Capacitance and Capacitor

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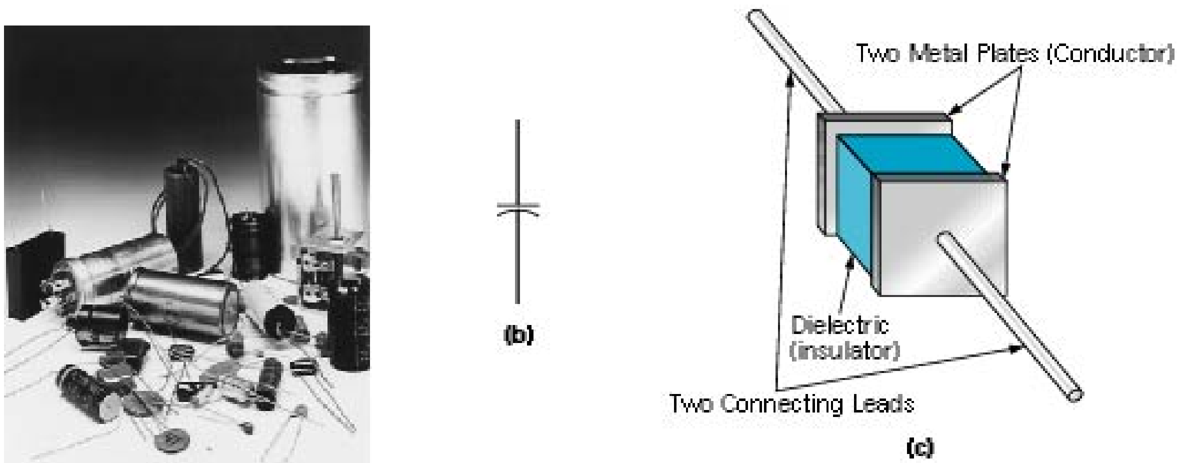
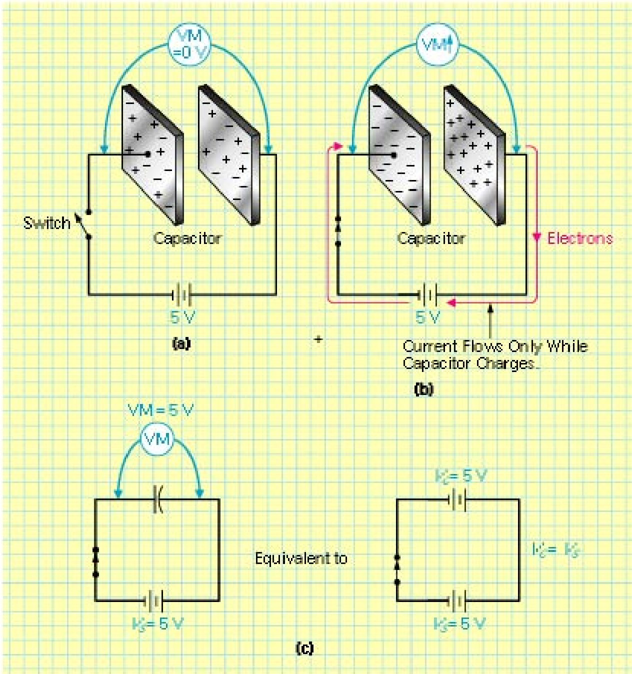
커패시터 (Capacitor)

