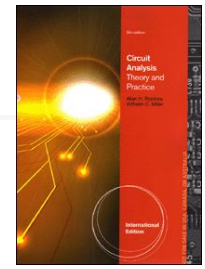

Chapter 10

Capacitors and Capacitance

Capacitance of a Parallel-Plate Capacitor

$C = \epsilon A / d$

- Directly **proportional to** plate area ***A***
- **Inversely proportional to** plate separation ***d***
- **Dependent on dielectric** ϵ
- $\epsilon = \epsilon_r \epsilon_0$, $\epsilon_0 = 8.854 \times 10^{-12}$ **F/m**
- A farad(**F**) is a very large unit, e.g., **μF** or **pF**

Example

Compute the capacitance of a parallel-plate capacitor with plates 10cm by 20cm, separation of 5mm, and a **mica** dielectric. **(ϵ_0=8.854x10^{-12}F/m)**

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Capacitor Voltage Rating

Capacitors rated for **maximum operating voltage** (**Working Voltage dc** or **WV**)

- Rating is necessary due to dielectric breakdown

G = ±2 %
J = ±5 %
K = ±10 %
M = ±20 %

Capacitor2_10pF

Capacitor1_100uF

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Capacitors in Parallel

- **Total charge** on capacitors is **sum of all charges**

  $Q = CV$, $Q = C_T E = C_1V_1 + C_2V_2 + C_3V_3$
- **All voltages are equal,** $E = V_1 = V_2 = V_3$
- **Total capacitance** C_T of capacitors **in parallel**
  - **Sum of their capacitances** (like resistors in series)

  $C_T = C_1 + C_2 + C_3$

Capacitors in Series

- **Same charge** appears on all capacitors $Q = Q_1 = Q_2 = Q_3$
- Total V: Sum of individual voltages $E = V = V_1 + V_2 + V_3$
- $C_T = 1 / (1/C_1 + 1/C_2 + 1/C_3)$ **(like resistors in parallel)**

Voltage Divider for Capacitors in Series

$E = V_1 + V_2 + V_3$

$Q = Q_1 = Q_2 = Q_3$

$= C_1 V_1 = C_2 V_2 = C_3 V_3$

Smaller *C* to get Larger *V*

Energy Stored by a Capacitor

- **A capacitor does not dissipate power**
- **Stored energy**: When power is transferred to a capacitor, $W = C V^2 / 2$

Capacitor Failures and Troubleshooting

- Reasons for **capacitor's failure**
  - **Excessive voltage, current,** or **temperature,** or **aging**
- Test with an **ohmmeter**
  - **Good capacitor will read low, then gradually increase to infinity**
- Capacitor **short**
  - Meter resistance will **stay low**
- If capacitor is **leaky**
  - Reading will be **lower than normal**
- If capacitor is **open**
  - **Stays at infinity**

Kernel abilities

1. **Can give the definition of capacitance for a capacitor.**
2. **Can distinct all the different types of capacitors.**
3. **Can calculate the total capacitance of capacitors in series-parallel circuits.**
4. **Can understand the voltage divider for capacitors in series-parallel circuits.**
5. **Can understand the capacitor voltage and current during charging.**