회로 이론/실습

8. 커패시터

8. 커패시터

8-1. 목적 및 배경

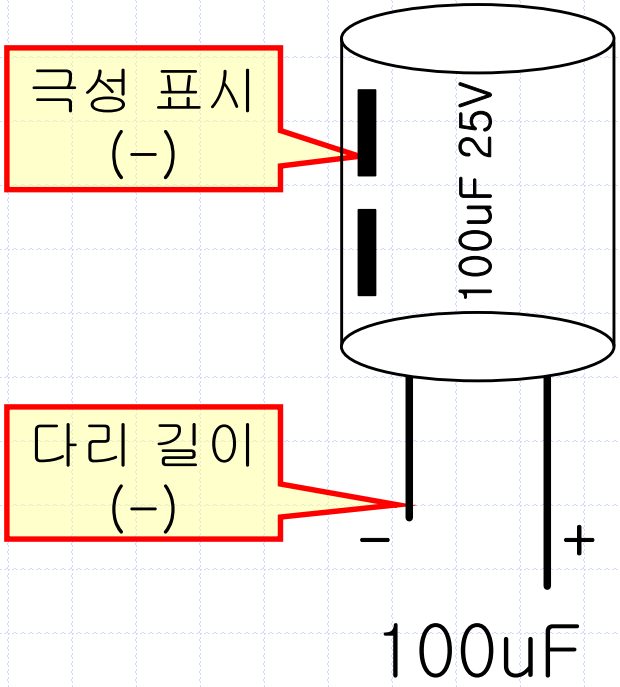
- ✓ 커패시터의 용량을 읽는 법을 학습한다.
- ✓ 커패시터와 저항의 직렬회로를 해석한다.
- ✓ 주파수에 따라 커패시터의 리액턴스값의 변화를 실험한다.
- ✓ 커패시터에 의한 위상의 변화를 관측한다.

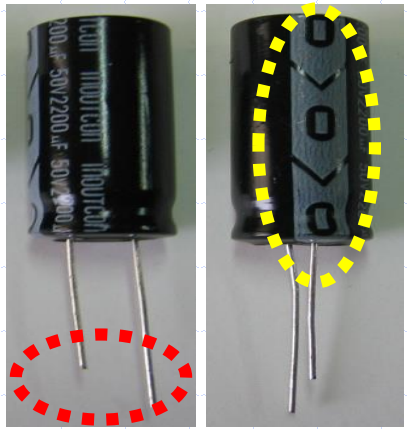
8-2. 소요 부품 및 장비

- 부품
  - 저항 (1/4W) : 10Ω, 100Ω, 1kΩ, 10kΩ
  - 캐패시터 : 0.047uF, 0.1uF, 2.2uF, 100uF
- 장비
  - 브레드 보드
  - 디지털 멀티미터 (Digital Multi-Meter)
  - 직류전원장치 (DC Power Supply)
  - 오실로스코프 (Oscilloscope)
  - 신호발생기 (Function Generator)

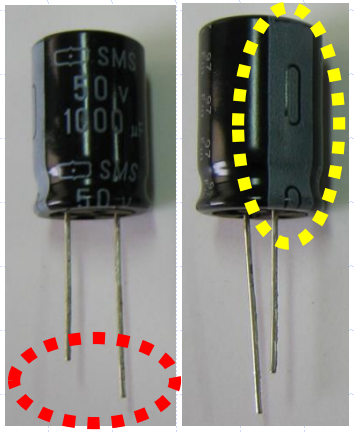
8-3. 유용한 공식

✓ 전해 컨덴서 : 극성(+,-)이 있으며, 원통형 모양





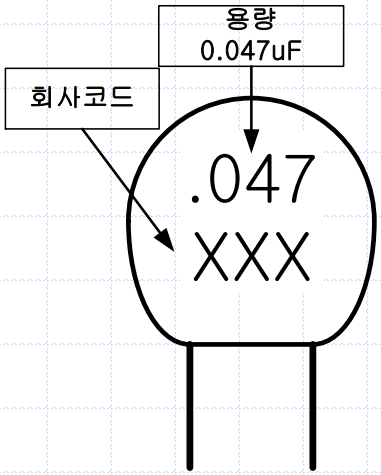
✓ 용량 : 2,200uF
✓ 내압 : 50V



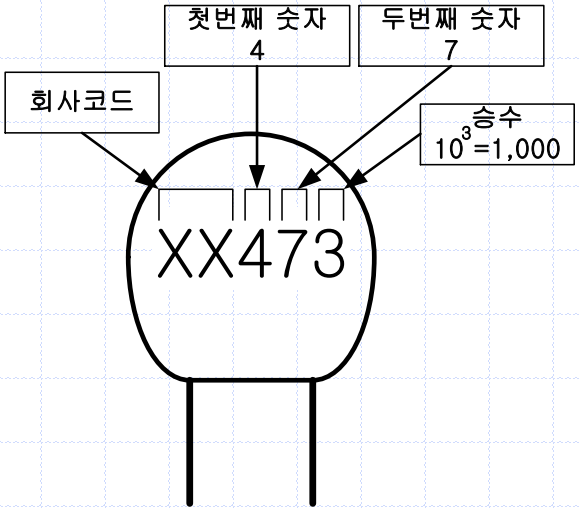
✓ 용량 : 100uF
✓ 내압 : 50V

8-3. 유용한 공식

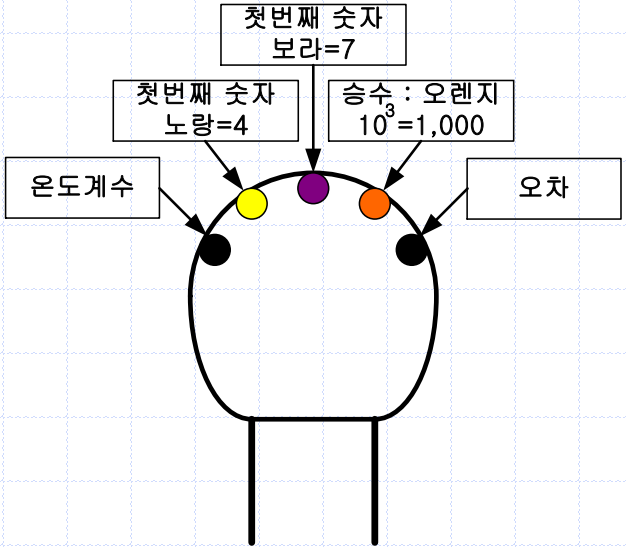
✓ 마일러, 세라믹 컨덴서 : 극성이 없음



47000pF



47000pF



47000pF

8-3. 유용한 공식

✓ 마일러, 세라믹 컨덴서 : 극성이 없음

✓ 용량 : 10,000pF

1	0	3	
▼	▼	▼	
1	0	X1000	pF

✓ 용량 : 47,000pF

4	7	3	
▼	▼	▼	
4	7	X1000	pF

8-3. 유용한 공식

- ✓ 커패시터의 리액턴스

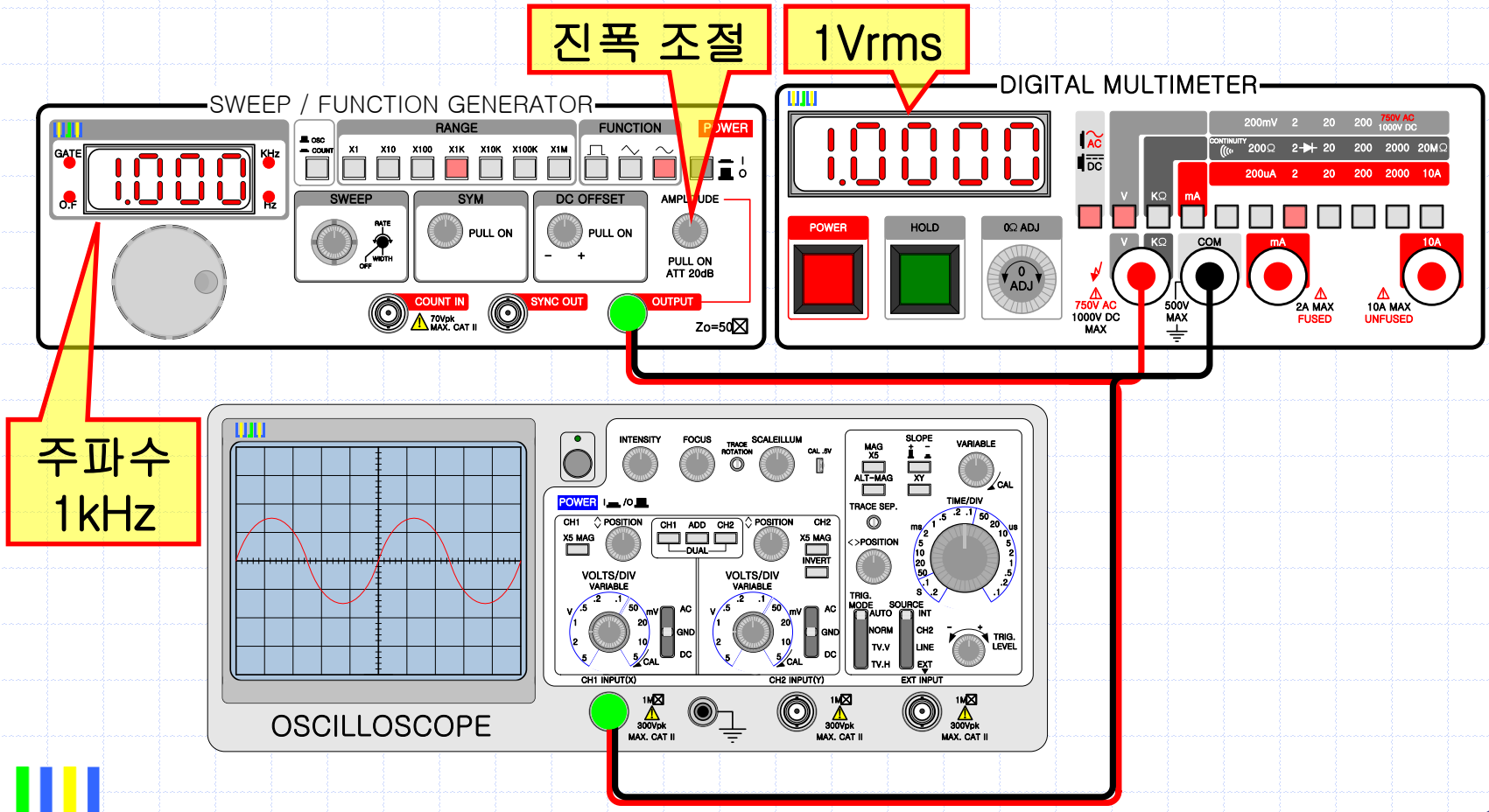
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

- ✓ 각주파수 (ω)

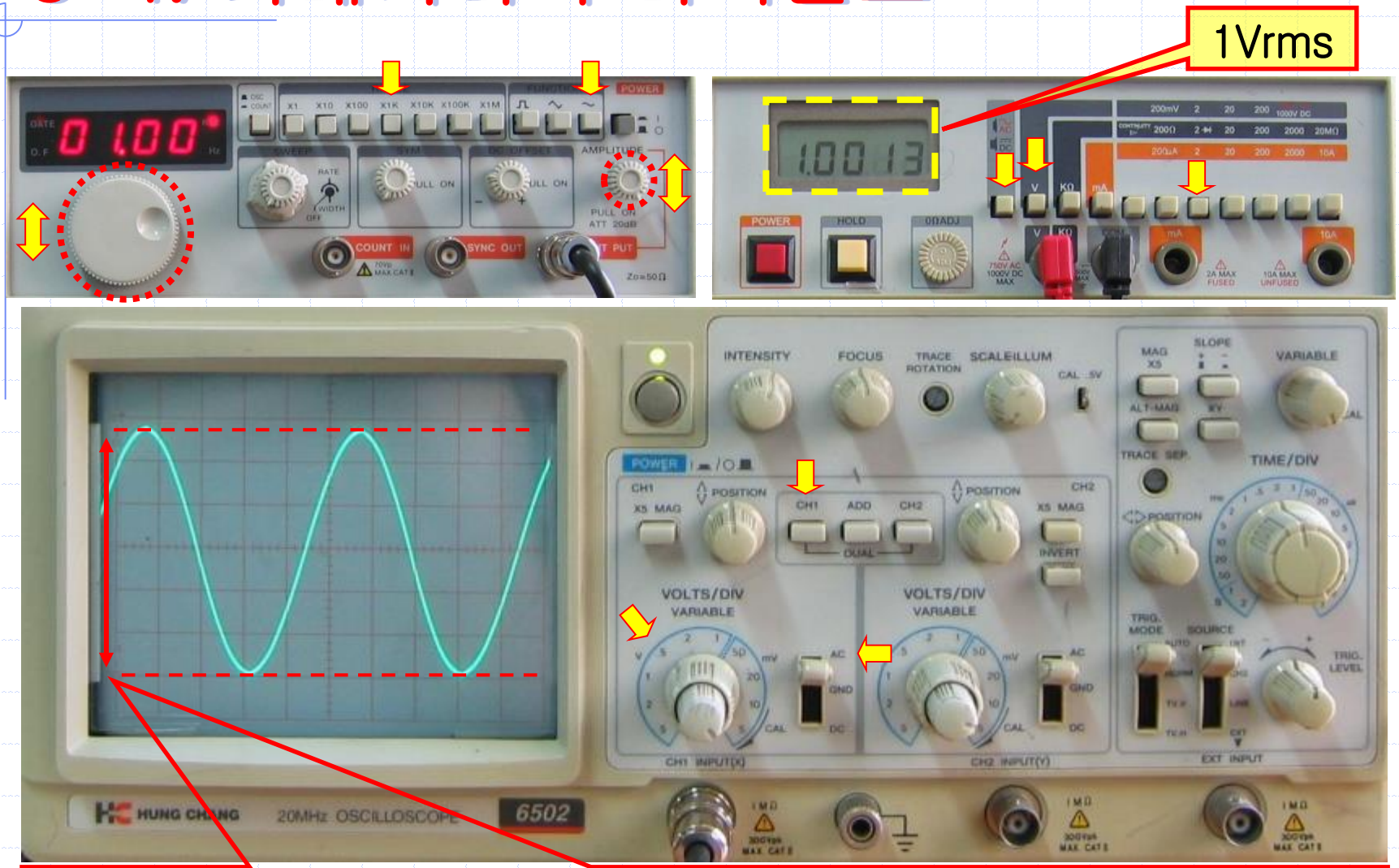
$$\omega = 2\pi f$$

8-4. 커패시터의 리액턴스

- 다음과 같이 회로를 연결하고, 신호발생기를 조절하여 주파수 1kHz, 1Vrms 의 정현파가 나오도록 한다.



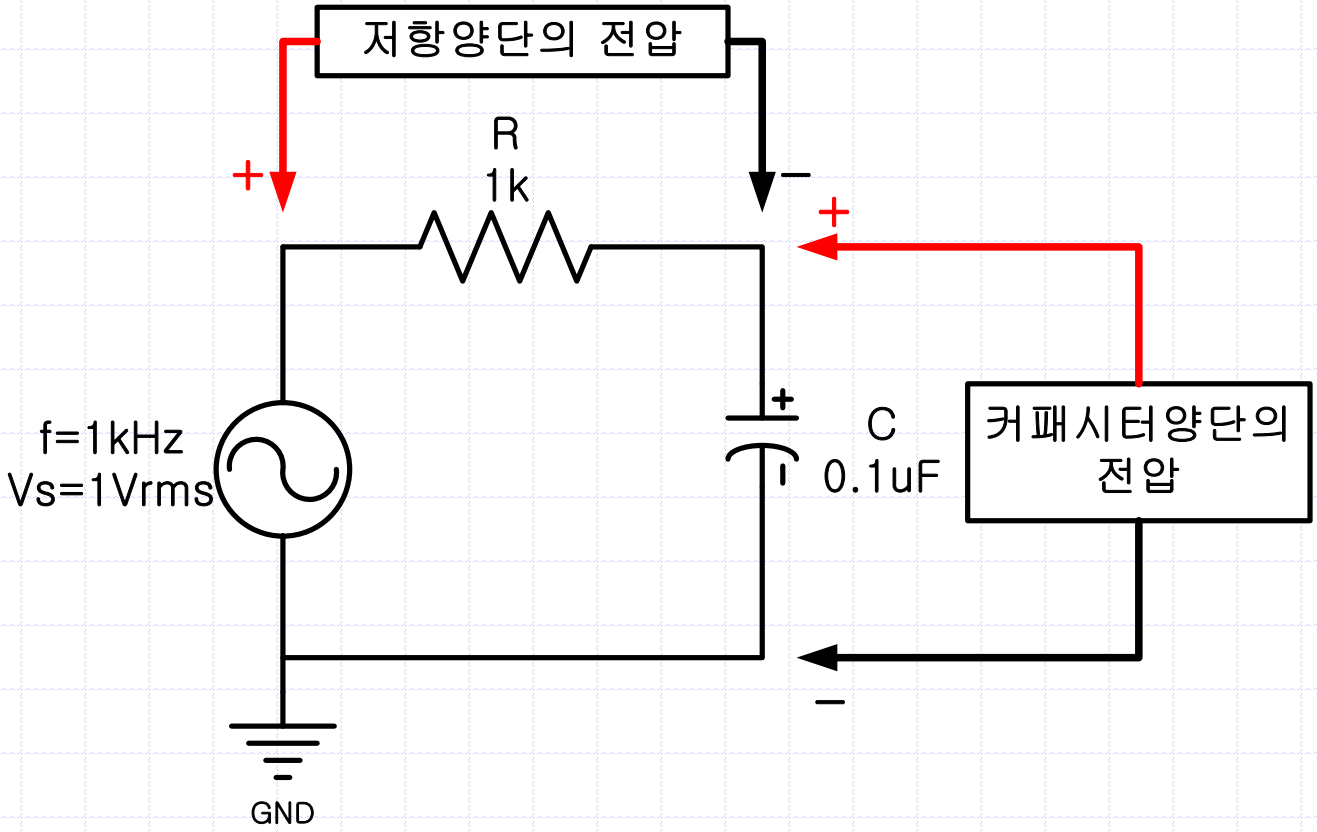
8-4. 커패시터의 리액턴스



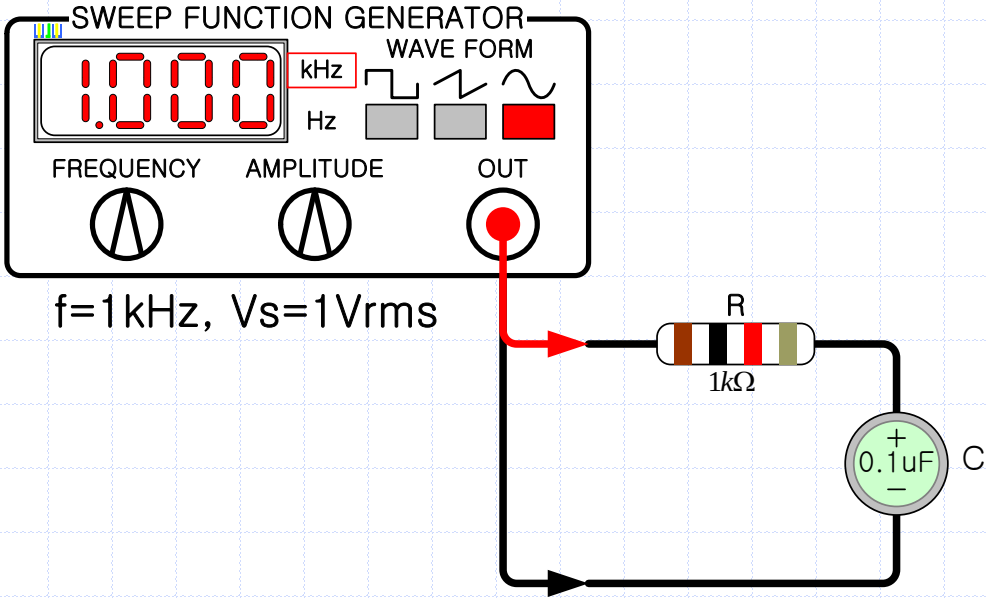
5.6칸X0.5V/DIV=2.8Vpp, 2.8Vpp/2=1.4Vp, 1.4VpX0.707=1Vrms

8-4. 커패시터의 리액턴스

- 다음과 같이 회로를 연결하고, 저항과 커패시터 양단의 전압을 디지털 멀티미터 (DMM) 을 사용하여 측정하라.