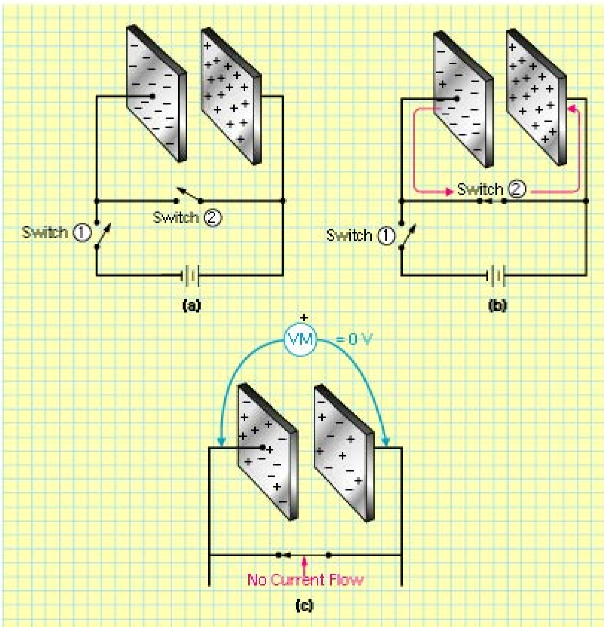
- 전기에너지를 축적하는 장치



커패시터의 충전

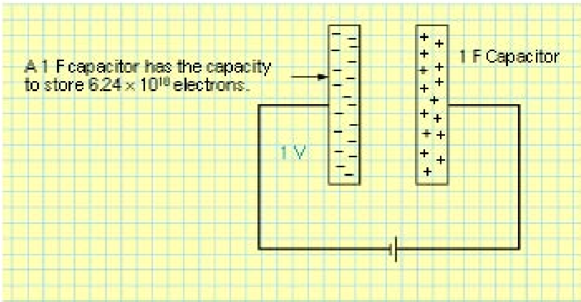


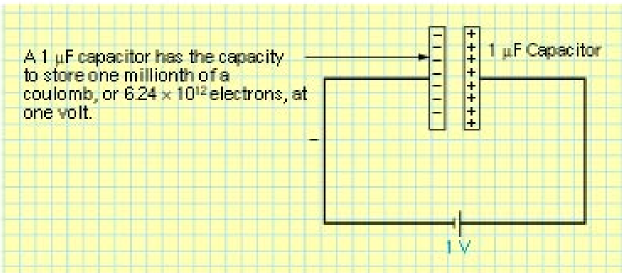
커패시터의 방전



커패시턴스 (Capacitance)

- 커패시턴스: 커패시터가 전하를 축적할 수 있는 능력
- 단위: 패럿 (farad), Coulomb/Volt





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

$$C = \frac{8.85 \times 10^{-12} \times K \times A}{d}$$

$C =$ capacitance, farad

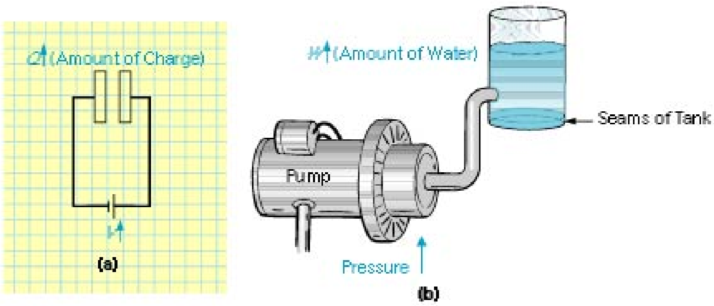
$K =$ 유전률

$A =$ 금속판의 면적

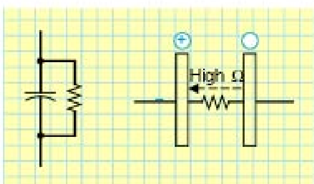
$d =$ 금속판간의 거리

유전체의 절연파괴 및 누설 (leakage)

