge times calculated and compared to measured values	**5**
	Expected output frequency calculated and compared to measured values	**5**
Monostable Multivibrator	Expected output operation time calculated and compared to measured value	**5**
	Waveforms drawn accurately with annotations	**5**
Conclusions	Questions answered completely & accurately.	**10**
	Total	**55**