8-4. 커패시터의 리액턴스

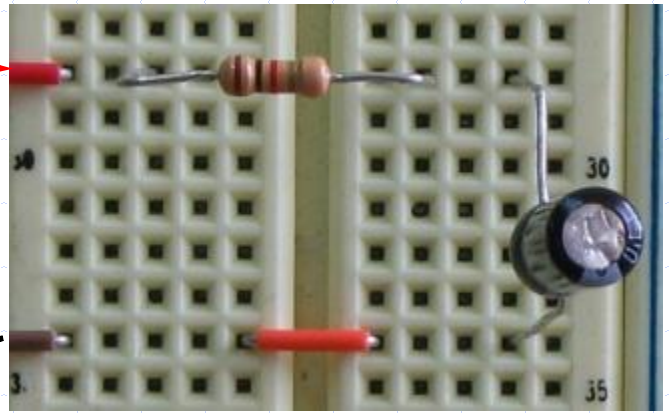


신호발생기

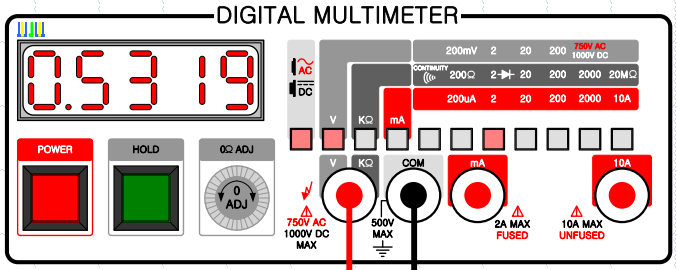
Function Generator

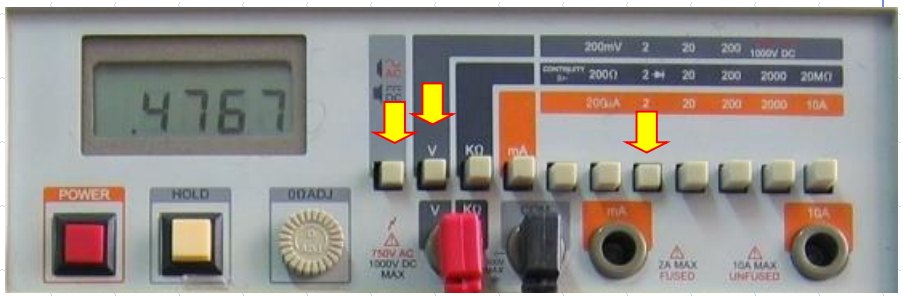
정현파
1kHz
1Vrms

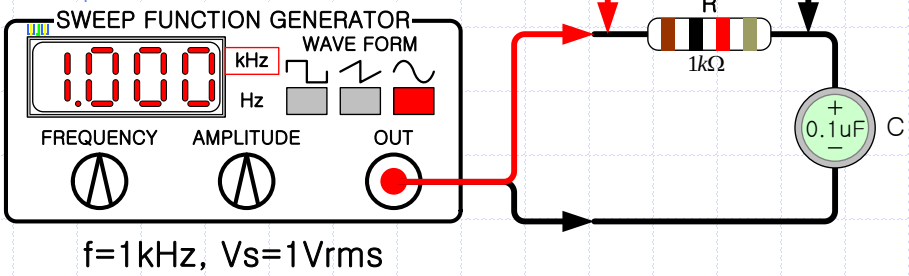
GND



8-4. 커패시터의 리액턴스







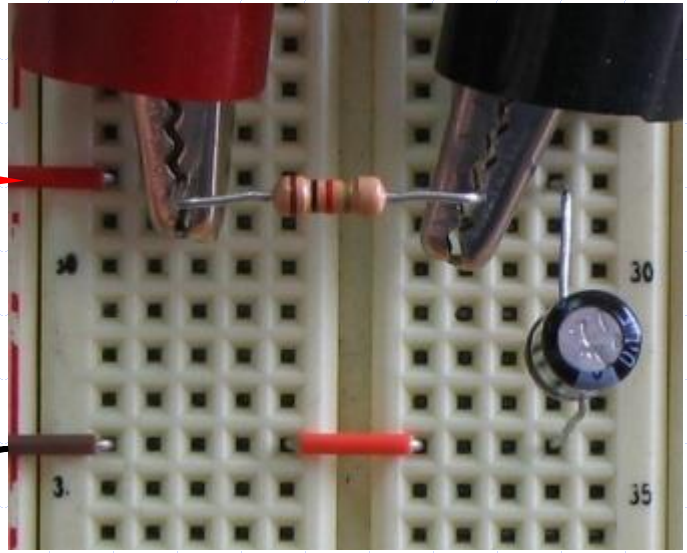
f=1kHz, Vs=1Vrms

신호발생기

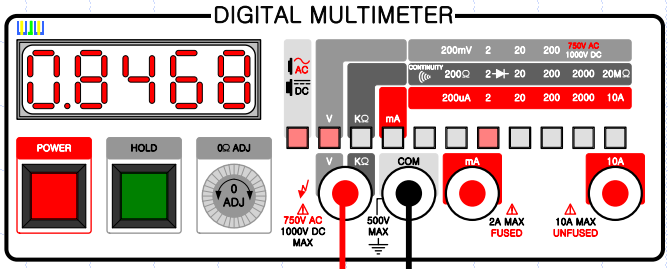
Function Generator

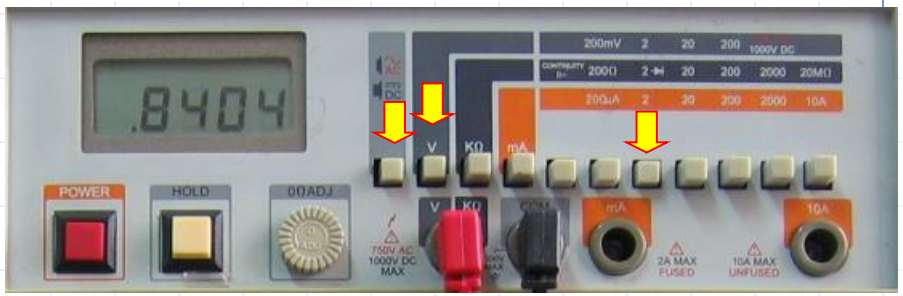
정현파
1kHz
1Vrms

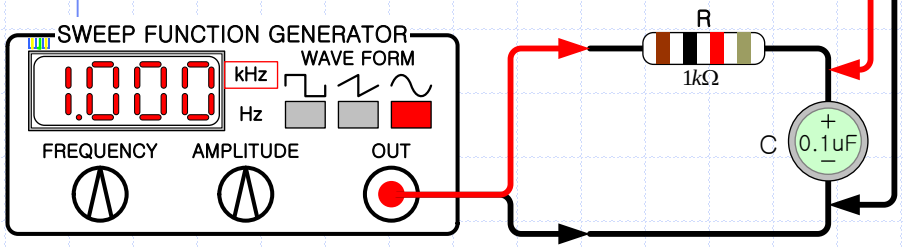
GND



8-4. 커패시터의 리액턴스







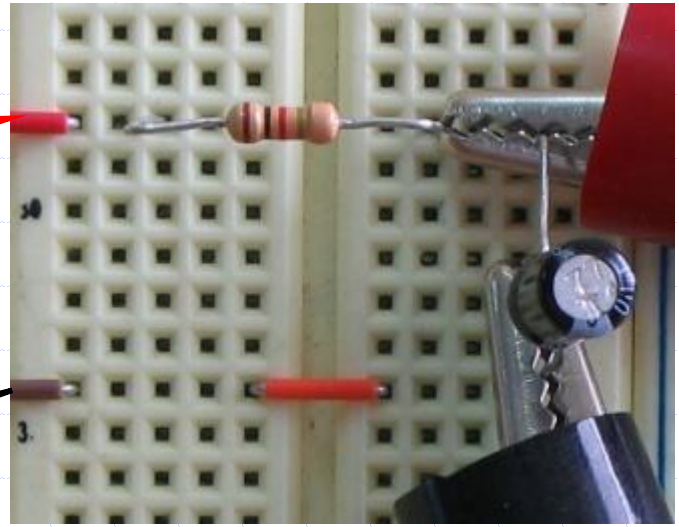
f=1kHz, Vs=1Vrms

신호발생기

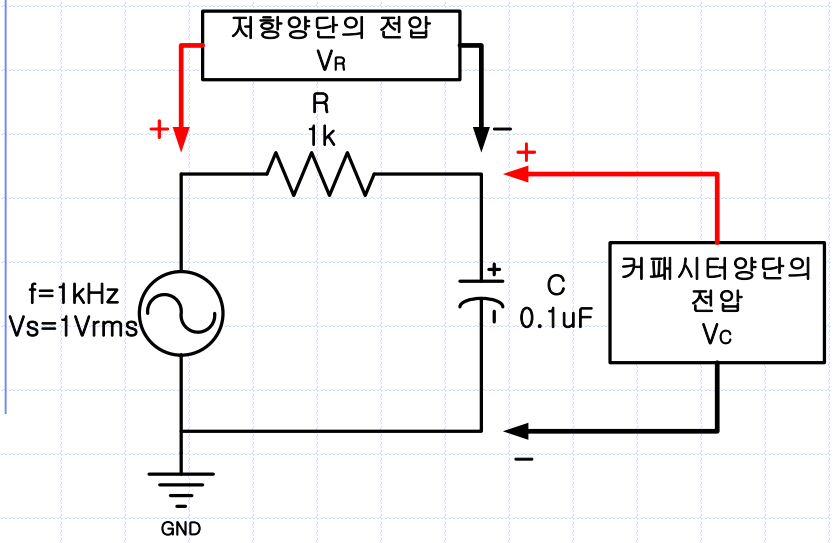
Function Generator

정현파
1kHz
1Vrms

GND



8-4. 커패시터의 리액턴스



$$R = 1{,}000\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$= \frac{1}{2\pi \times 1{,}000Hz \times 0.1 \times 10^{-6} F}$$

$$= 1591.55\Omega$$

$$Z = R - jX_C = 1{,}000 - j1591.55[\Omega]$$

$$= 1879.64\angle -57.88°[\Omega]$$

$$V_R = \frac{R}{R - jX_C} \times v_S = \frac{1{,}000[\Omega]}{1{,}000 - j1591.55[\Omega]} \times 1V_{rms} = \frac{1{,}000\angle 0°[\Omega]}{1879.64\angle -57.88°[\Omega]} \times 1V_{rms}$$

$$= 0.5319\angle 57.88°V_{rms}$$

$$V_C = \frac{jX_C}{R - jX_C} \times v_S = \frac{-j1591.55[\Omega]}{1{,}000 - j1591.55[\Omega]} \times 1V_{rms} = \frac{1591.55\angle -90°[\Omega]}{1879.64\angle -57.88°[\Omega]} \times 1V_{rms}$$

$$= 0.8468\angle -32.12°V_{rms}$$

8-4. 커패시터의 리액턴스

$V_R(\text{이론}) = 0.5319V$

$V_C(\text{이론}) = 0.8468V$

$$I_T(\text{이론}) = \frac{V_R}{R} = \frac{0.5319V}{1k\Omega} = 0.5319mA$$

$$X_C(\text{이론}) = \frac{V_C}{I_T} = \frac{0.8468V}{0.5319mA} = 1592\Omega$$

$$C(\text{이론}) = \frac{1}{2\pi f X_C}$$

$$= \frac{1}{2\pi \times 1{,}000Hz \times 1592\Omega}$$

$$= 0.1\mu F$$

$V_R(\text{실험}) = 0.4767V$

$V_C(\text{실험}) = 0.8404V$

$$I_T(\text{실험}) = \frac{V_R}{R} = \frac{0.4767V}{1k\Omega} = 0.4767mA$$

$$X_C(\text{실험}) = \frac{V_C}{I_T} = \frac{0.8404V}{0.4767mA} = 1762.95\Omega$$

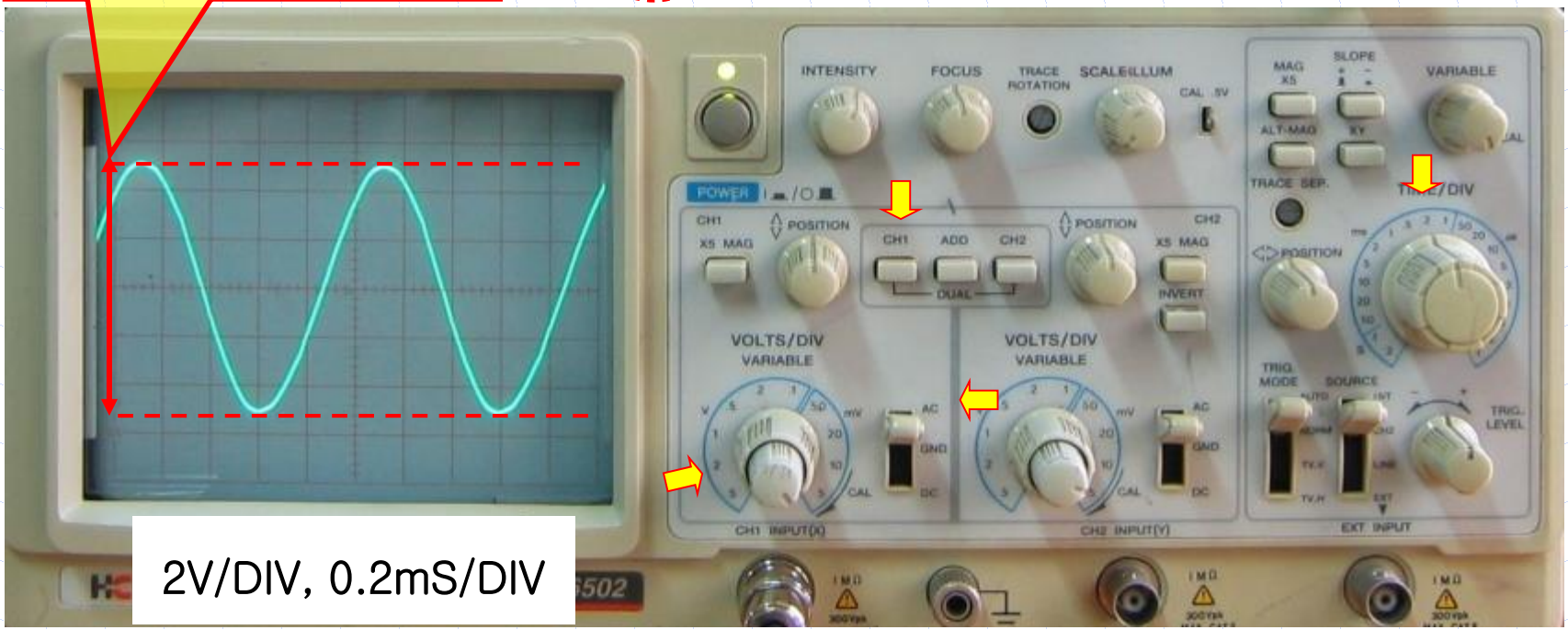
$$C(\text{실험}) = \frac{1}{2\pi f X_C}$$

$$= \frac{1}{2\pi \times 1{,}000Hz \times 1762.95\Omega}$$

$$= 0.0903\mu F$$

8-5A. 주파수에 따른 커패시터의 특성

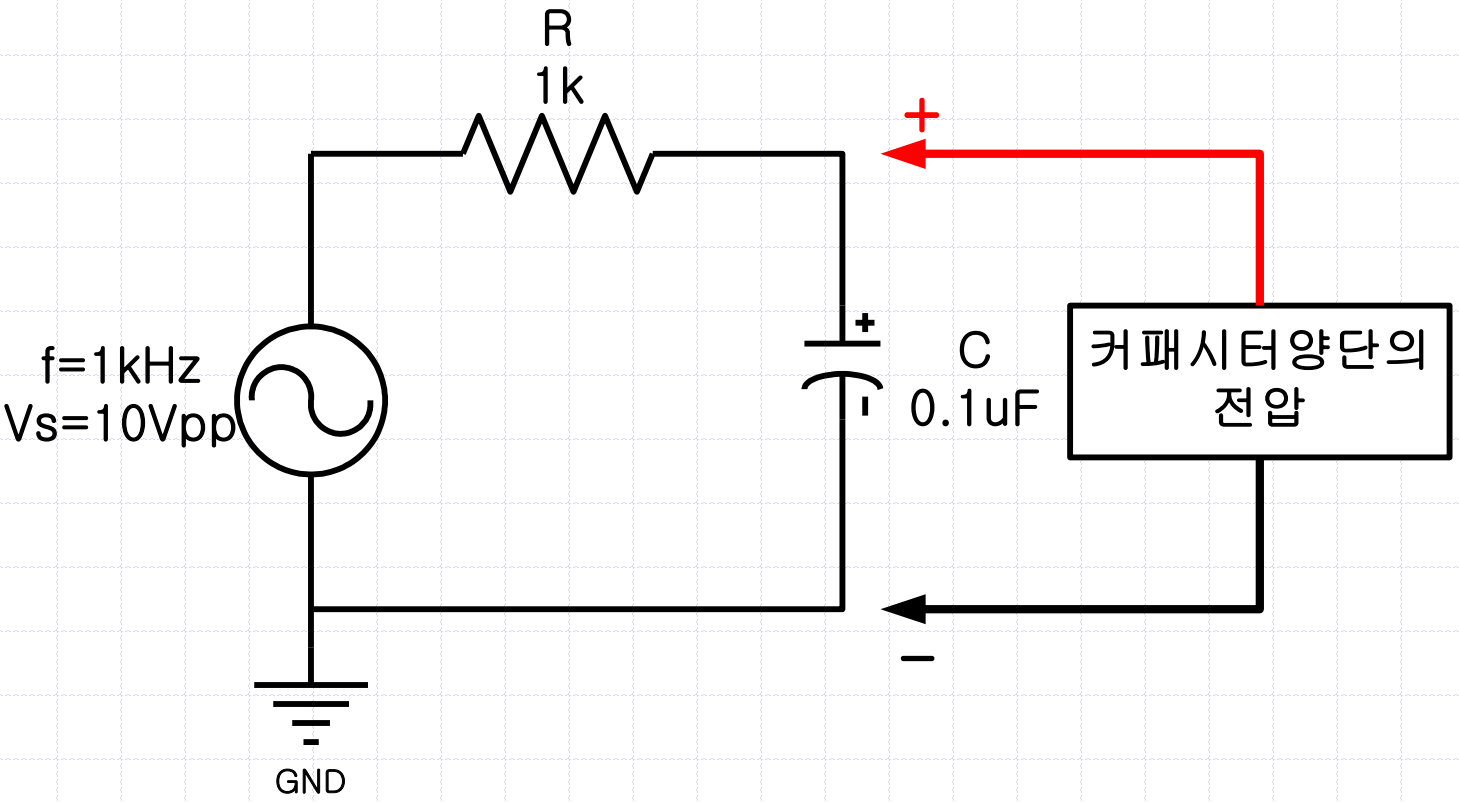
5칸X2V/DIV=10Vpp



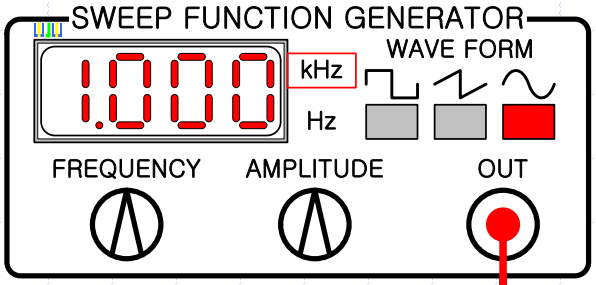
2V/DIV, 0.2mS/DIV

8-5A. 주파수에 따른 커패시터의 특성

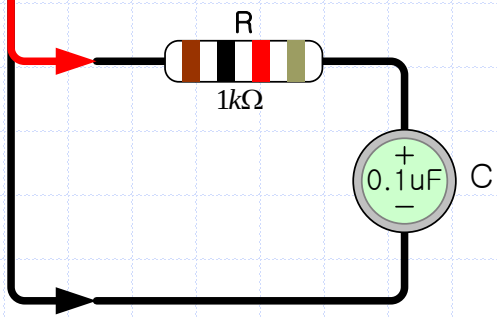
- 다음과 같이 회로를 연결하고, 커패시터 양단의 전압을 오실로스코프를 사용하여 측정하라.



8-5A. 주파수에 따른 커패시터의 특성



f=1kHz, Vs=10Vpp

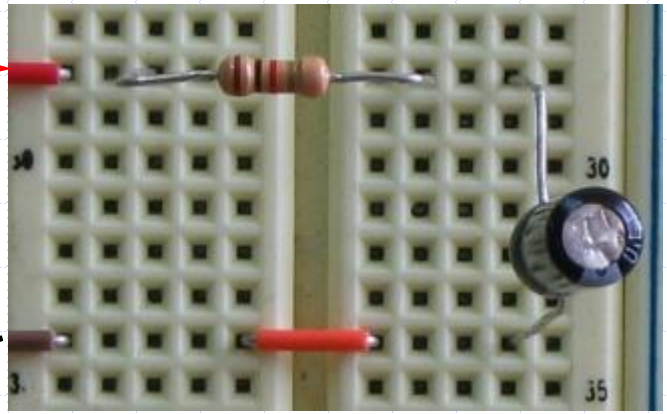


신호발생기

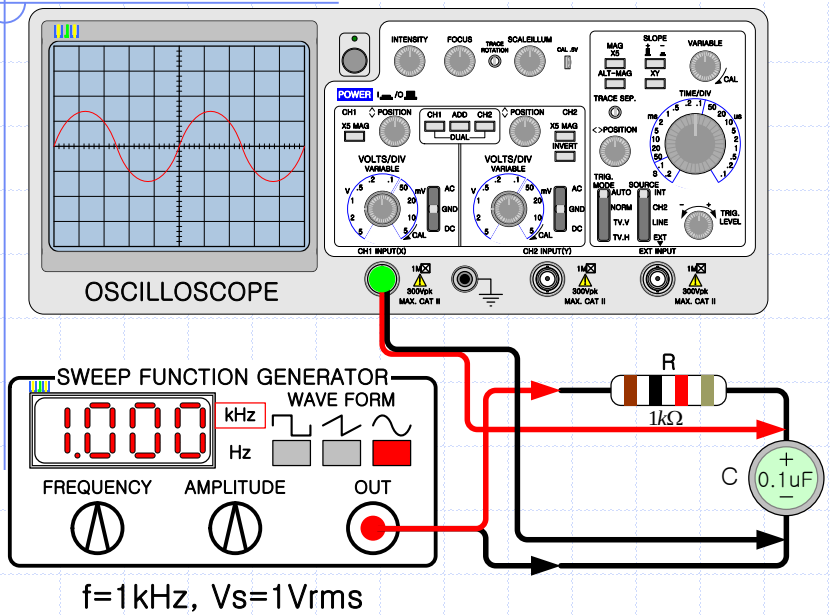
Function Generator

정현파
1kHz
10Vpp

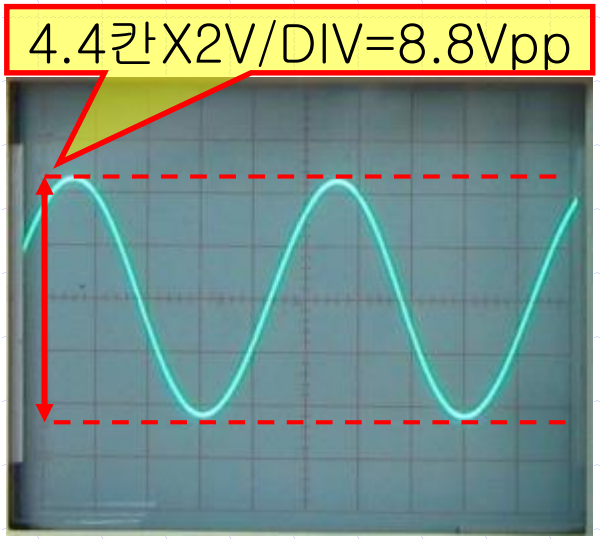
GND



8-5A. 주파수에 따른 커패시터의 특성



f=1kHz, Vs=1Vrms



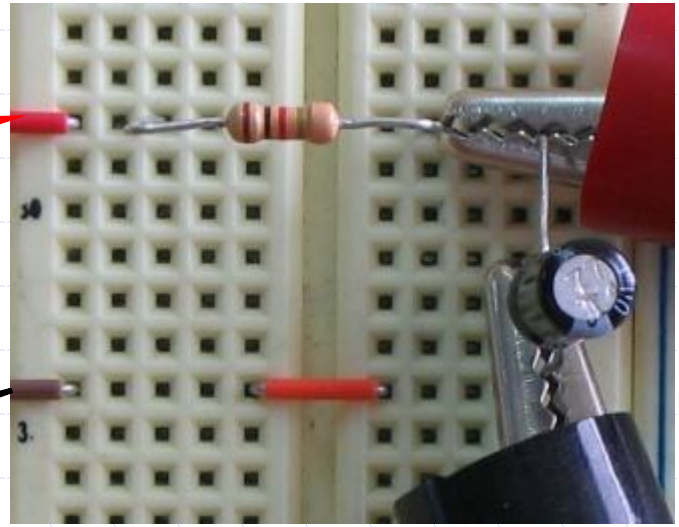
1V/DIV, 0.2mS/DIV

신호발생기

Function Generator

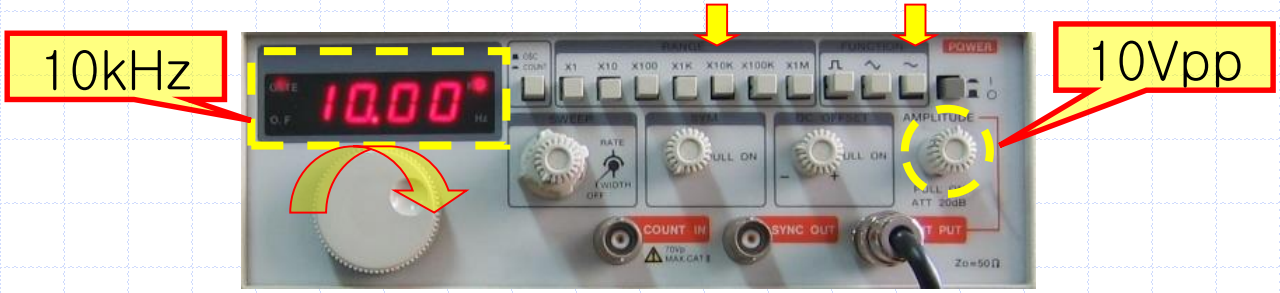
정현파
1kHz
10Vpp

GND

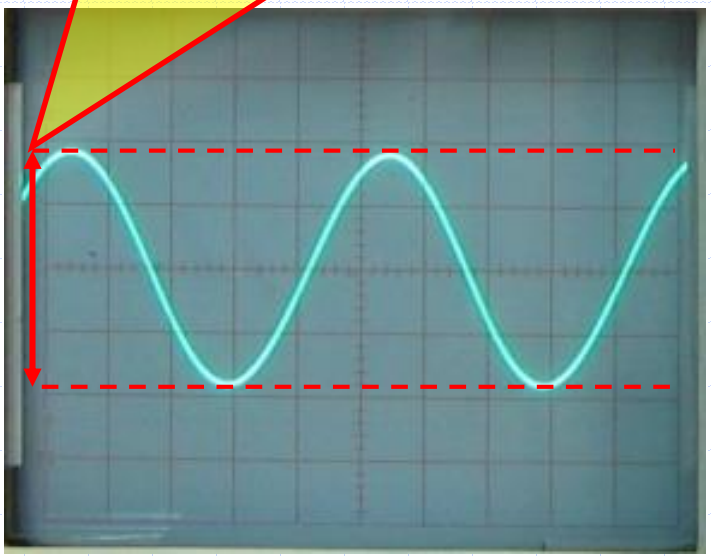


8-5A. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 10kHz로 변경하고, 측정을 반복한다.