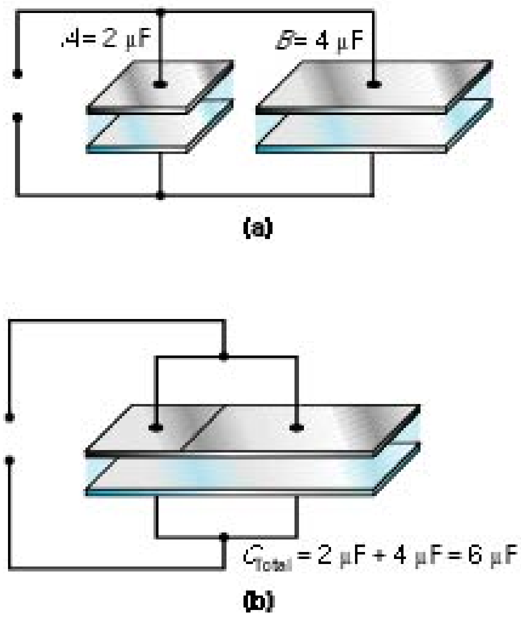
절연파괴 전압: 유전체 또는 절연체에서 절연파괴가 일어나는 전압



누설전류(Leakage Current): 절연체 또는 유전체를 통해 흐르는 원치 않는 작은 전류

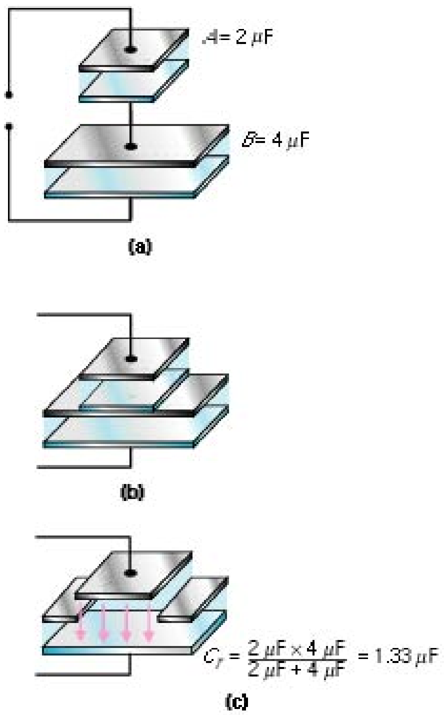


커패시터의 병렬연결



$$C_T = C_1 + C_2 + \cdots$$

커패시터의 직렬연결

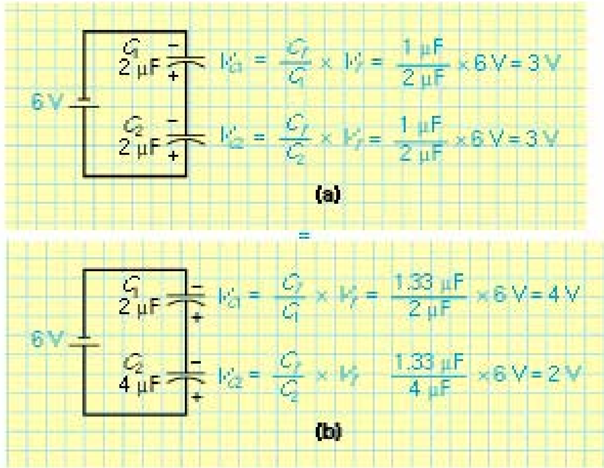


$$C_T = \frac{1}{1/C_1 + 1/C_2 + \cdots}$$

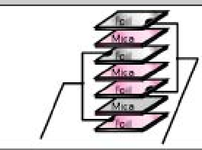
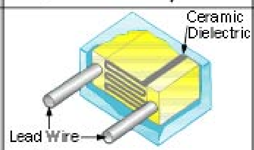
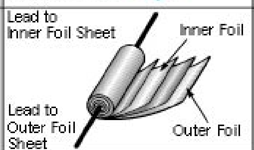
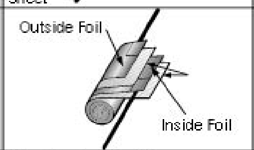
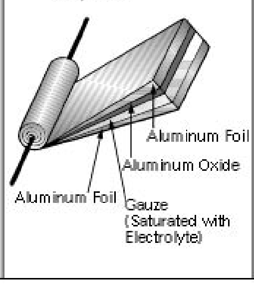
커패시터의 전압분배

$$V_{cx} = \frac{C_T}{C_x} V_T$$

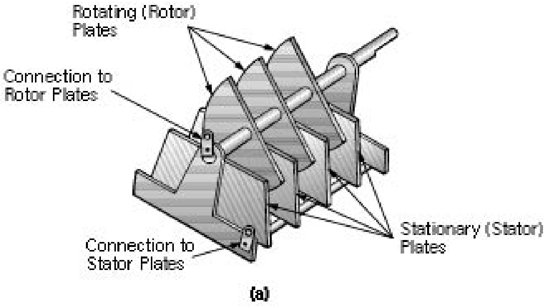
동일한 전하량을 가진다.