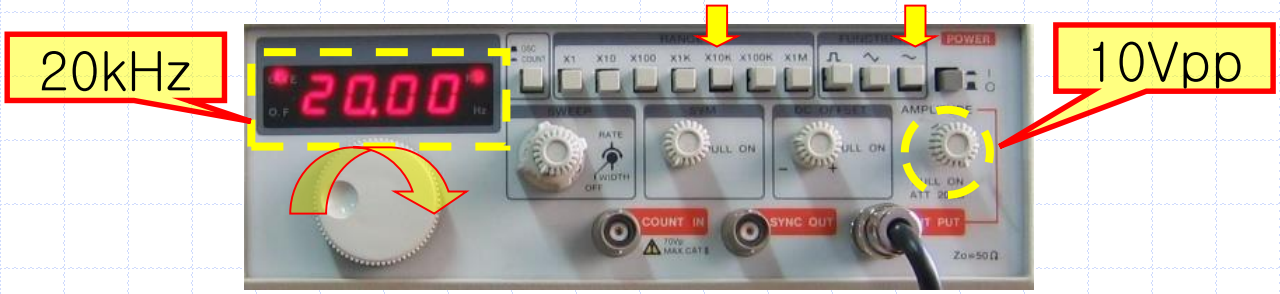
Vc : 3.6칸X0.5V/DIV=1.8Vpp



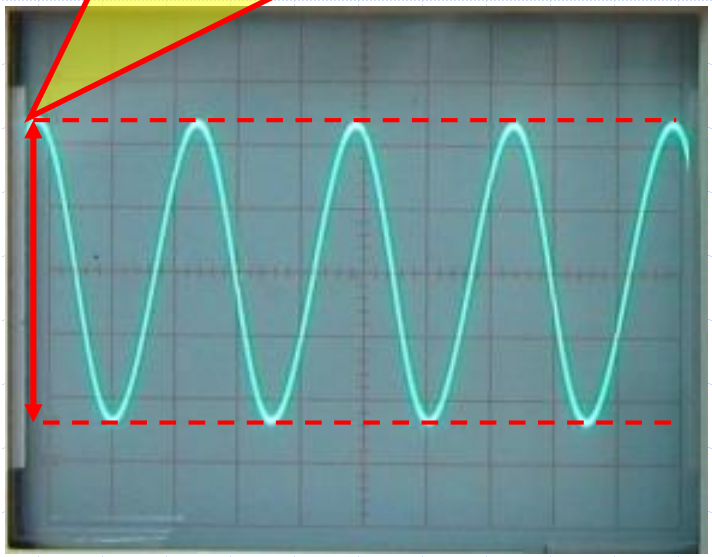
0.5V/DIV, 20uS/DIV

8-5A. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 20kHz로 변경하고, 측정을 반복한다.



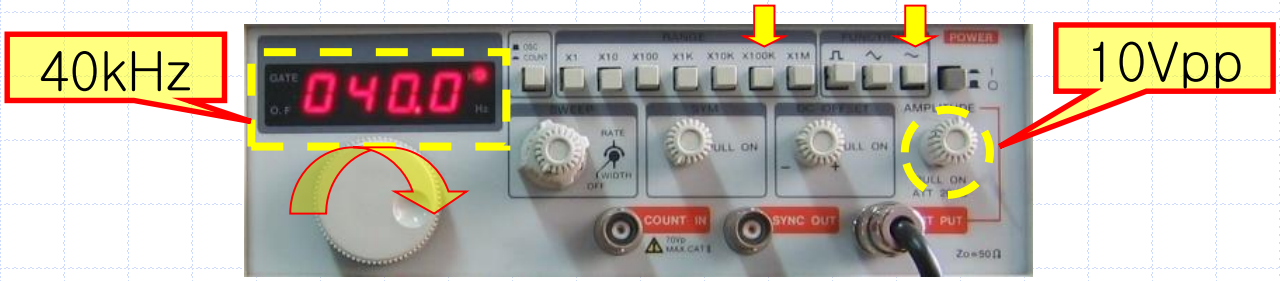
Vc : 4.4칸X0.2V/DIV=0.88Vpp



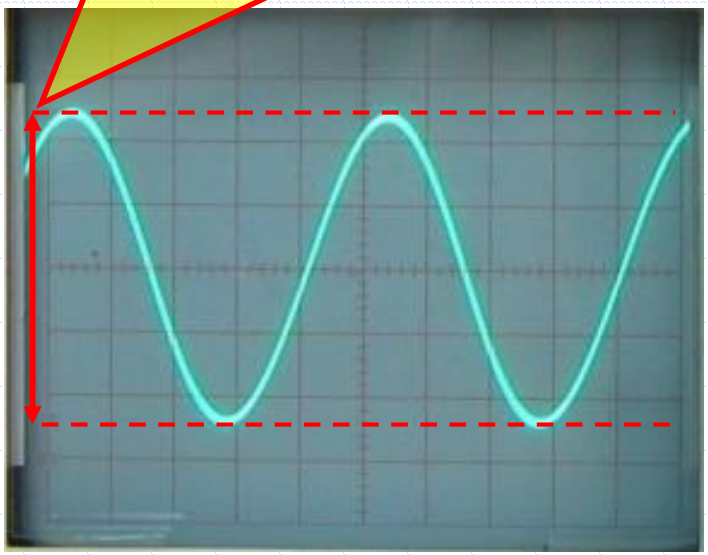
0.2V/DIV, 20uS/DIV

8-5A. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 40kHz로 변경하고, 측정을 반복한다.



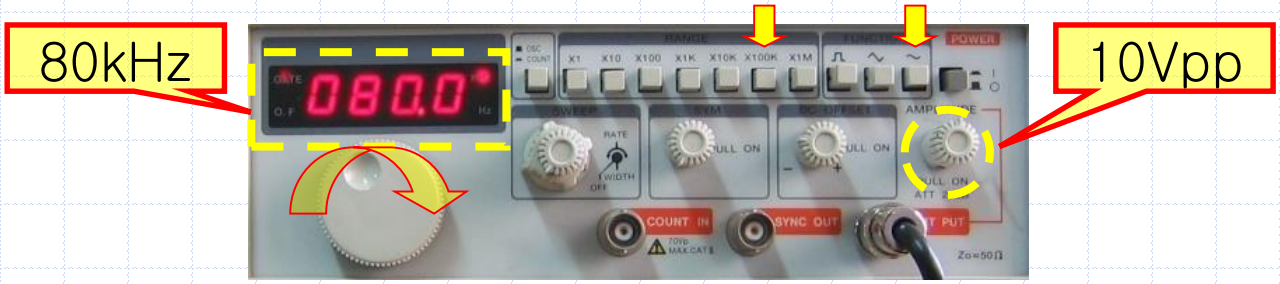
Vc : 4.8칸X0.1V/DIV=0.48Vpp



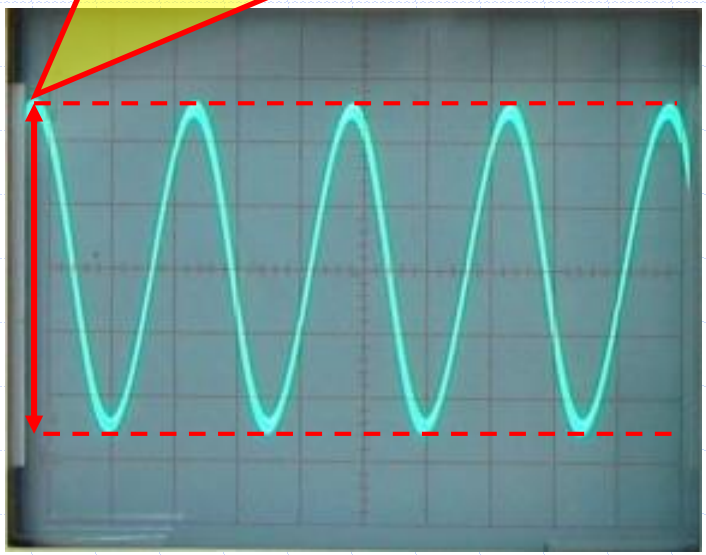
0.1V/DIV, 5uS/DIV

8-5A. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 80kHz로 변경하고, 측정을 반복한다.



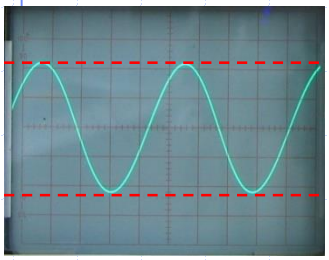
Vc : 5.2칸X50mV/DIV=0.26Vpp



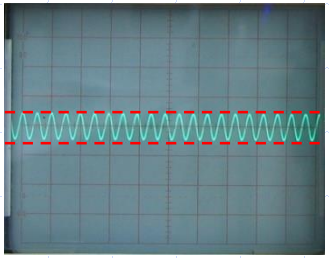
50mV/DIV, 2uS/DIV

8-5A. 주파수에 따른 커패시터의 특성

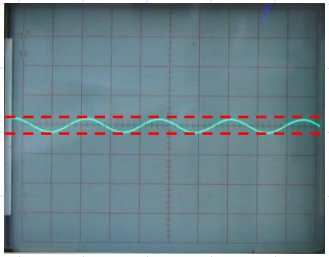
V_C 의 변화를 2V/DIV의 같은 크기로 비교



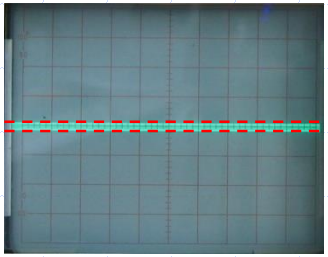
1kHz
이론 : 8.47Vpp
실험 : 8.80Vpp



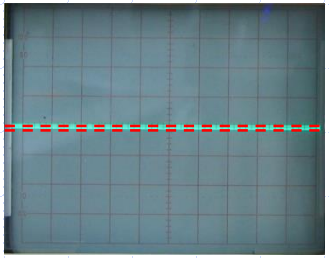
10kHz
이론 : 1.57Vpp
실험 : 1.80Vpp



20kHz
이론 : 0.794Vpp
실험 : 0.88Vpp



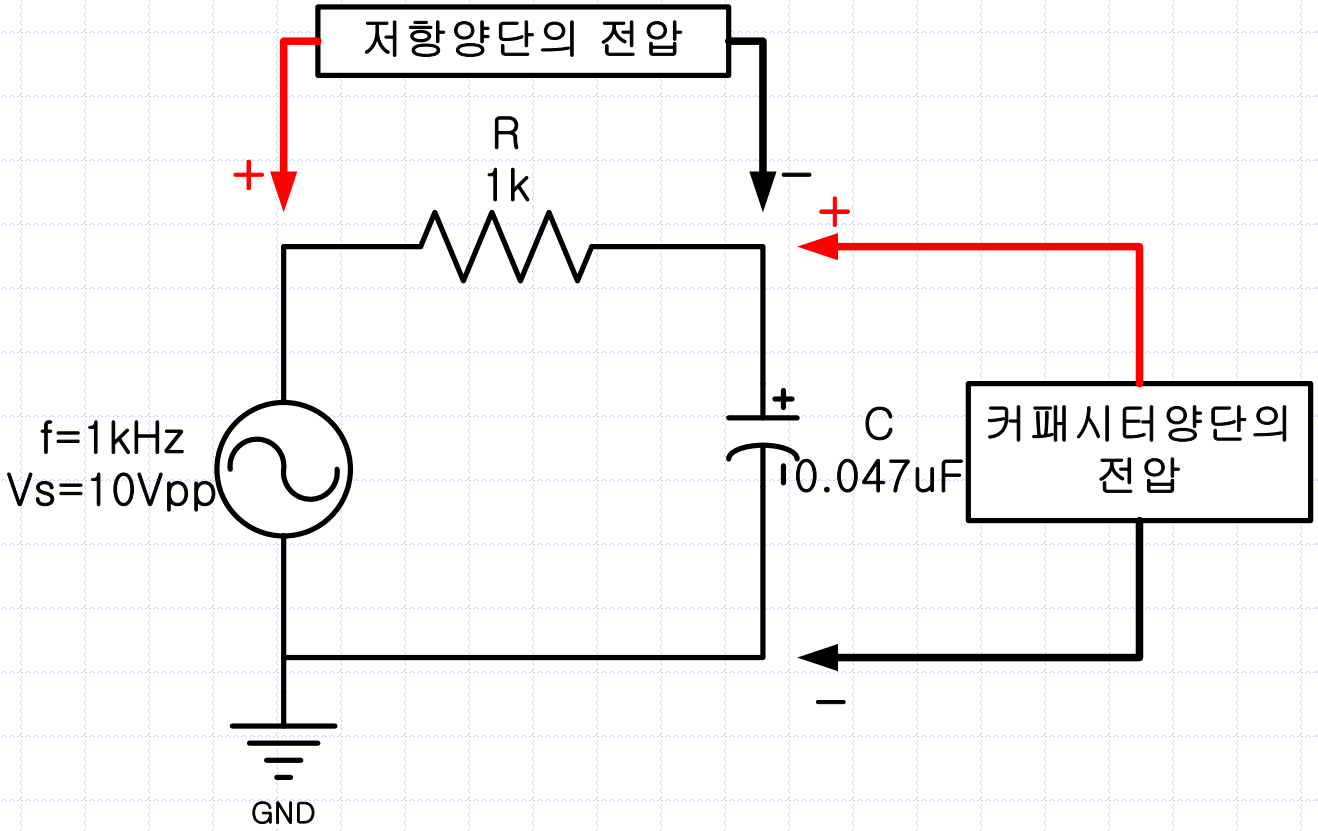
40kHz
이론 : 0.398Vpp
실험 : 0.48Vpp



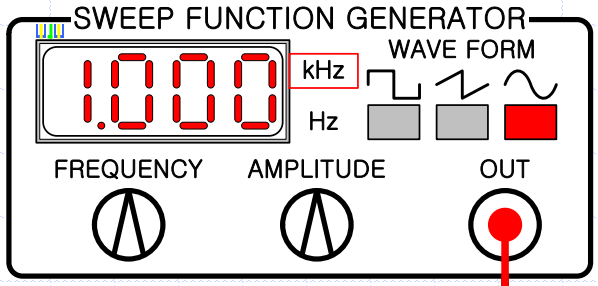
80kHz
이론 : 0.199Vpp
실험 : 0.26Vpp

8-5B. 주파수에 따른 커패시터의 특성

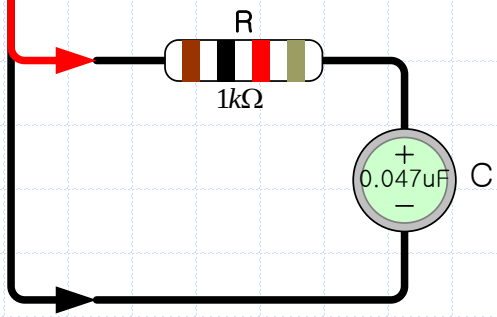
- ✓ 앞의 실험을 커패시터를 0.047uF 으로 바꾸어서 측정하라.



8-5B. 주파수에 따른 커패시터의 특성



f=1kHz, Vs=10Vpp

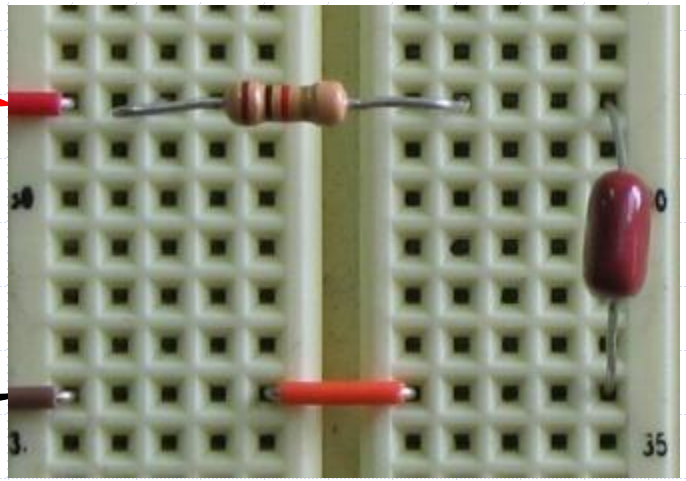


신호발생기

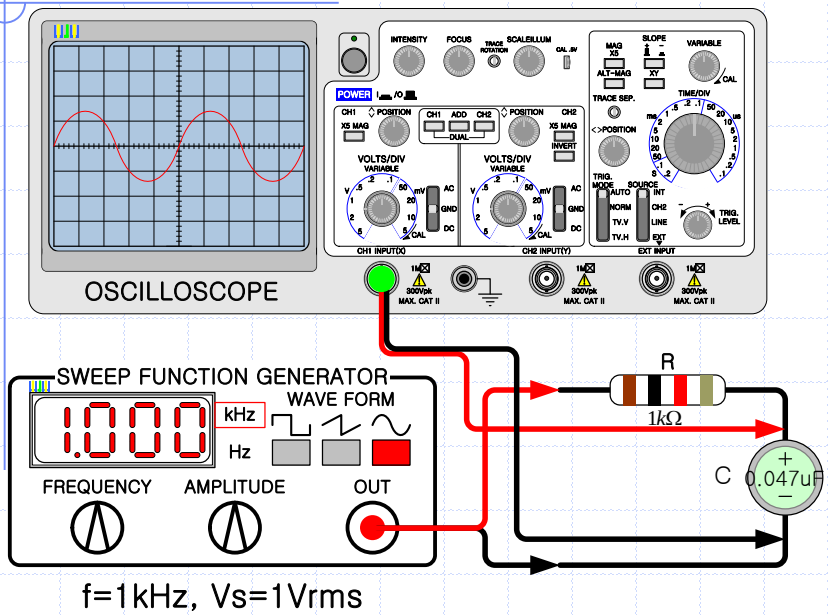
Function Generator

정현파
1kHz
10Vpp

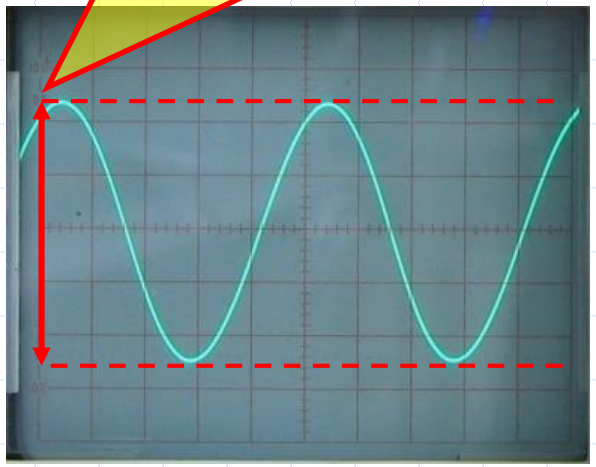
GND



8-5B. 주파수에 따른 커패시터의 특성



f=1kHz, Vs=1Vrms



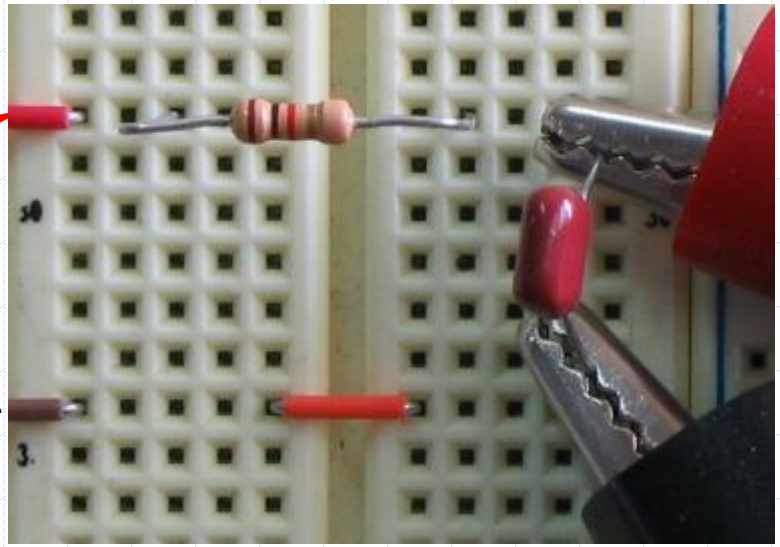
2V/DIV, 0.2mS/DIV

신호발생기

Function Generator

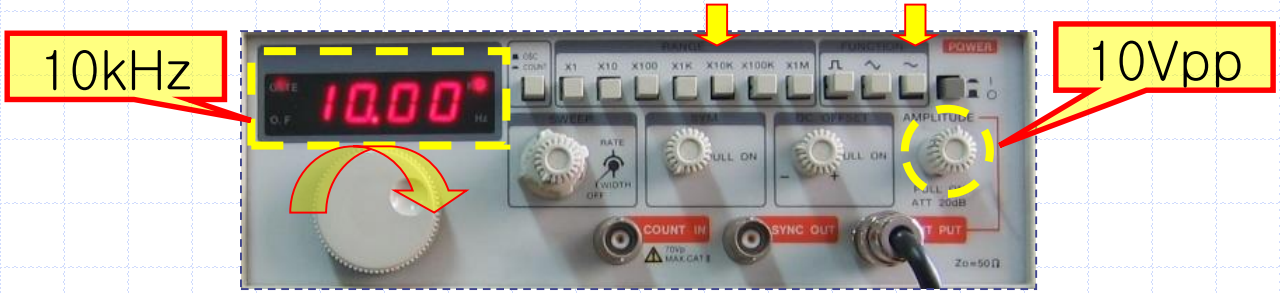
정현파
1kHz
10Vpp

GND

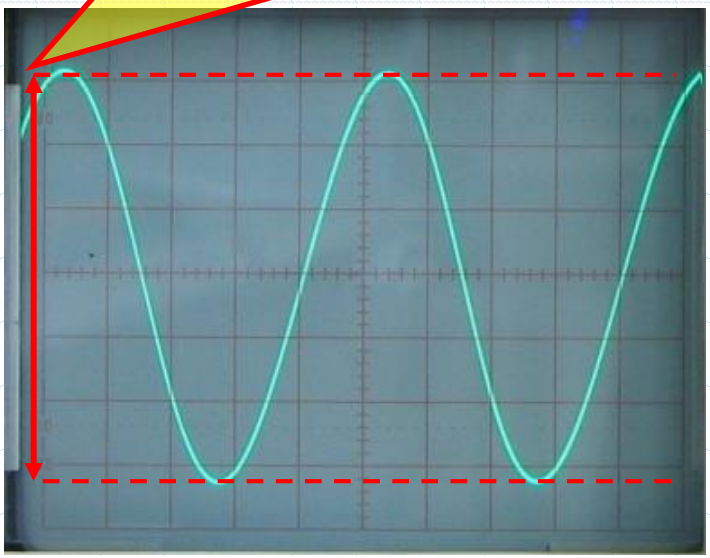


8-5B. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 10kHz로 변경하고, 측정을 반복한다.



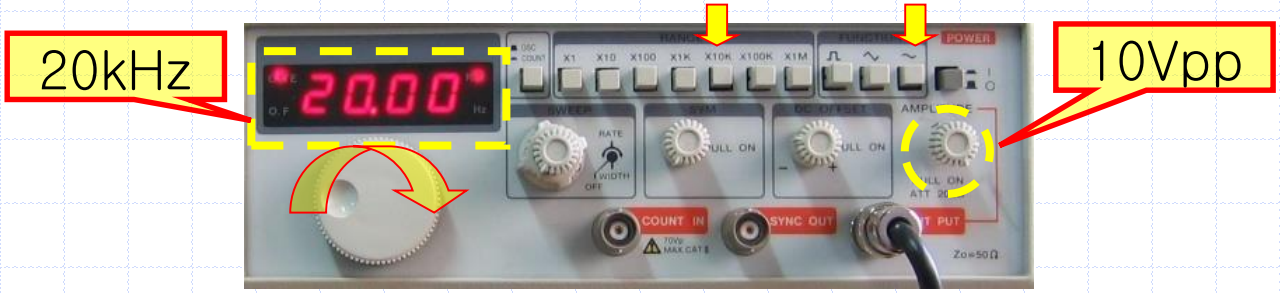
Vc : 6.5칸X0.5V/DIV=3.25Vpp



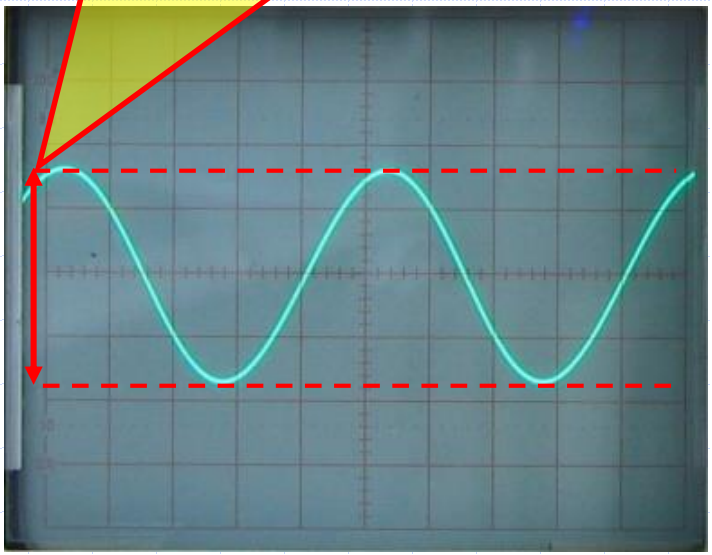
0.5V/DIV, 20uS/DIV

8-5B. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 20kHz로 변경하고, 측정을 반복한다.



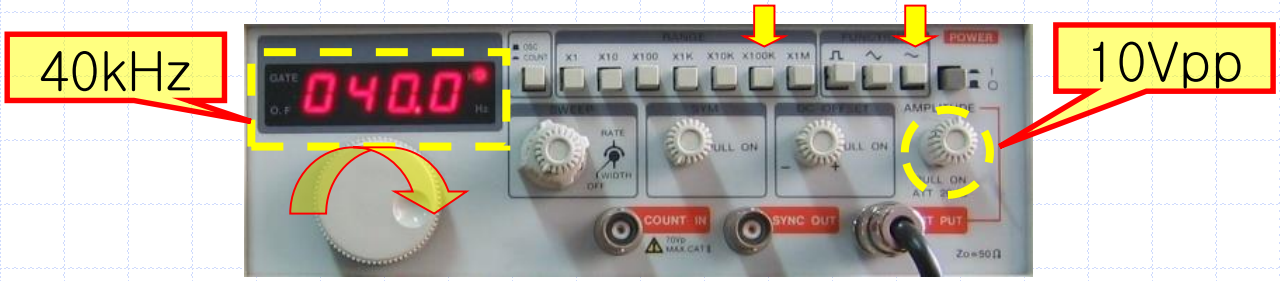
Vc : 3.3칸X0.5V/DIV=1.65Vpp



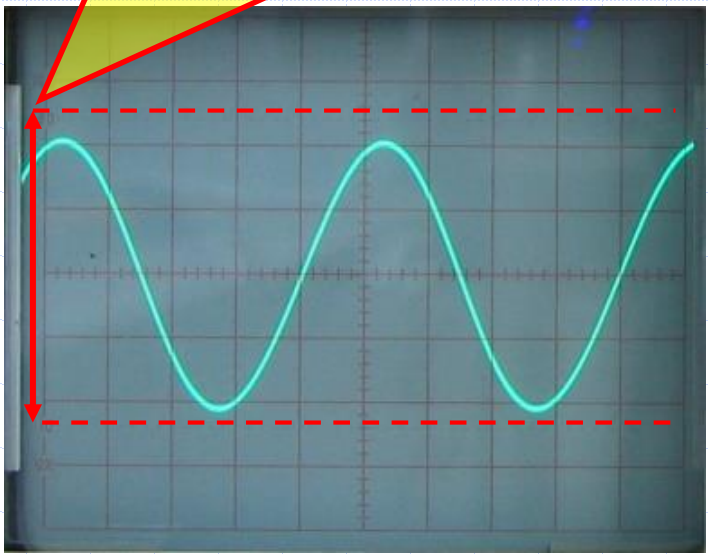
0.5V/DIV, 10uS/DIV

8-5B. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 40kHz로 변경하고, 측정을 반복한다.



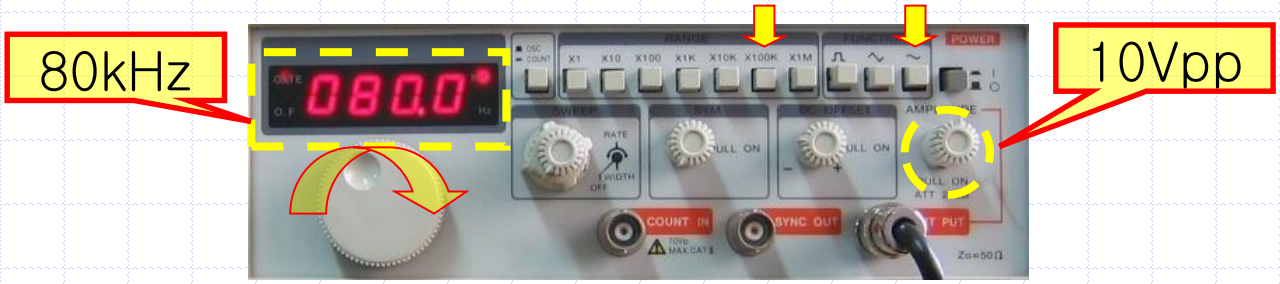
Vc : 4.2칸X0.2V/DIV=0.84Vpp



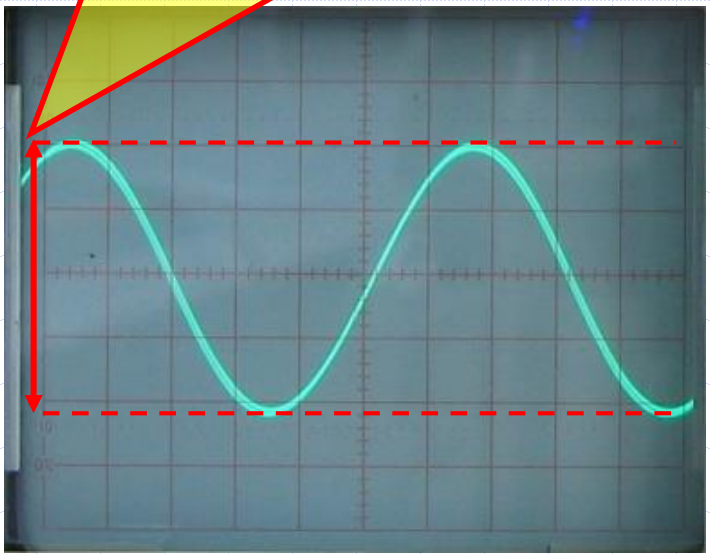
0.2V/DIV, 5uS/DIV

8-5B. 주파수에 따른 커패시터의 특성

- ✓ 주파수를 80kHz로 변경하고, 측정을 반복한다.



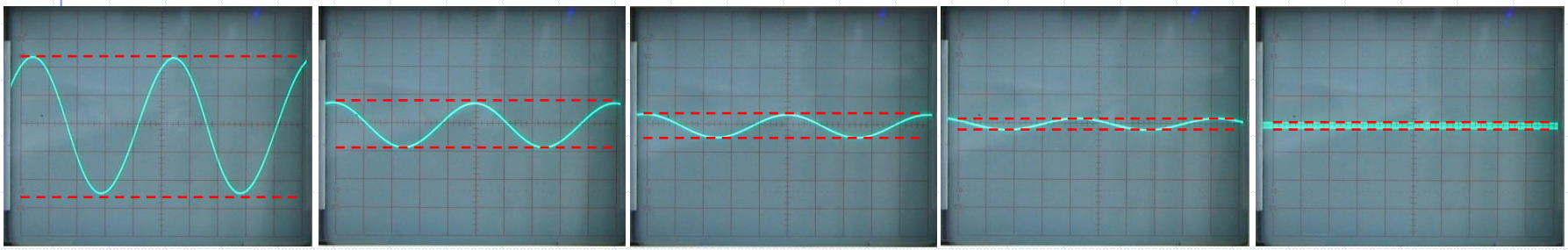
Vc : 4.2칸X0.1V/DIV=0.42Vpp



0.1V/DIV, 2uS/DIV

8-5B. 주파수에 따른 커패시터의 특성

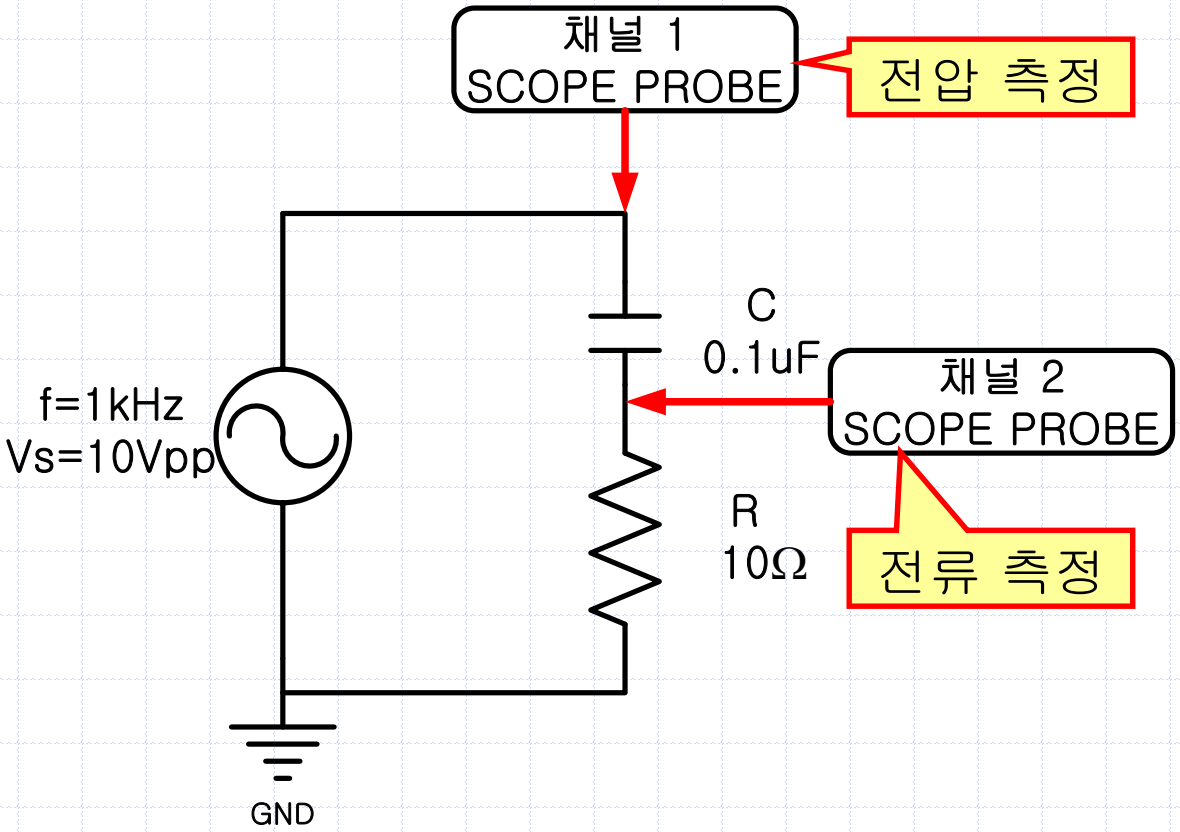
V_C 의 변화를 2V/DIV의 같은 크기로 비교



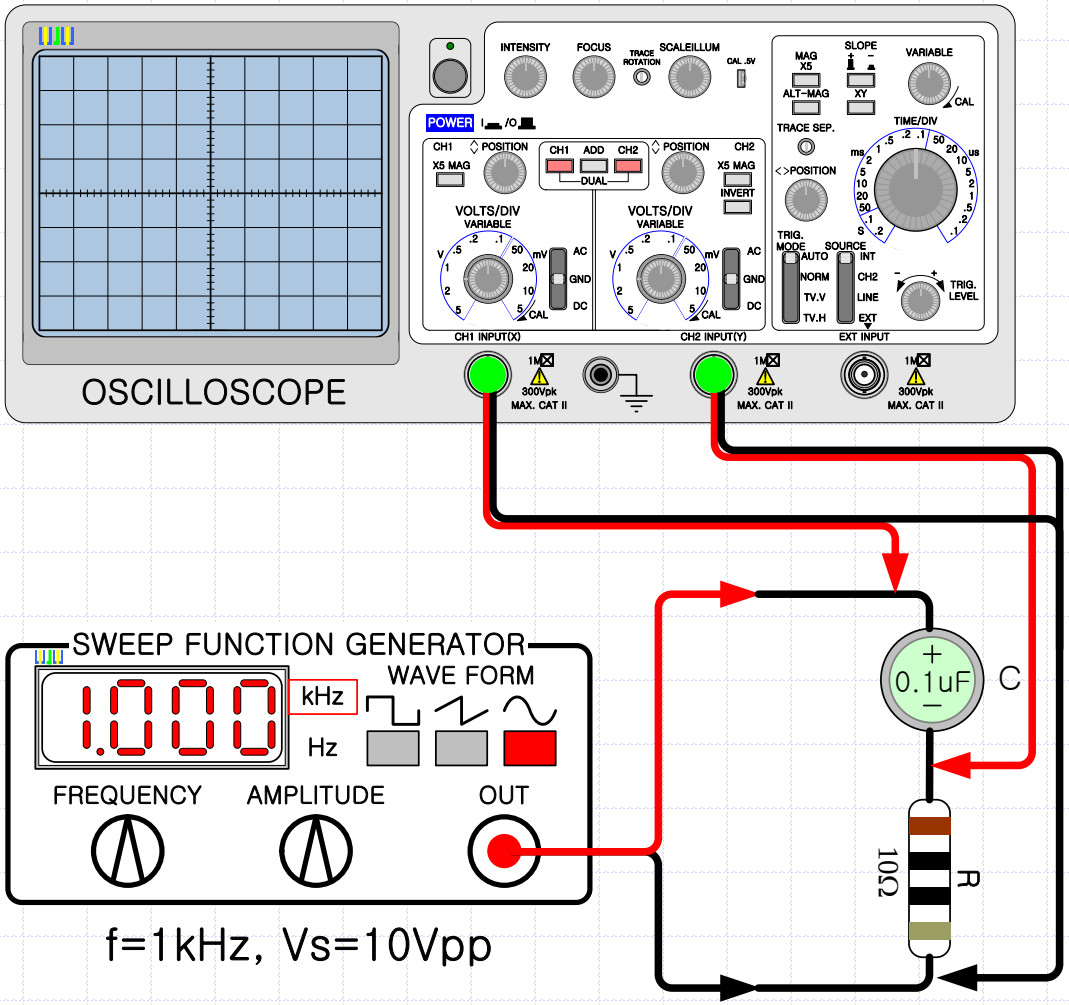
1kHz	10kHz	20kHz	40kHz	80kHz
이론 : 9.59Vpp	이론 : 3.21Vpp	이론 : 1.67Vpp	이론 : 0.84Vpp	이론 : 0.338Vpp
실험 : 9.60Vpp	실험 : 3.25Vpp	실험 : 1.65Vpp	실험 : 0.84Vpp	실험 : 0.420Vpp

8-6. 커패시터의 전압, 전류 위상차

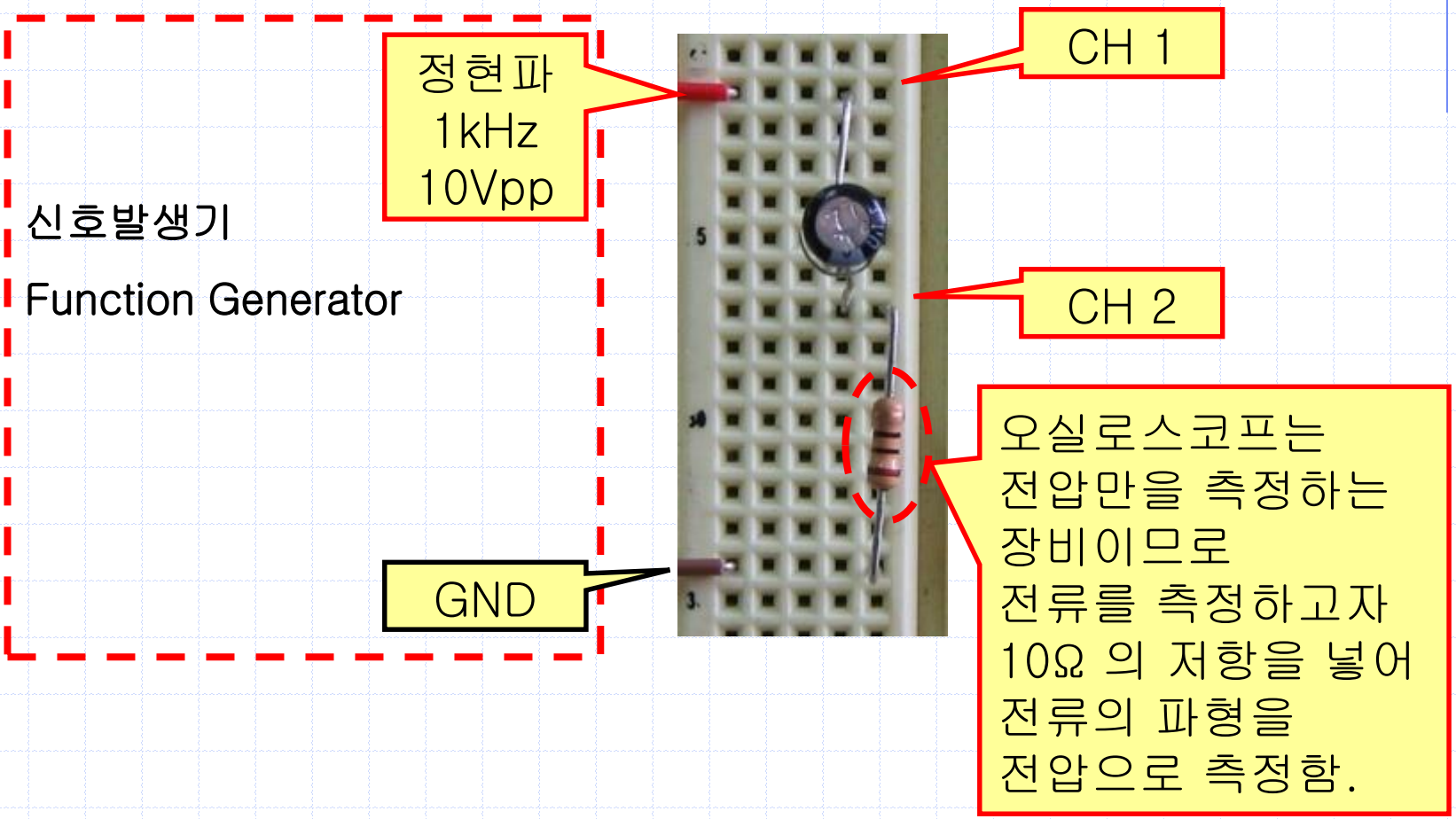
- 아래와 같이 회로를 연결하고, 오실로스코프의 CH 1과 CH 2를 이용하여 측정하라.