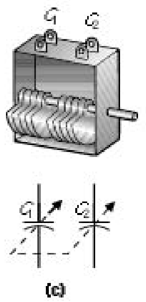


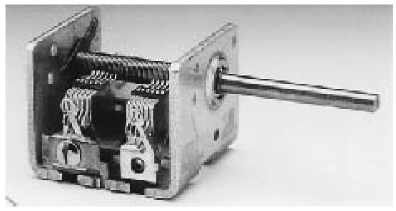
고정값 커패시터

Name	Construction	Approximate Range of Values and Tolerances	Characteristics	
Mica		1 pF–0.1 μF ±1% to ±5%	Lower voltage rating than other capacitors of the same size	Small Capacitor Values
Ceramic	 Ceramic Dielectric, Lead Wire	*Low Dielectric K* 1 pF–0.01 μF ±0.5% to ±10% *High Dielectric K* 1 pF–0.1 μF ±10% to ±80%	Most popular small value capacitor due to lower cost than mica, and its ruggedness	
Paper	 Lead to Inner Foil Sheet, Inner Foil, Lead to Outer Foil Sheet, Outer Foil	1 pF–1 μF ±10%	Has a large plate area and therefore large capacitance for a small size	Large Capacitor Values
Plastic	 Outside Foil, Inside Foil	1 pF–10 μF ±5% to ±10%	Has almost completely replaced paper capacitors; has large capacitance values for small size and high voltage ratings	
Electrolytic (Aluminum and Tantalum)	(Tantalum has tantalum rather than aluminum foil plates)  Aluminum Foil, Aluminum Oxide, Aluminum Foil, Gauze (Saturated with Electrolyte)	1 μF–1 F ±10% to ±50%	Most popular large value capacitor: large capacitance into small area, wide range of values. Disadvantages are: cannot be used in AC circuits as they are polarized; poor tolerances; low leakage resistance and so high leakage current. *Tantalum* advantages over aluminum include smaller size, longer life than aluminum, which has an approximate lifespan of 12 years. Disadvantages: 4 to 5 times the price.	

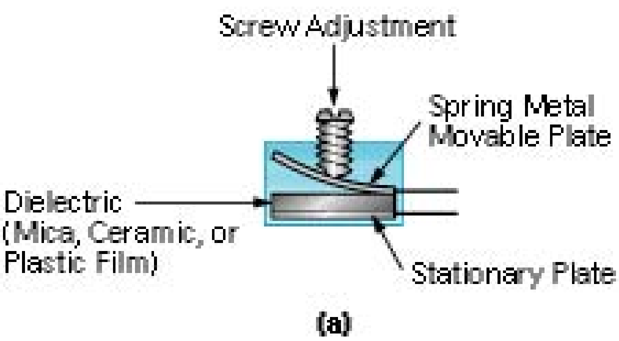
가변 커패시터 (공기)

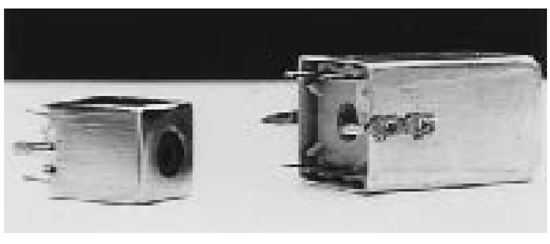






가변 커패시터 (운모, 세라믹, 플라스틱)