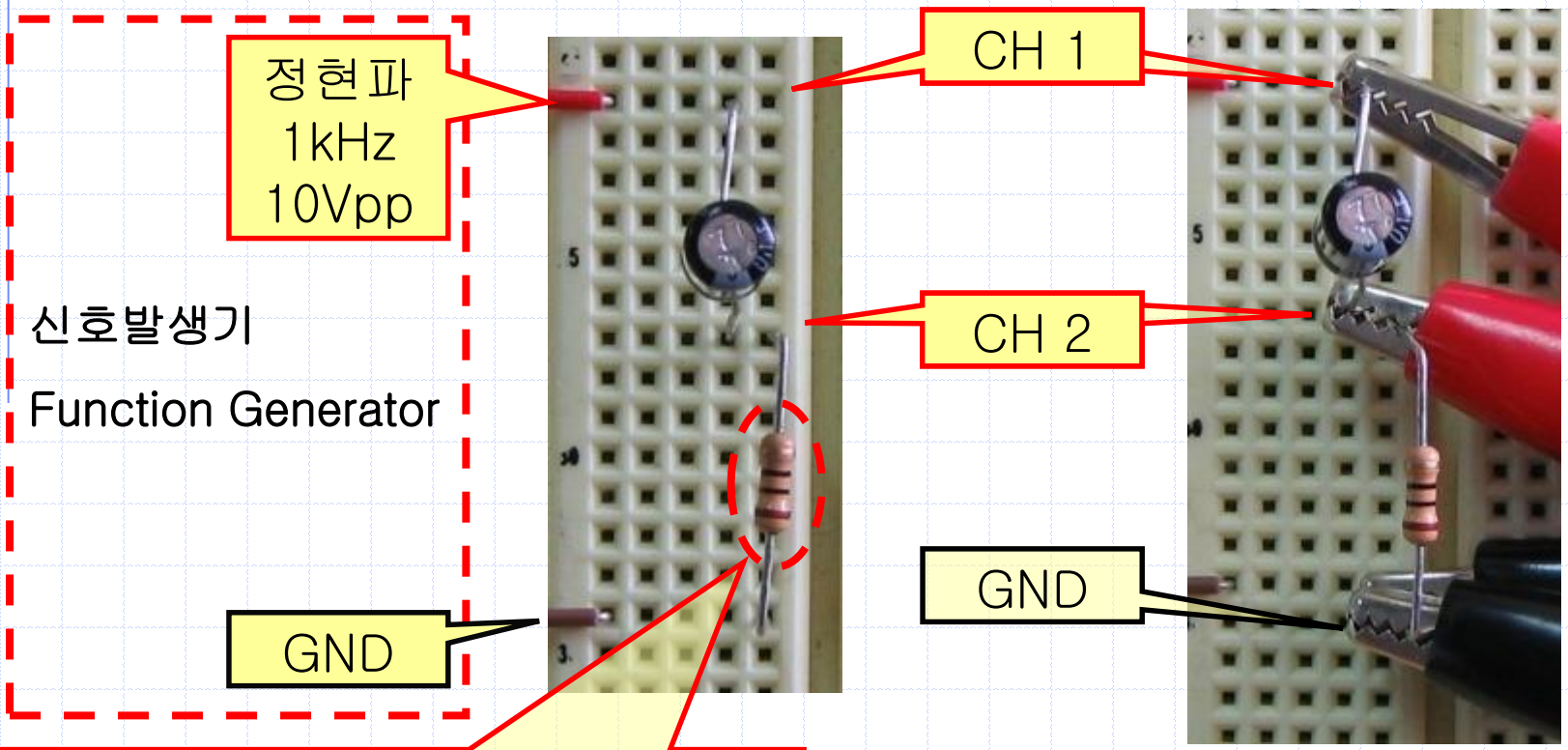
8-6. 커패시터의 전압, 전류 위상차



8-6. 커패시터의 전압, 전류 위상차



8-6. 커패시터의 전압, 전류 위상차

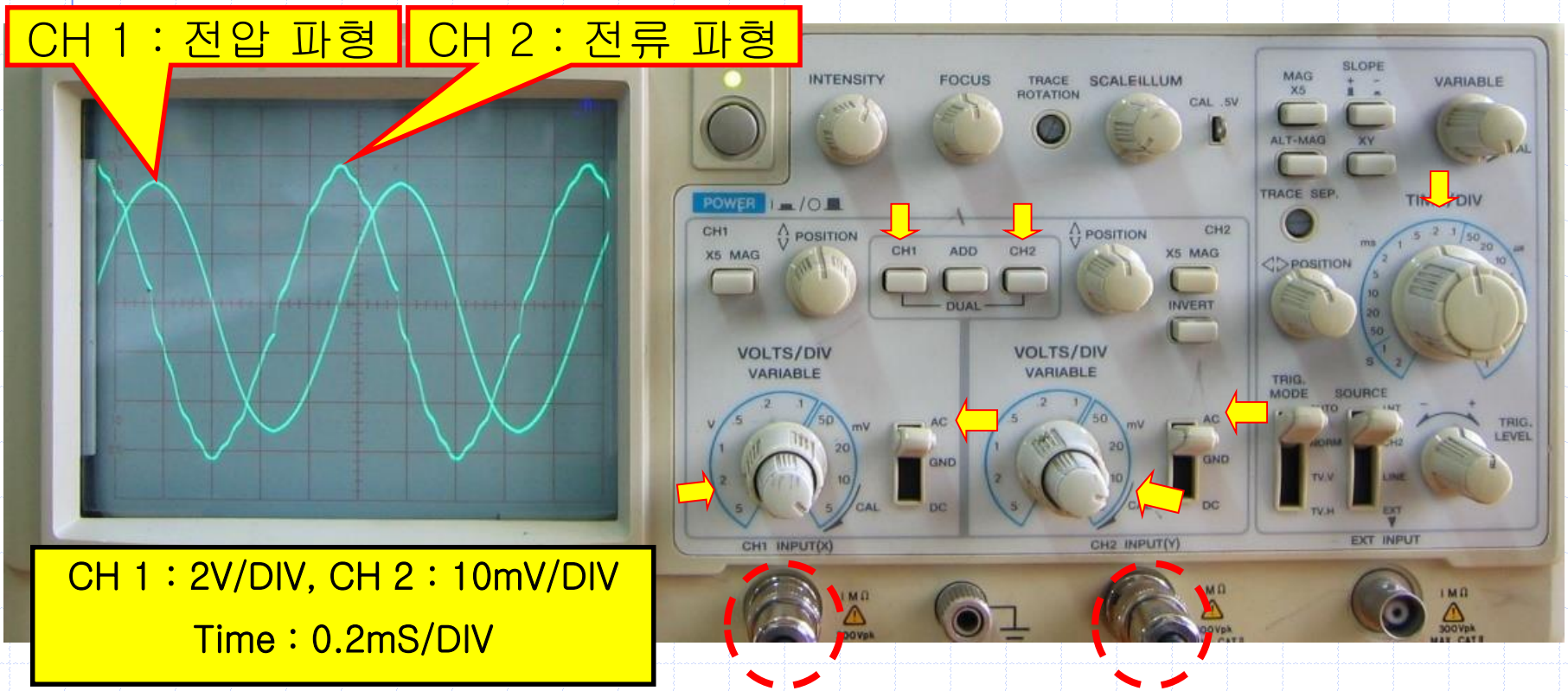


오실로스코프는 전압만을 측정하는 장비이므로 전류를 측정하고자 10Ω 의 저항을 넣어 전류의 파형을 전압으로 측정함.

8-6. 커패시터의 전압, 전류 위상차

CH 1 : 전압 파형

CH 2 : 전류 파형

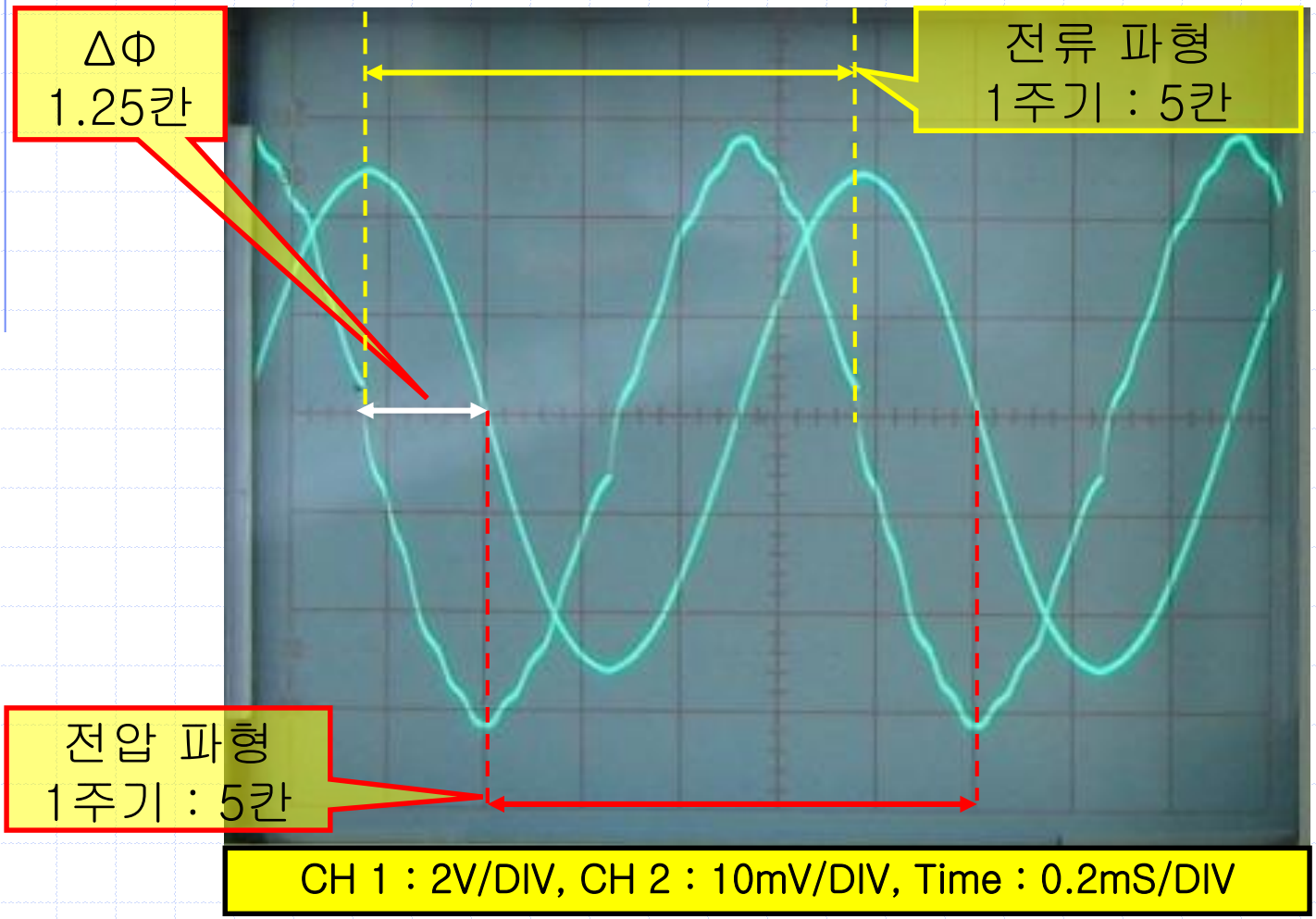


CH 1 : 2V/DIV, CH 2 : 10mV/DIV

Time : 0.2mS/DIV

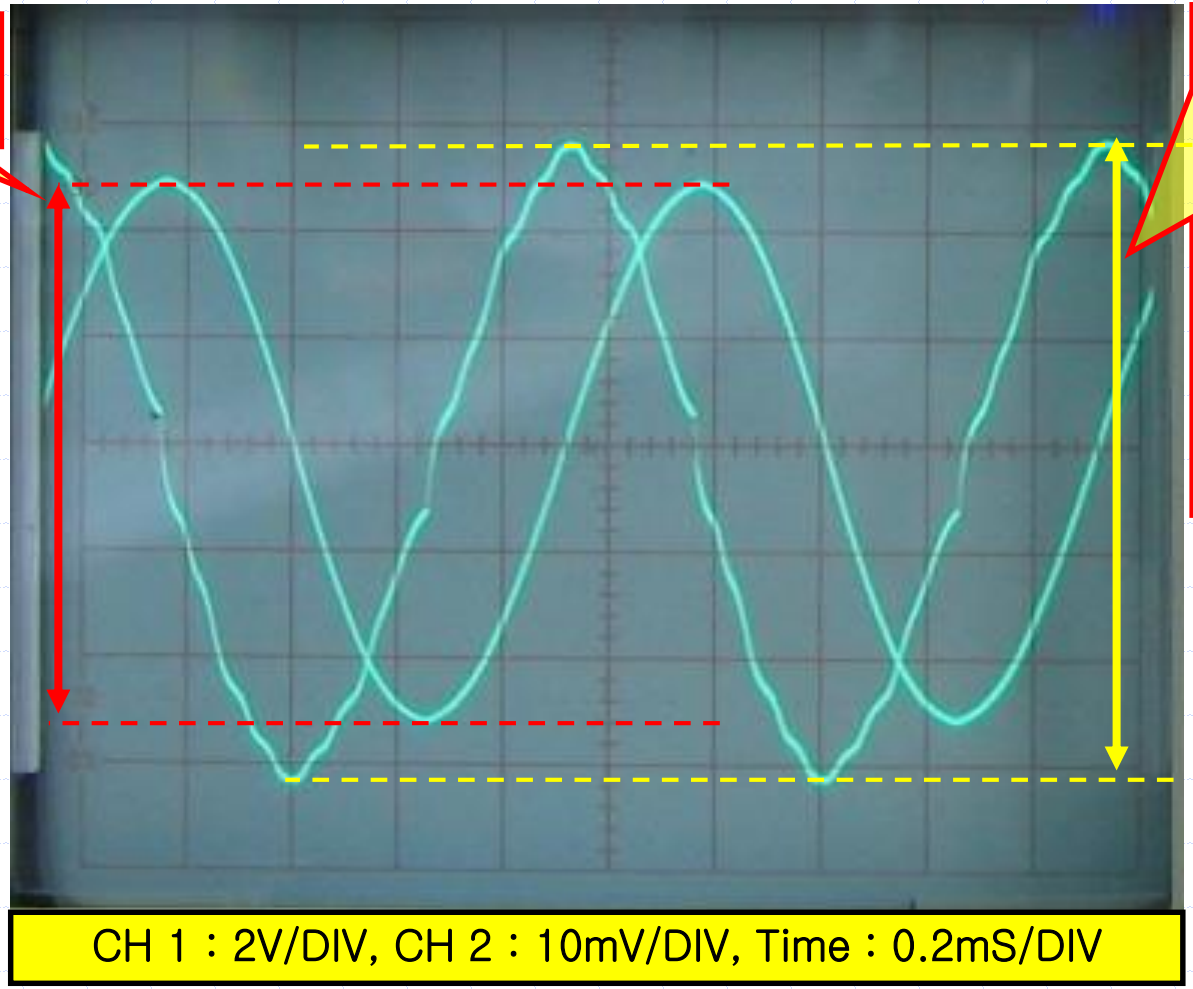
8-6. 커패시터의 전압, 전류 위상차

✓ 위상차를 측정하라.



8-6. 커패시터의 전압, 전류 위상차

✓ 전압과 전류의 크기



8-6. 커패시터의 전압, 전류 위상차

✓ 위상차

$$1T = 5칸 \times 0.2mSec = 1mSec$$

$$\Delta t = 1.25칸 \times 0.2mSec = 0.25mSec$$

$$1mSec : 0.25mSec = 360° : \Delta\Delta$$

$$\Delta\theta = 90°$$

✓ 전압과 전류의 크기

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$= \frac{1}{2\pi \times 1{,}000Hz \times 0.1 \times 10^{-6} F}$$

$$= 1591.55\Omega$$

$$Z = -jX_C = -j1591.55[\Omega]$$

$$= 1591.55\angle -90°[\Omega]$$

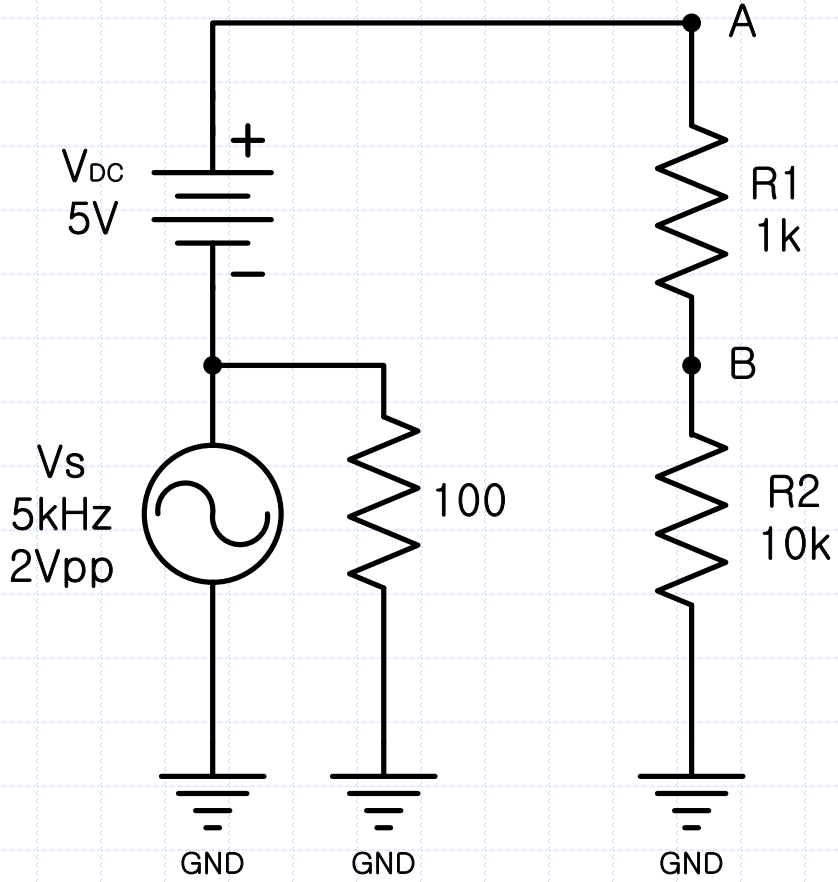
$$v_S = 10V_{PP}\angle 0°$$

$$i_C = \frac{v_S}{Z} = \frac{10V_{PP}\angle 0°}{1591.55\angle -90°[\Omega]}$$

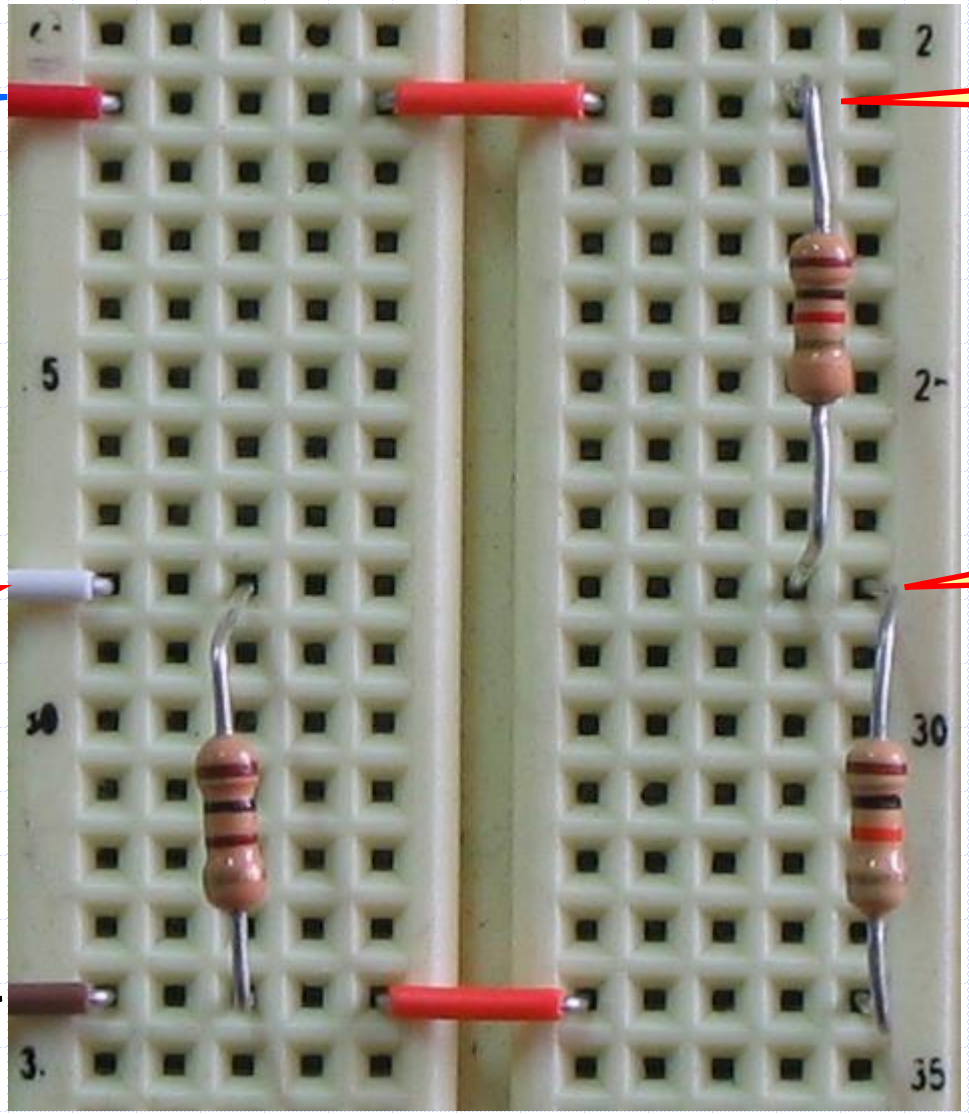
$$= 6.283mA_{PP}\angle 90°$$

8-7A. 커패시터의 바이패스 특성

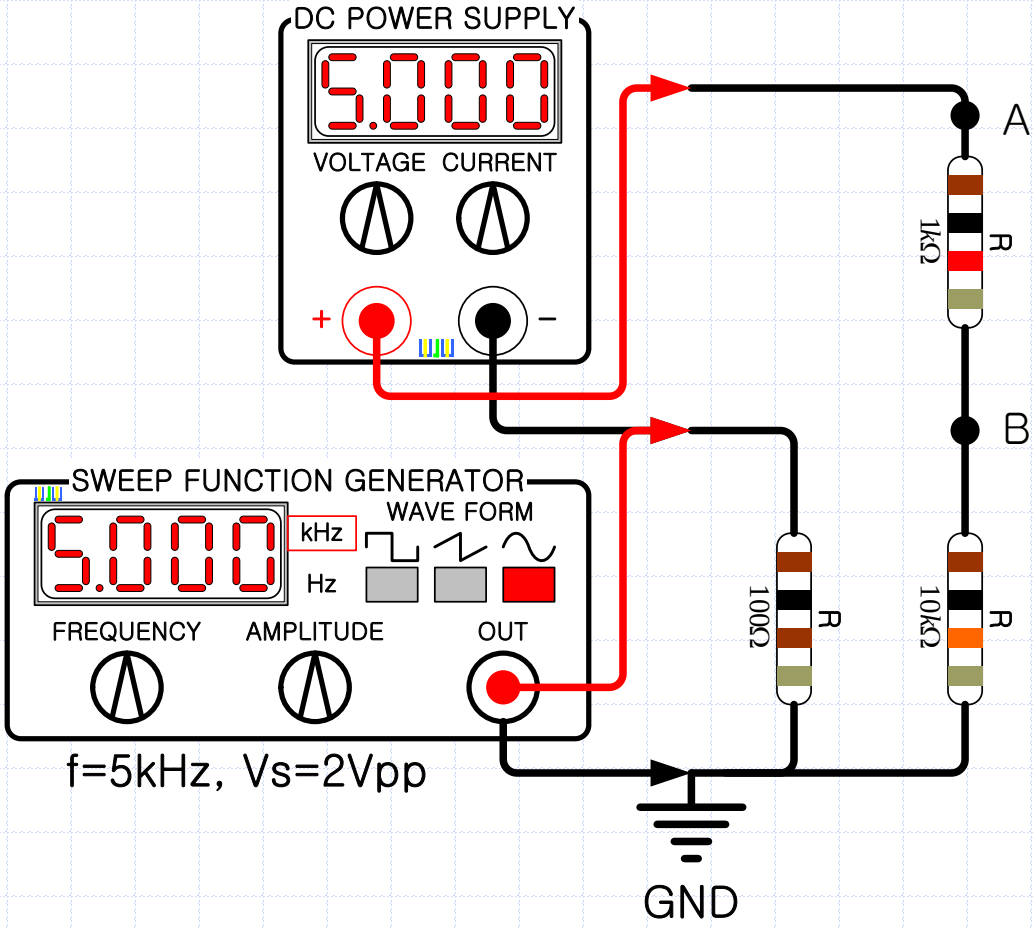
- 다음과 같이 회로를 연결하고, 오실로스코프를 이용하여 각 지점 (V_A, V_B) 의 전압을 측정한다.



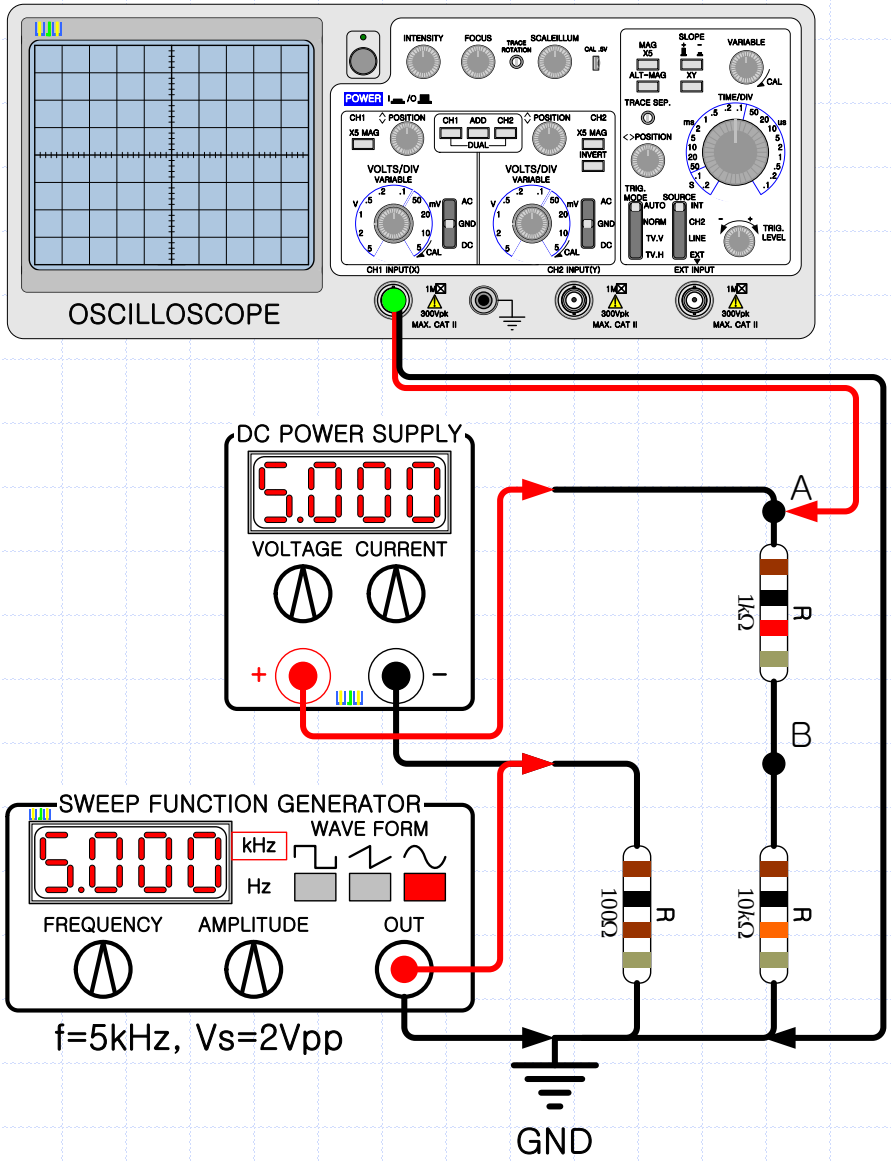
8-7A. 커패시터의 바이패스 특성



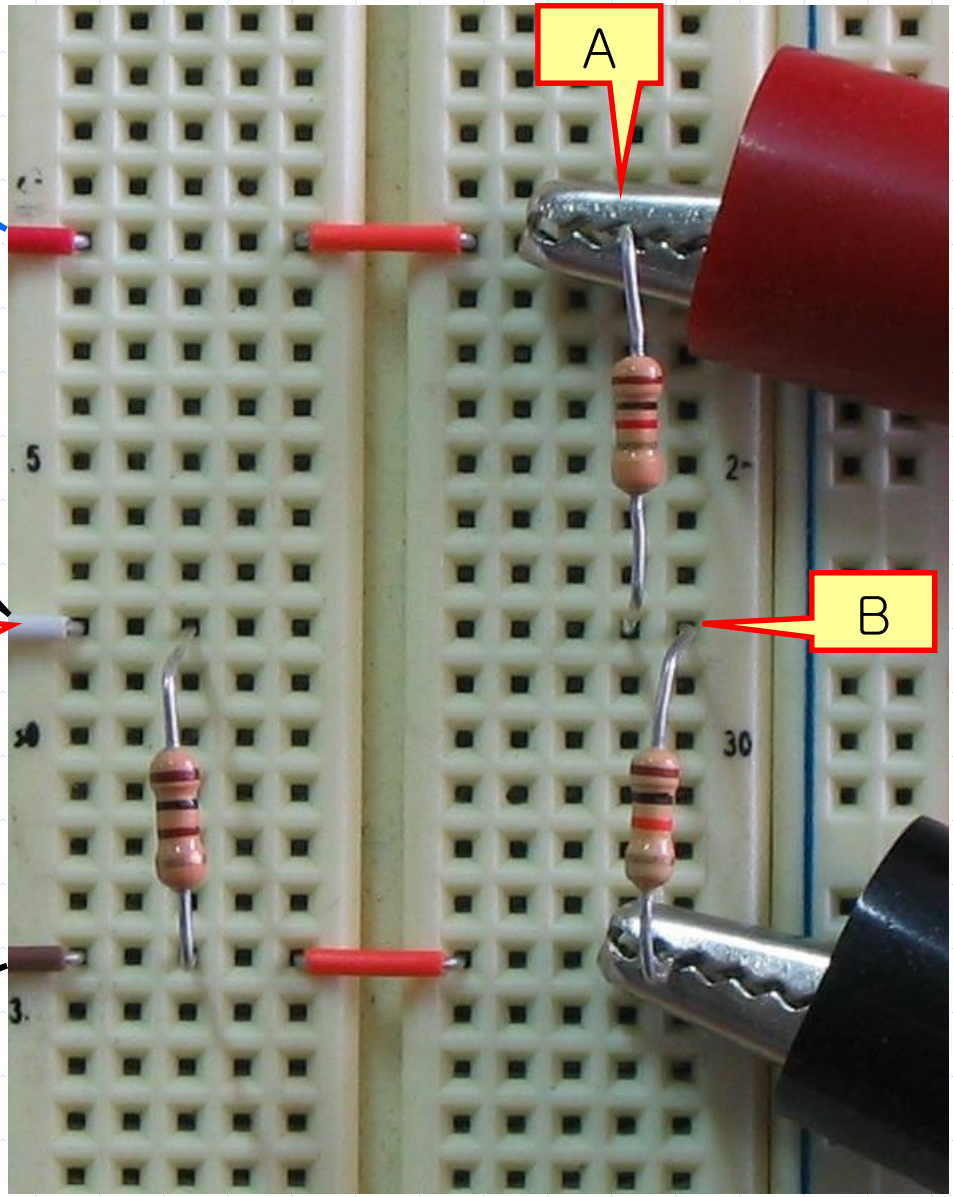
8-7A. 커패시터의 바이패스 특성



8-7A. 커패시터의 바이패스 특성



8-7A. 커패시터의 바이패스 특성



+5V

직류전원장치

DC Power Supply

GND

정현파
1kHz
10Vpp

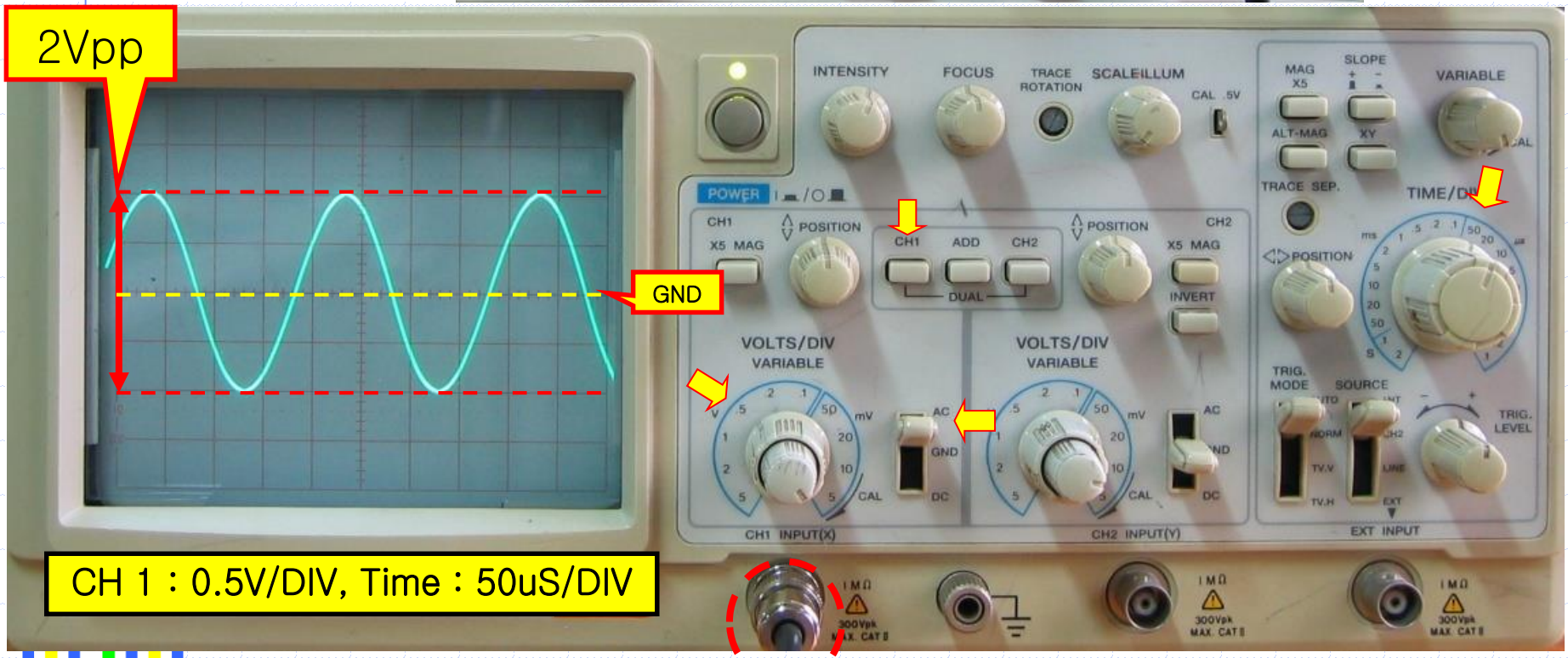
신호발생기

Function Generator

GND

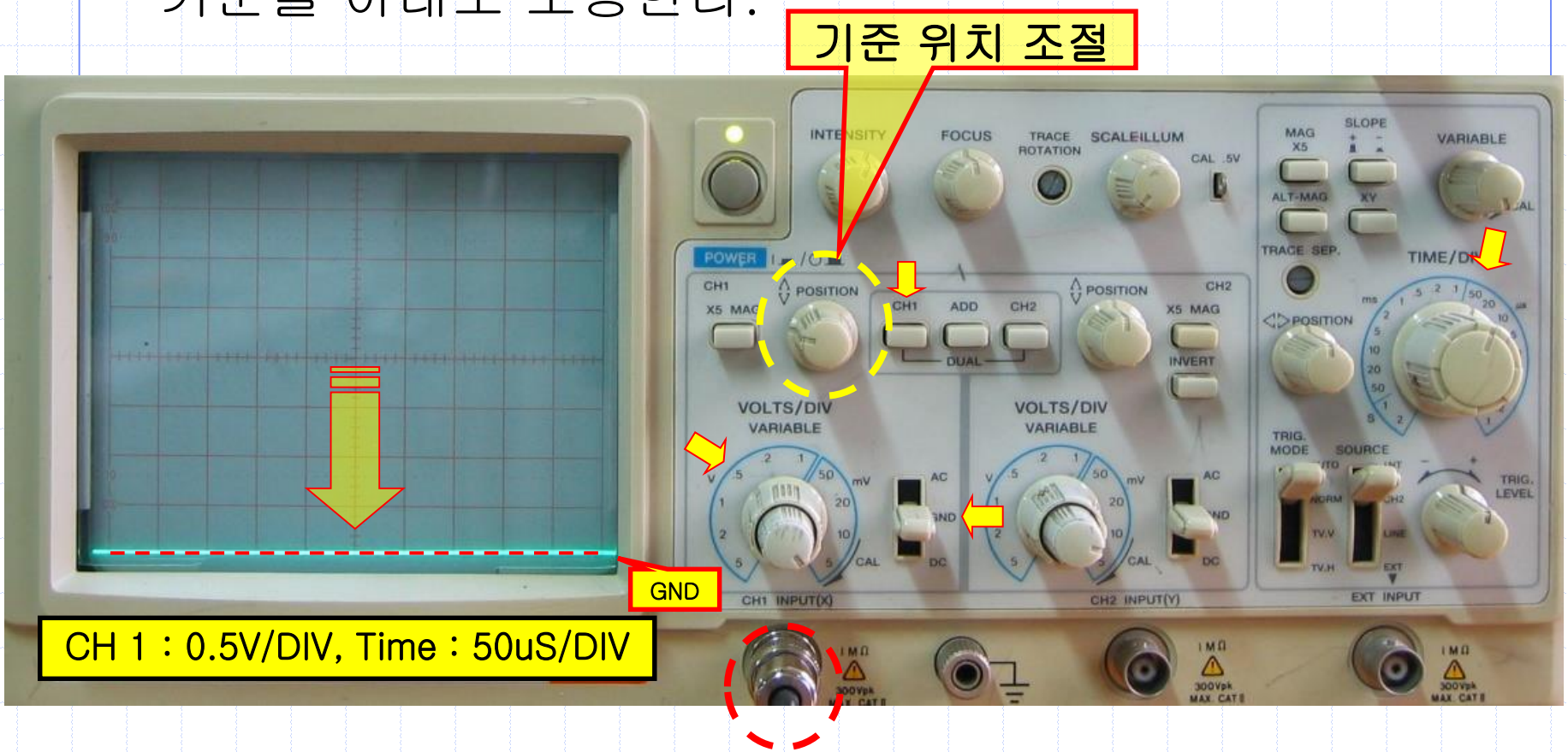
8-7A. 커패시터의 바이패스 특성

- ✓ AC 측정



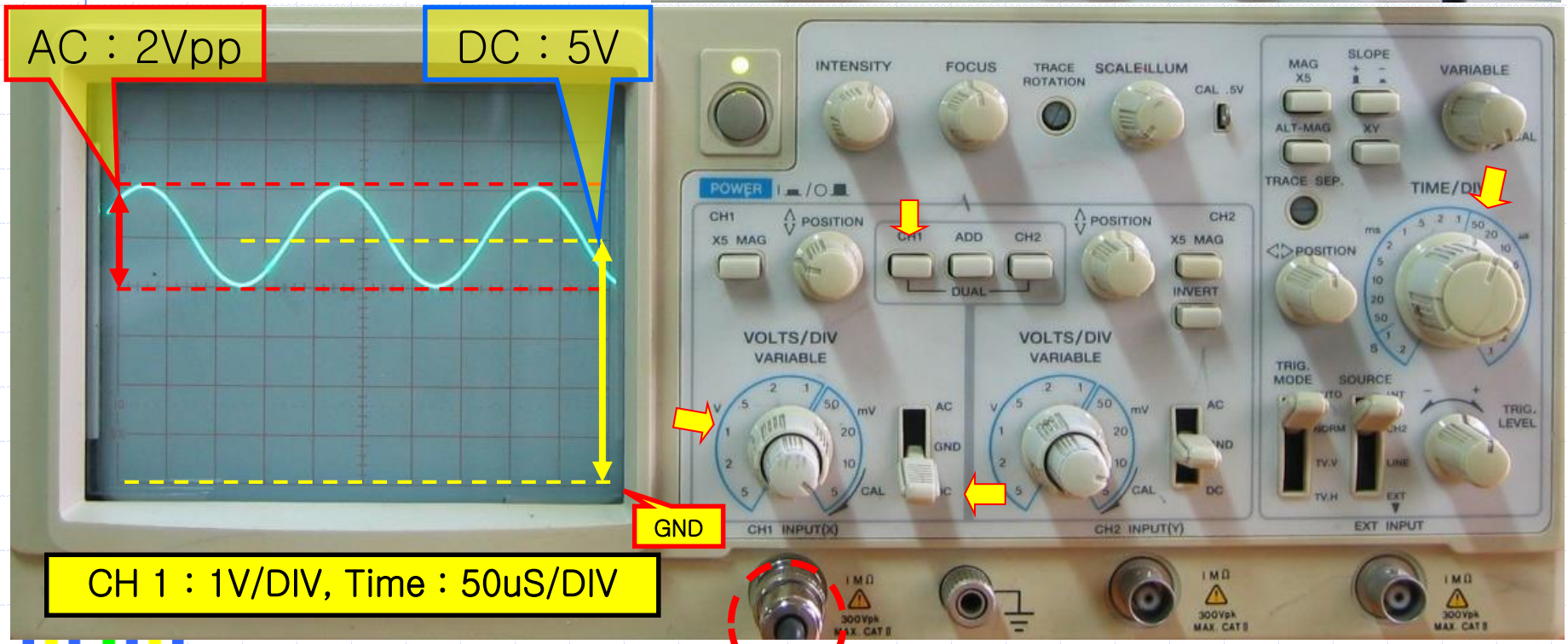
8-7A. 커패시터의 바이패스 특성

- ✓ AC + DC 측정을 위하여 CH 1 의 결합을 GND 로 하고, 기준을 아래로 조정한다.