커패시터 값 읽는 법

- 주로 micro or pico 단위
  - 소수점 존재 -> micro
  - 소수점 없으면 -> pico
- 소수점 없고 3개의 숫자존재
  - 마지막 숫자 -> 승수
- Example
  - 0.24 -> 0.24 uF
  - 22 -> pF
  - 220 -> 22 pF
  - 104 -> $10*10^4$ pF
  - 103J 10,000 pF with +/-5%

Third Digit	Multiplier
0	1
1	10
2	100
3	1,000
4	10,000
5	100,000
6 not used	
7 not used	
8	0.01
9	0.1

I-V relation for Capacitor

$$Q = CV,\ q(t) = Cv(t)$$

$$i(t) = \frac{dq(t)}{dt} = C\frac{dv(t)}{dt}$$

$$v_c(t) = \frac{1}{C}\int_{-\infty}^{t} i_c(\tau)d\tau$$

$$v_c(t) = \frac{1}{C}\int_{t_0}^{t} i_c(\tau)d\tau + V_0$$

$$v(t) = v_1(t) + v_2(t) + v_3(t)$$
$$= \frac{1}{C_1}\int_{-\infty}^{t} i(\tau)d\tau + \frac{1}{C_2}\int_{-\infty}^{t} i(\tau)d\tau + \frac{1}{C_3}\int_{-\infty}^{t} i(\tau)d\tau$$
$$= \frac{1}{C_T}\int_{-\infty}^{t} i(\tau)d\tau$$

Example

- 커패시터 전류와 초기 충전상태를 통하여 커패시터에 걸리는 전압을 구하여라

$$i_c(t) = \begin{cases} 0 & t < 0s \\ 10mA & 0 \le t \le 1s \\ 0 & t > 1s \end{cases}$$

$$v_c(t=0) = 2V$$

$$C = 1000\mu F$$

커패시터에서의 에너지 저장

$$w_c = \int P_c(t)dt$$

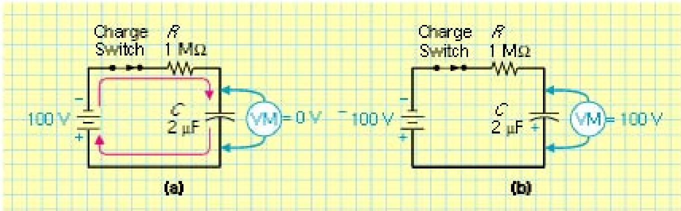
$$= \int v_c(t) i_c(t) dt$$

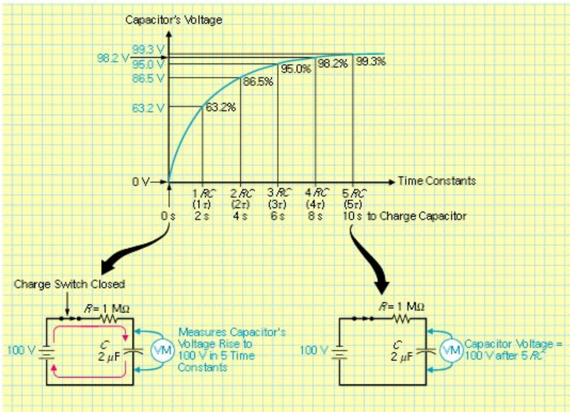
$$= \int v_c(t) C \frac{dv_c(t)}{dt} dt$$