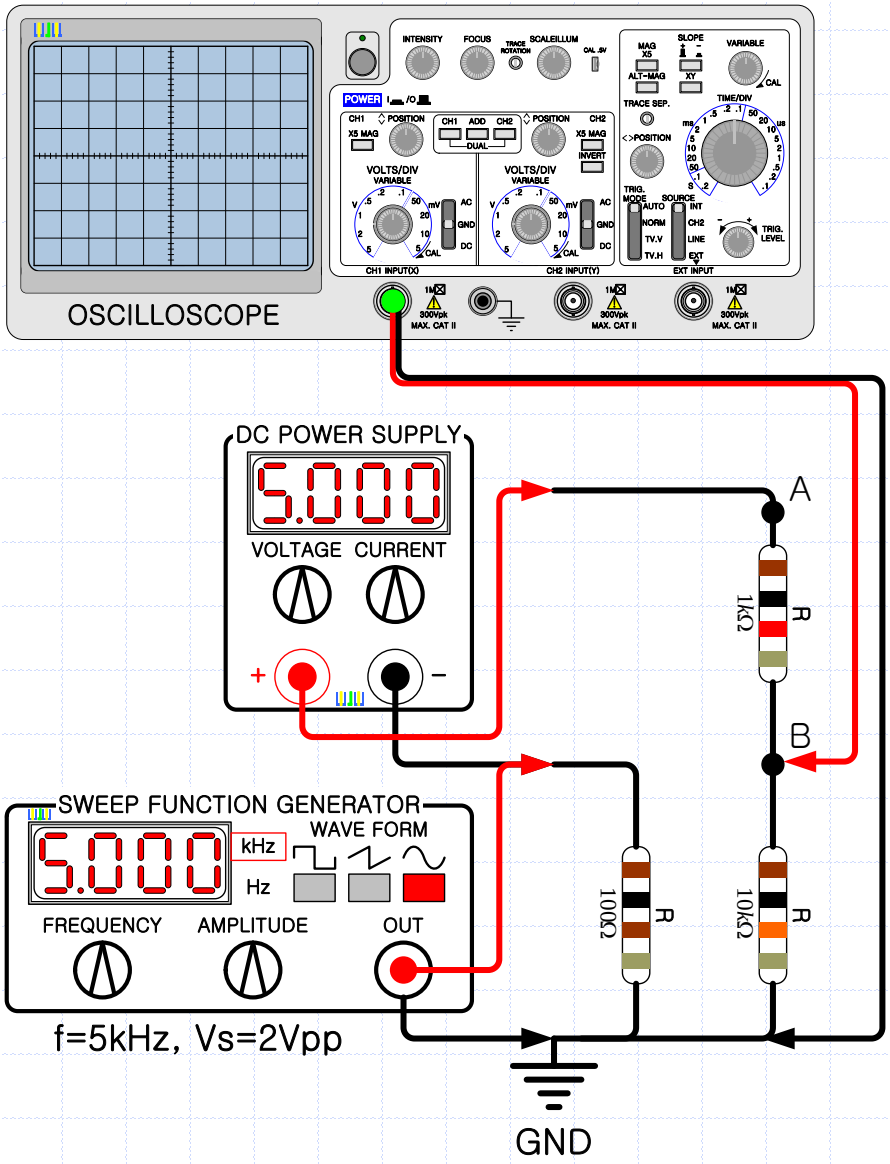


8-7A. 커패시터의 바이패스 특성

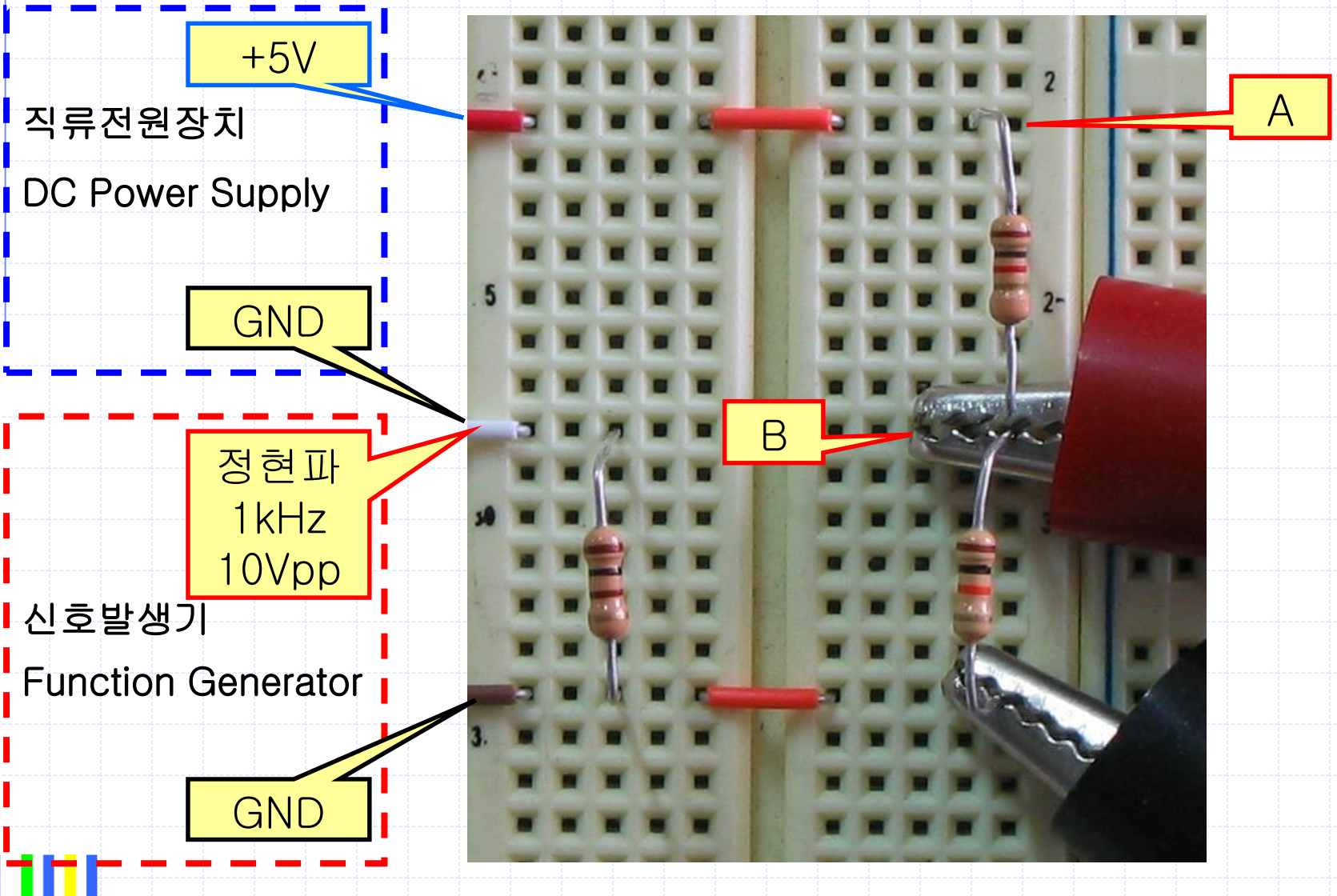
- ✓ AC + DC 측정



8-7A. 커패시터의 바이패스 특성

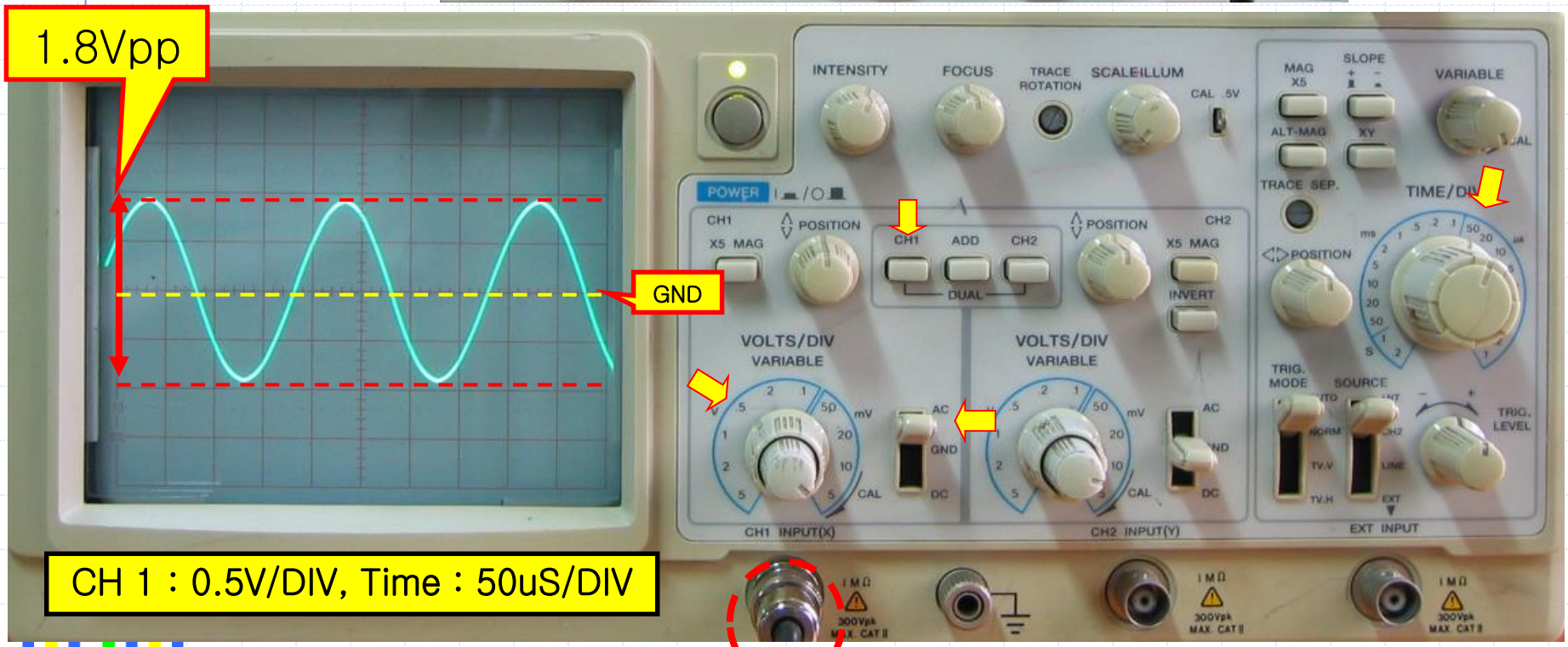


8-7A. 커패시터의 바이패스 특성



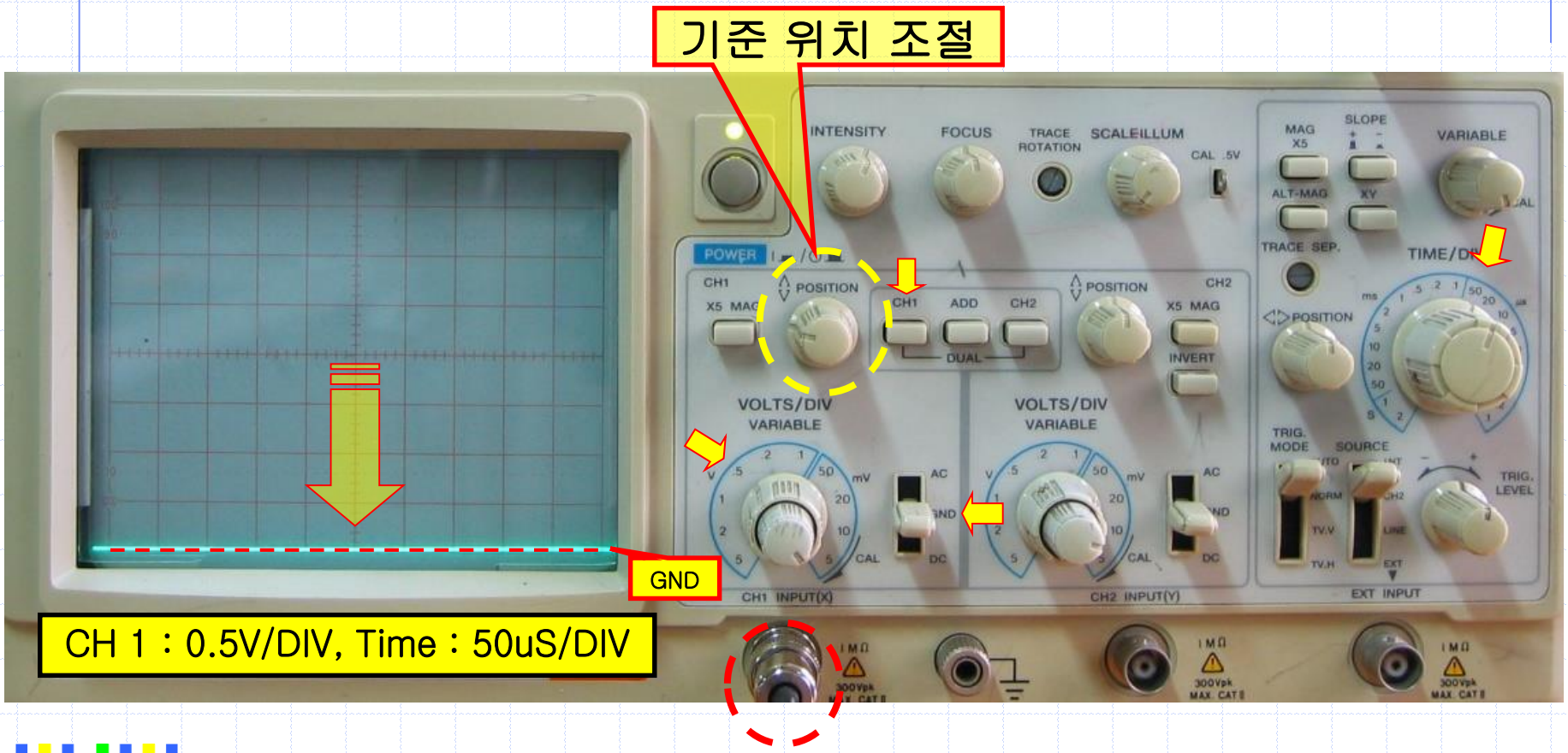
8-7A. 커패시터의 바이패스 특성

- ✓ AC 측정



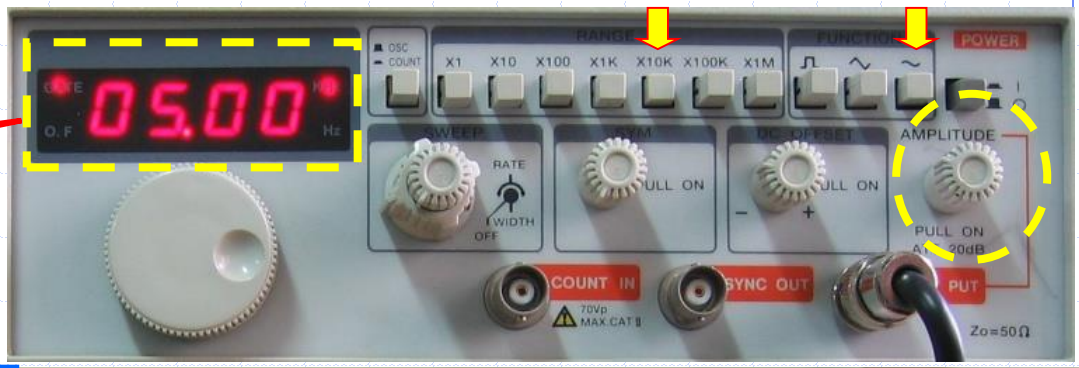
8-7A. 커패시터의 바이패스 특성

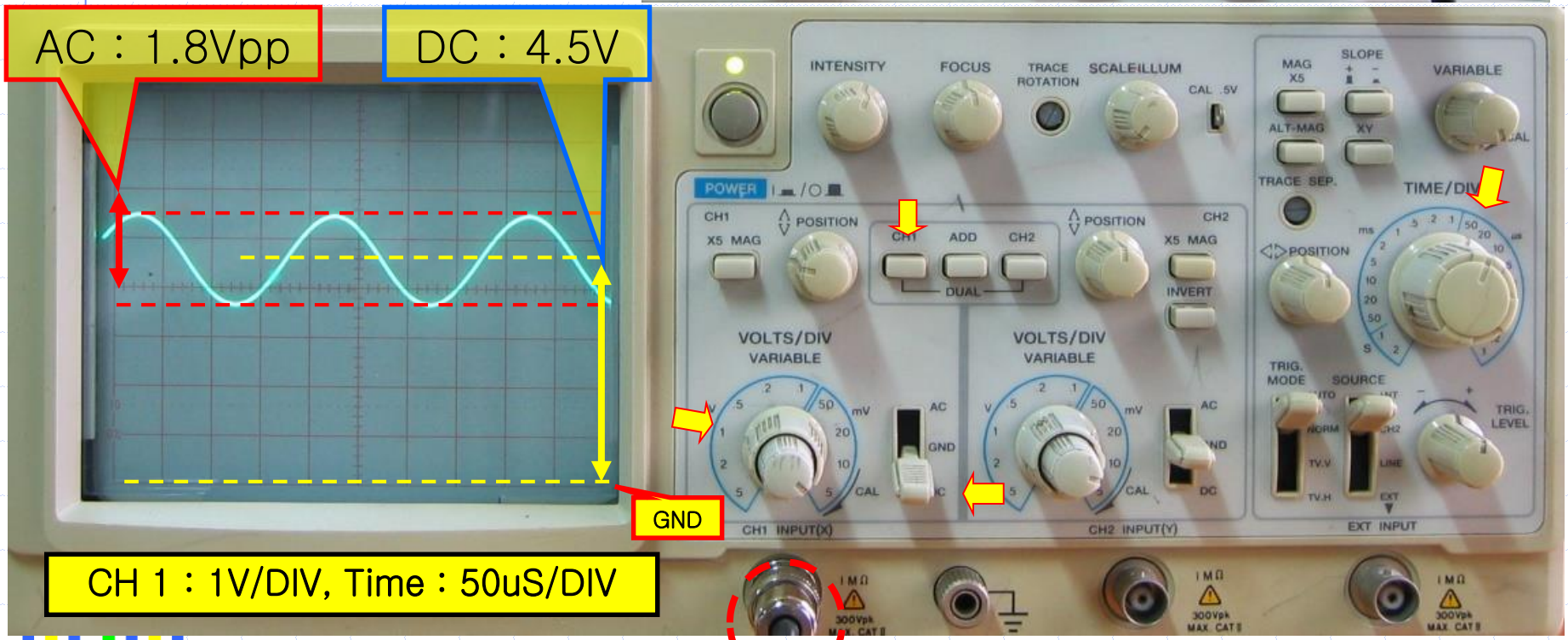
- ✓ AC + DC 측정을 위하여 CH 1 의 결합을 GND 로 하고, 기준을 아래로 조정한다.



8-7A. 커패시터의 바이패스 특성

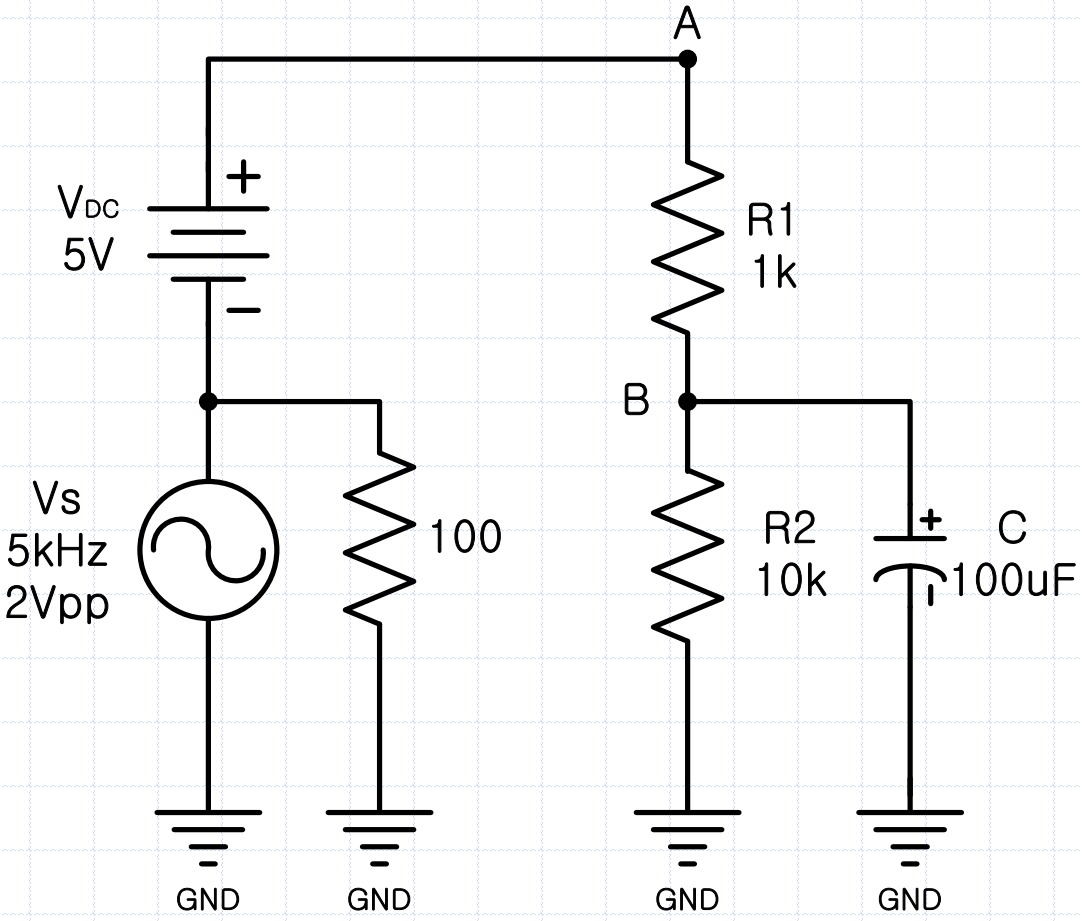
- ✓ AC + DC 측정



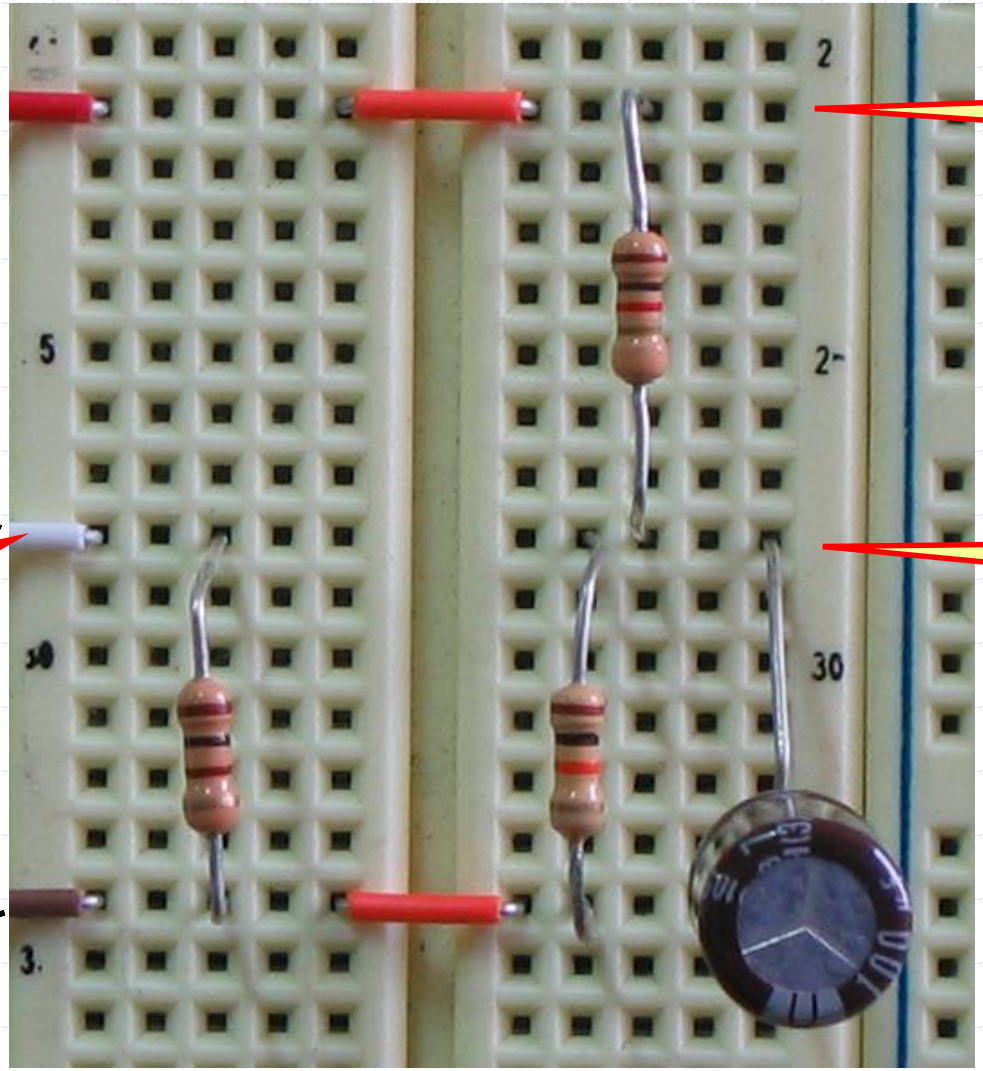


8-7B. 커패시터의 바이패스 특성

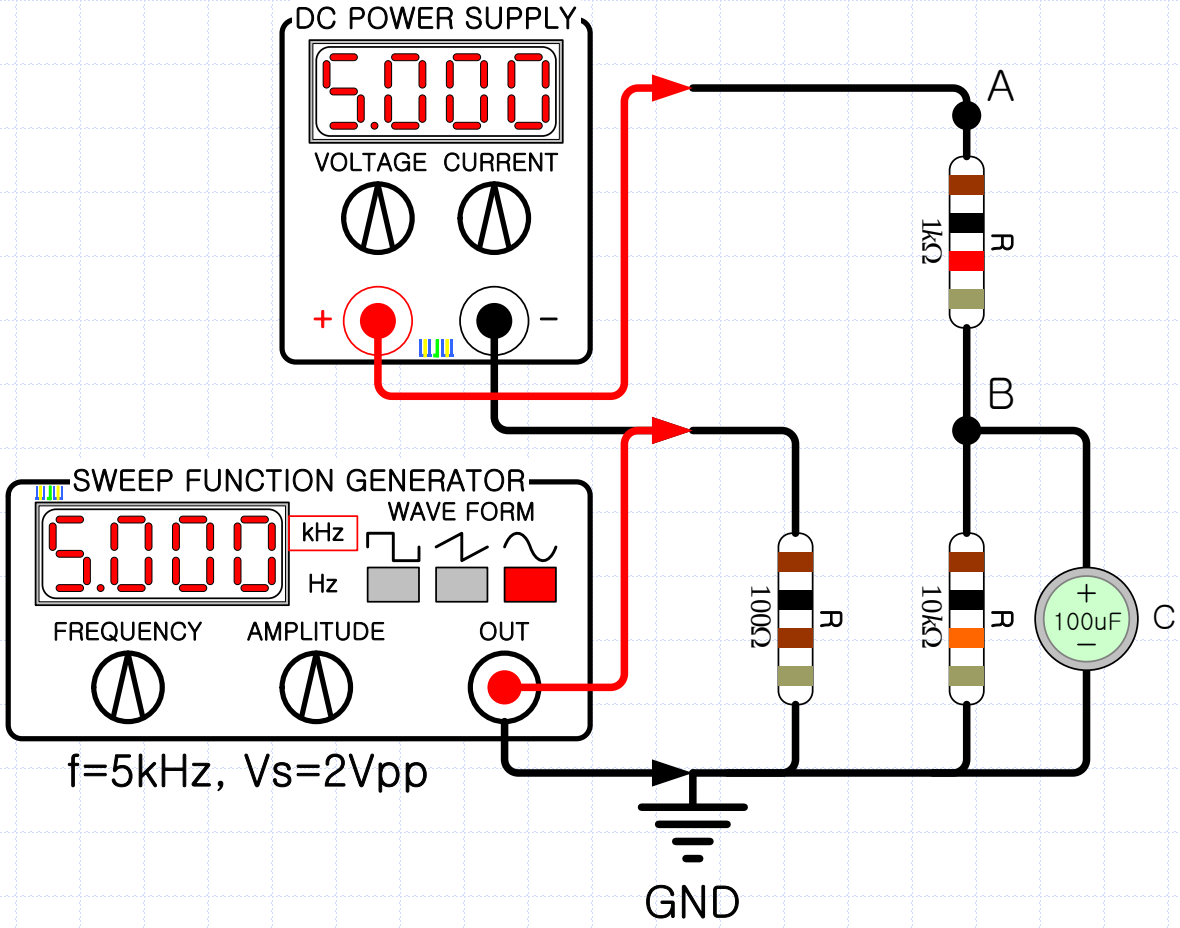
- 앞의 회로에 커패시터를 다음과 같이 연결하고, 오실로스코프를 이용하여 각 지점의 전압을 측정한다.