$$= \frac{1}{2} C v_c^{\,2}(t)$$

커패시터 시정수-직류충전

$$\tau = R \times C$$

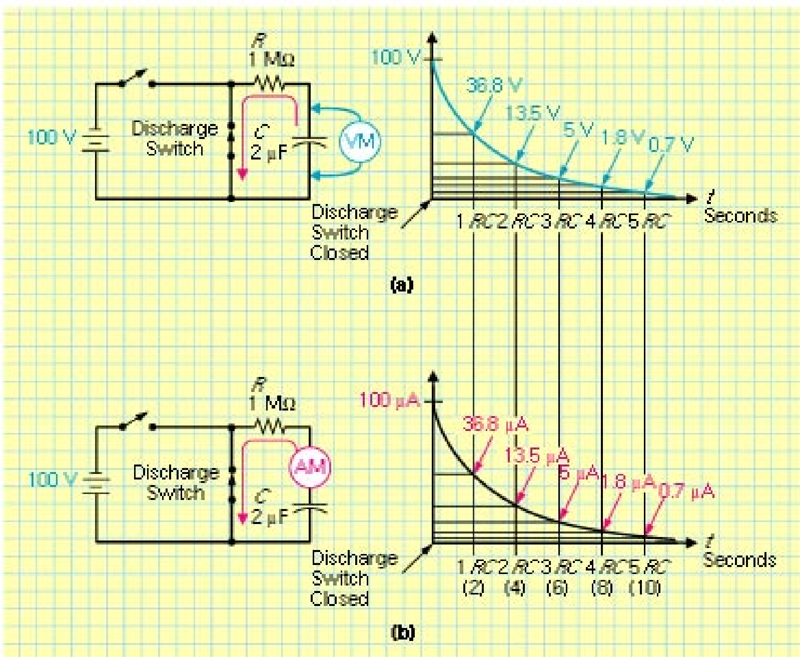




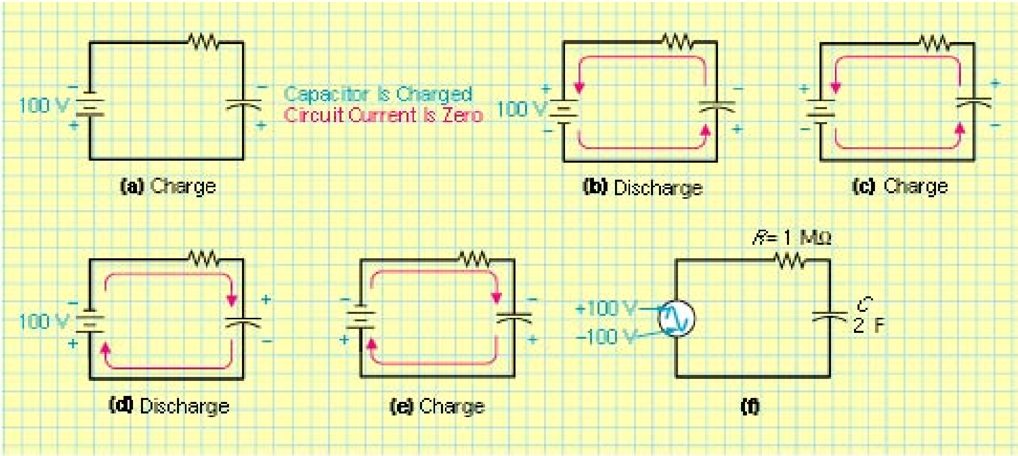
$$i = \frac{V_s - V_c}{R}$$

충전됨에 따라 전류감소

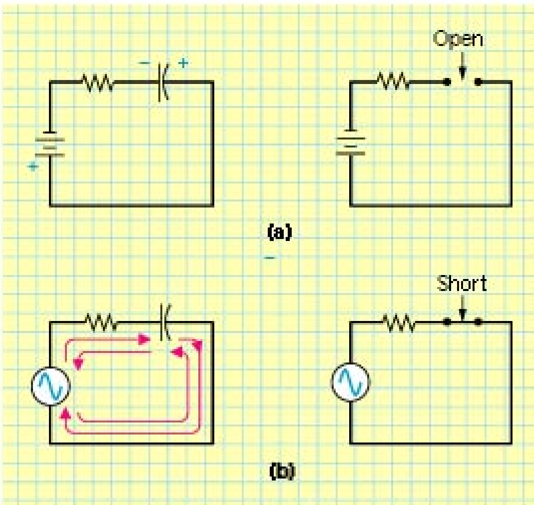
직류 방전



교류 충전과 방전



커패시터의 직,교류 특성



Open to DC

Short to AC

커패시터 전류와 전압간의 위상 관계

- 교류전류는 전압보다 위상이 90(deg) 앞선다.