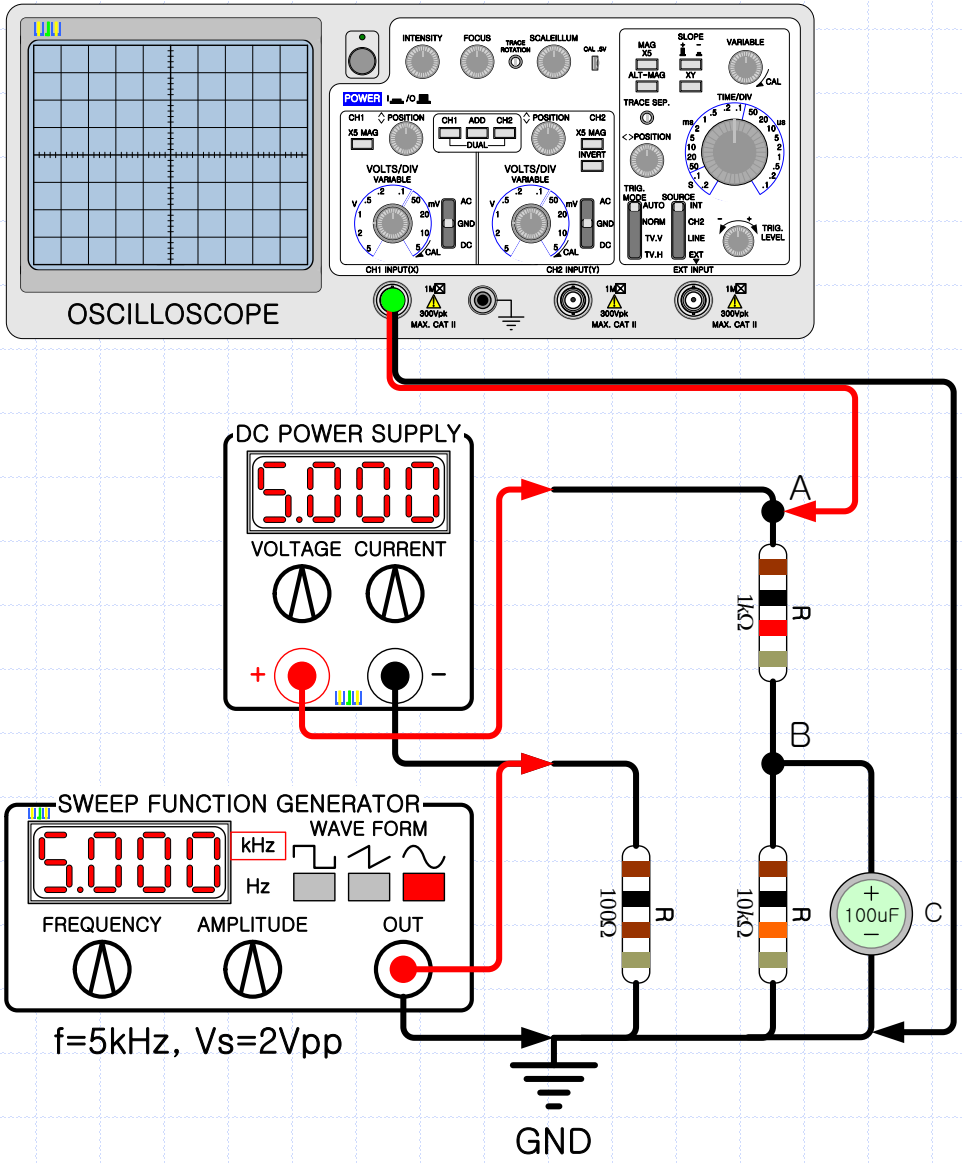
8-7B. 커패시터의 바이패스 특성



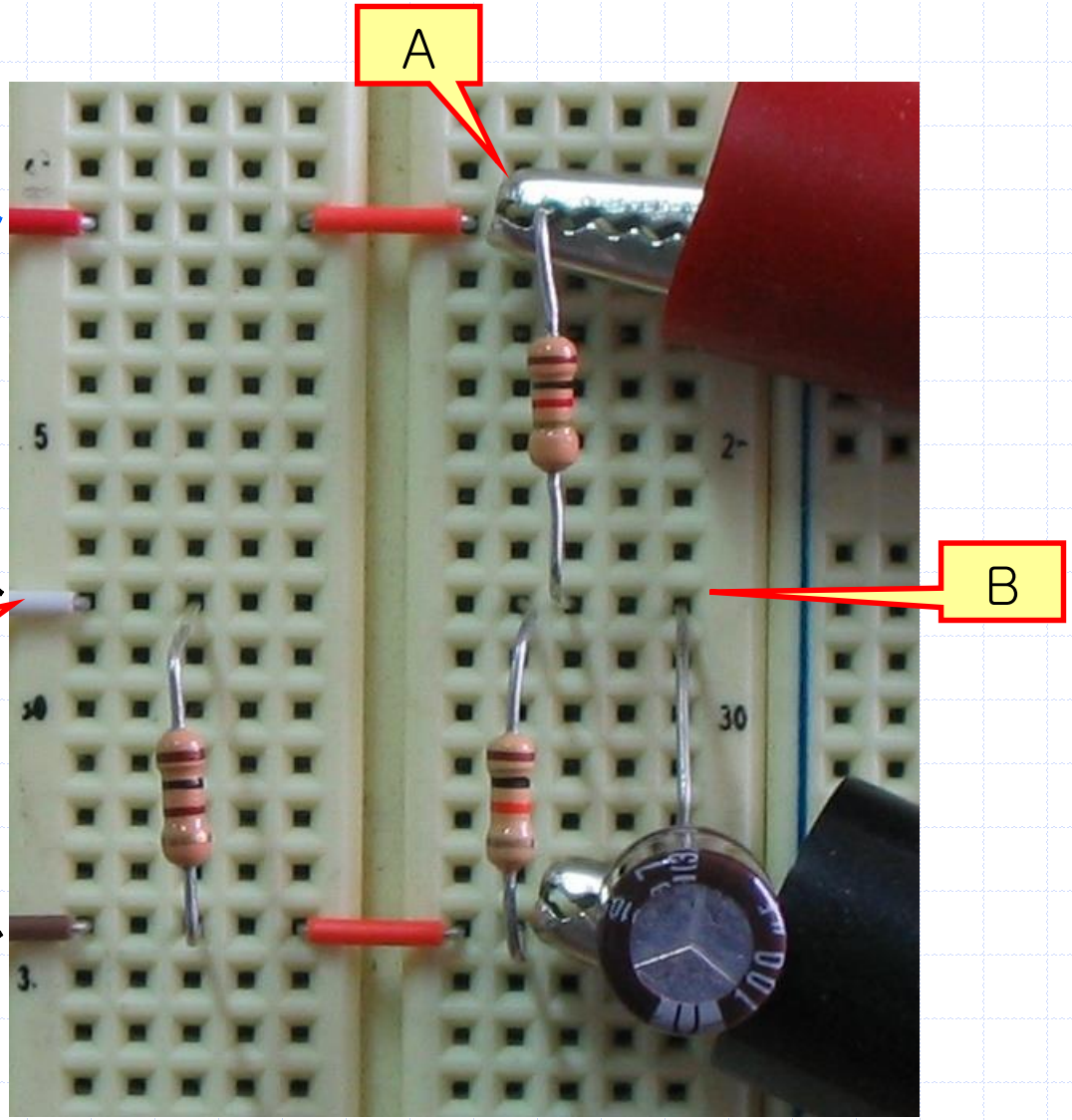
8-7B. 커패시터의 바이패스 특성



8-7B. 커패시터의 바이패스 특성



8-7B. 커패시터의 바이패스 특성



+5V

직류전원장치

DC Power Supply

GND

정현파
5kHz
10Vpp

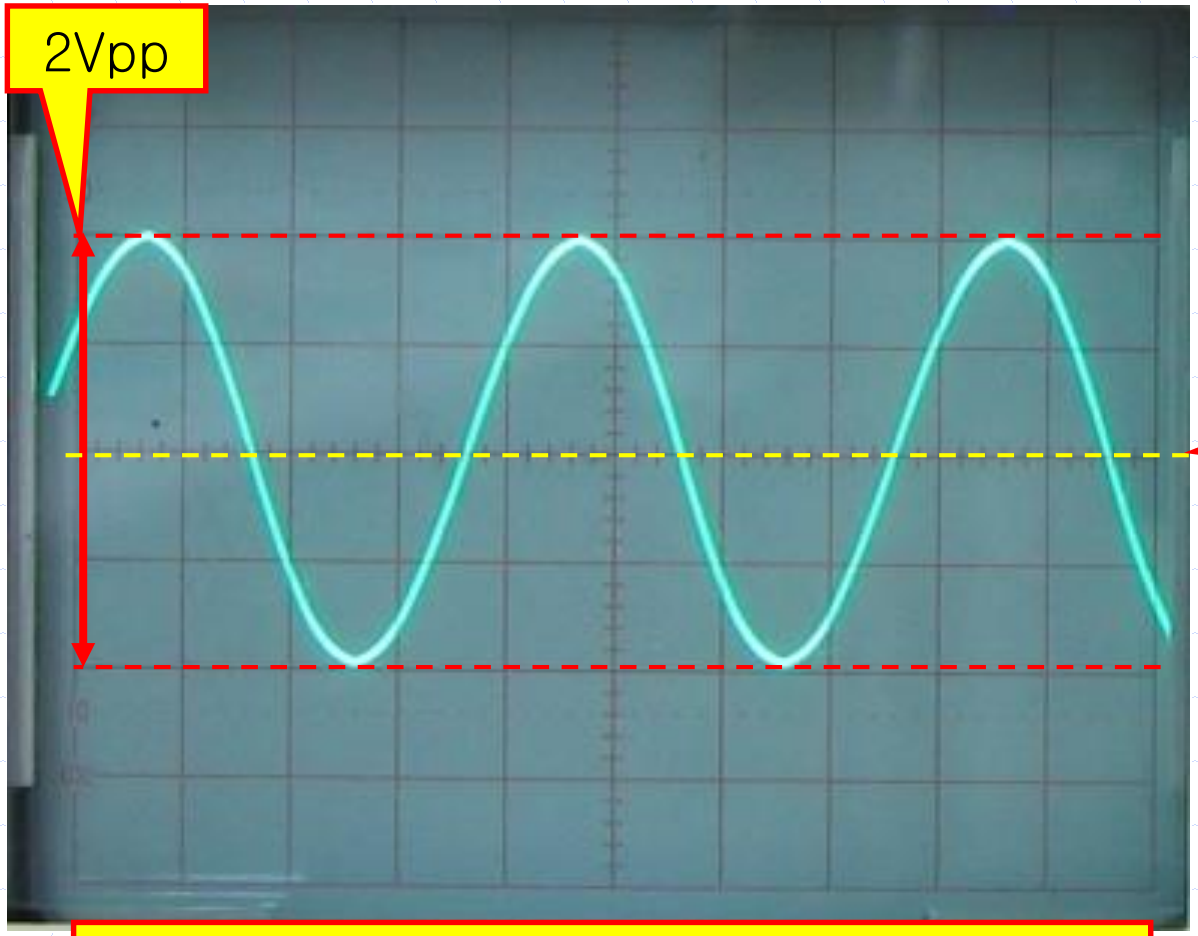
신호발생기

Function Generator

GND

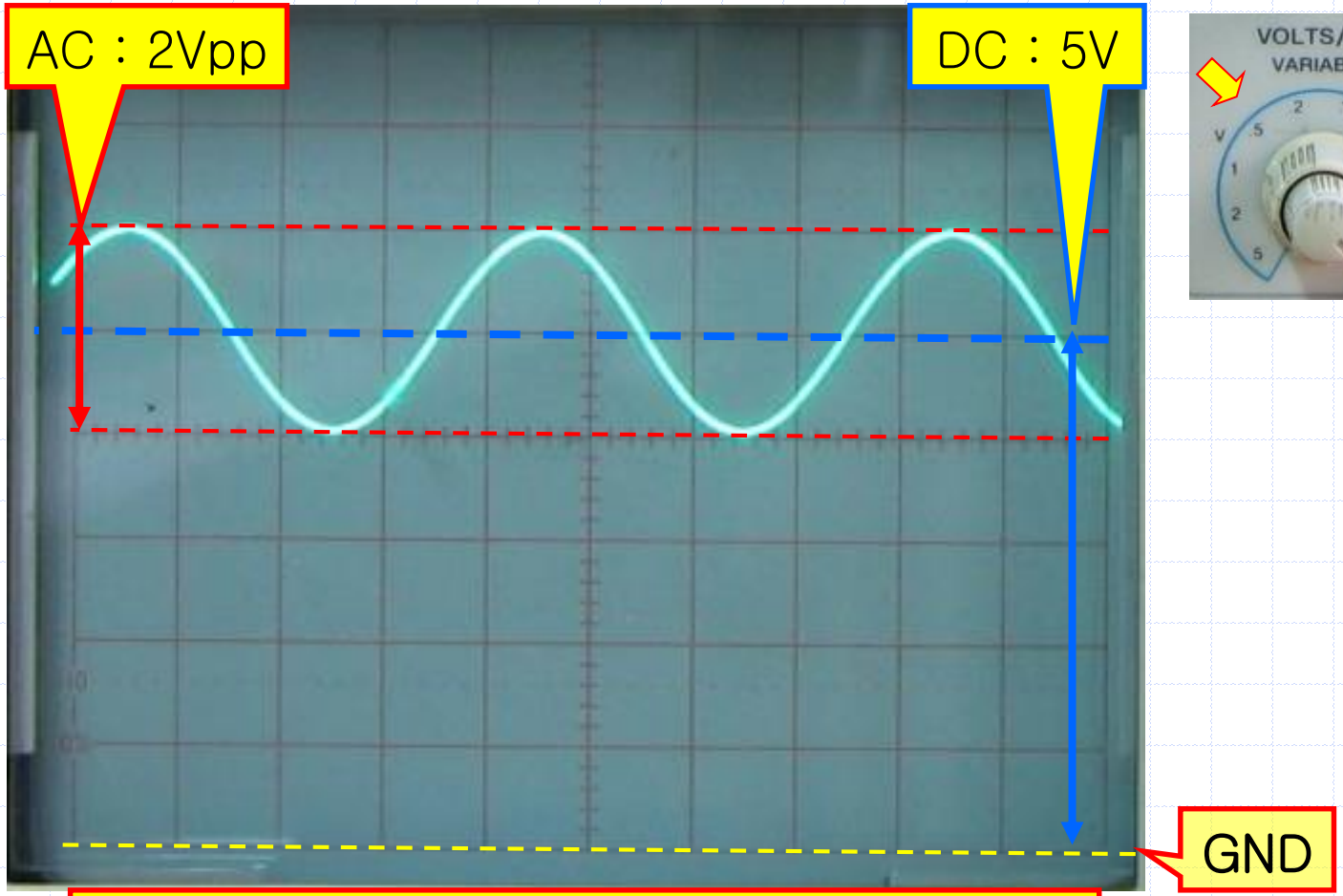
8-7B. 커패시터의 바이패스 특성

- ✓ AC 측정

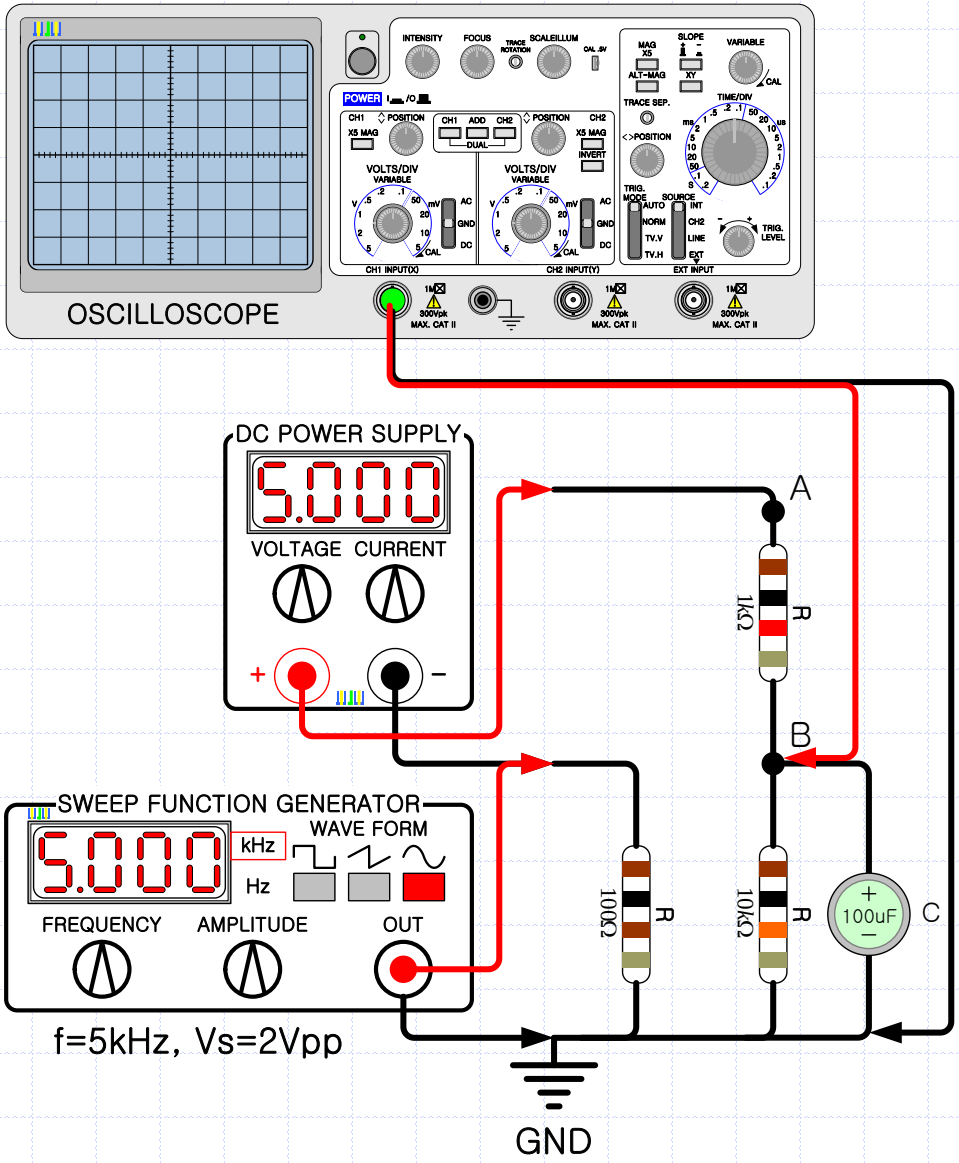


8-7B. 커패시터의 바이패스 특성

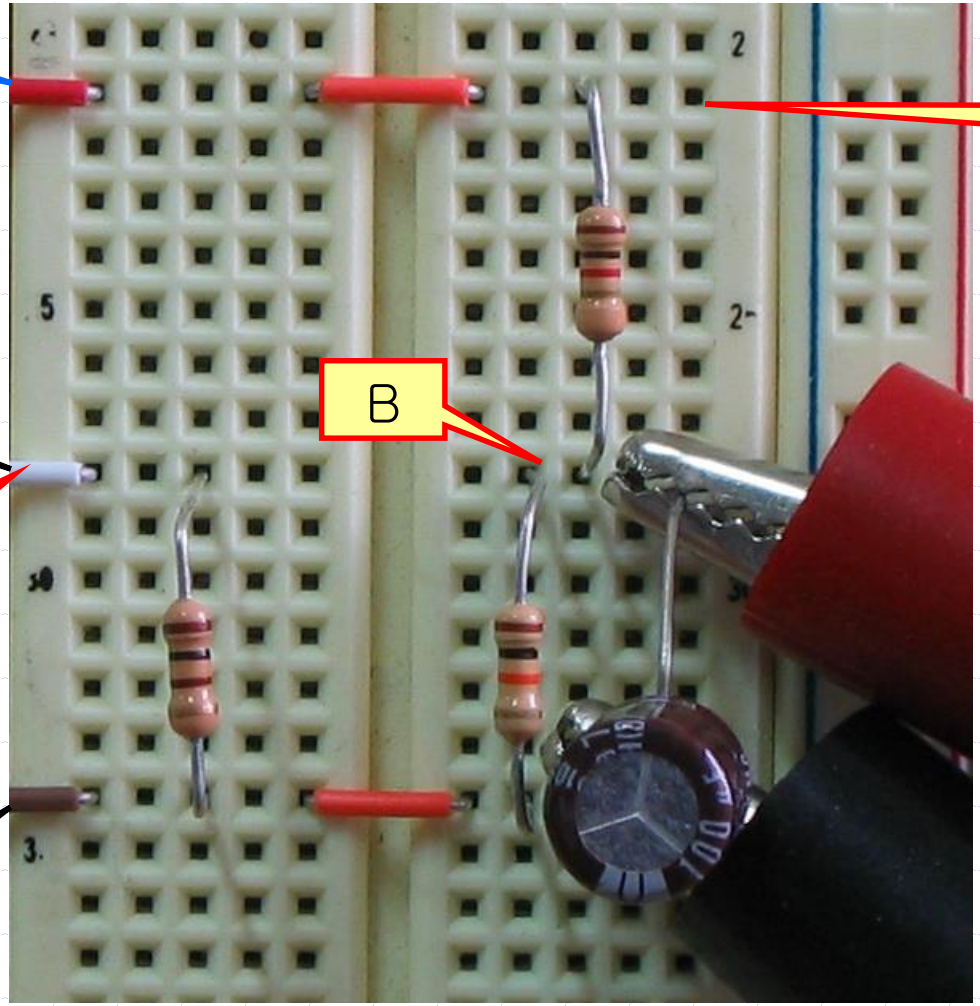
- ✓ AC + DC 측정



8-7B. 커패시터의 바이패스 특성

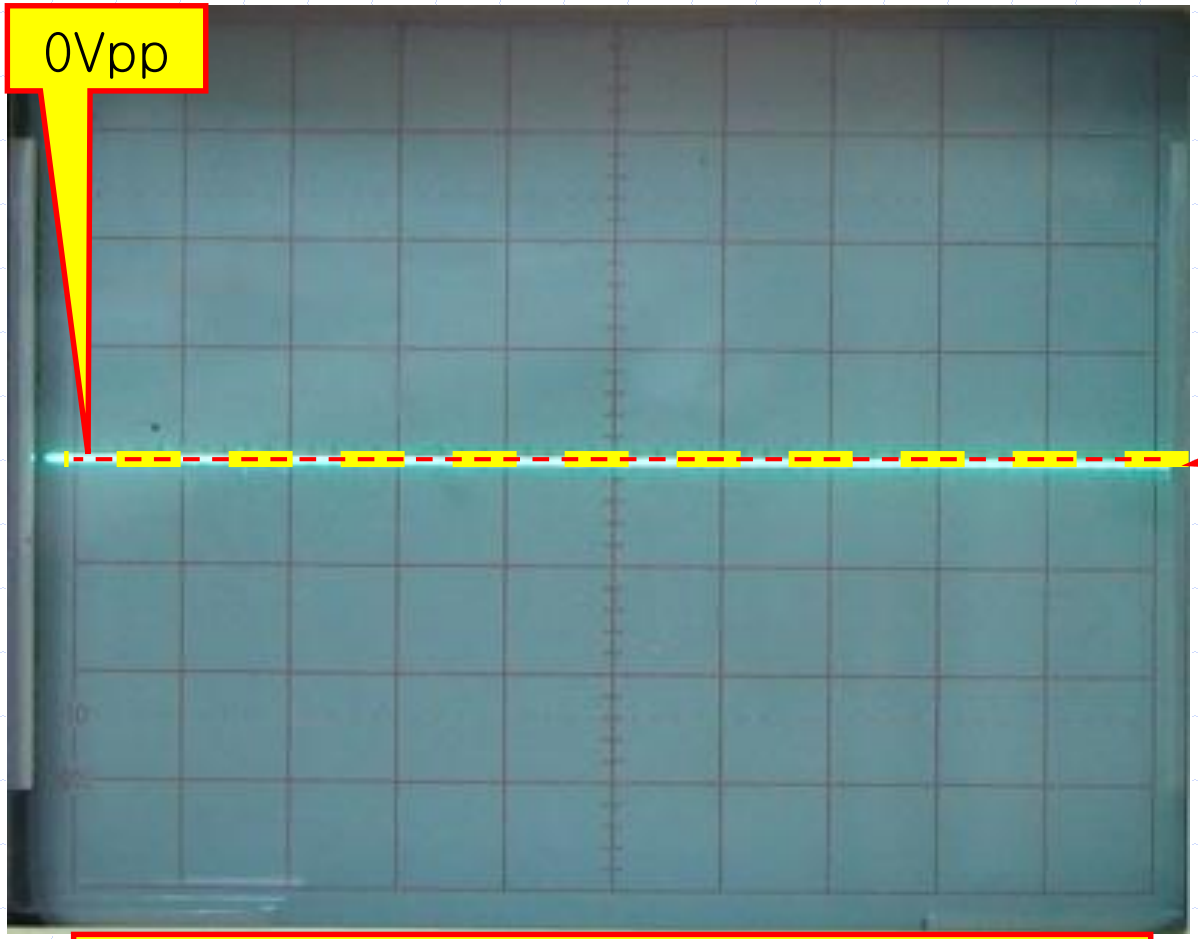


8-7B. 커패시터의 바이패스 특성



8-7B. 커패시터의 바이패스 특성

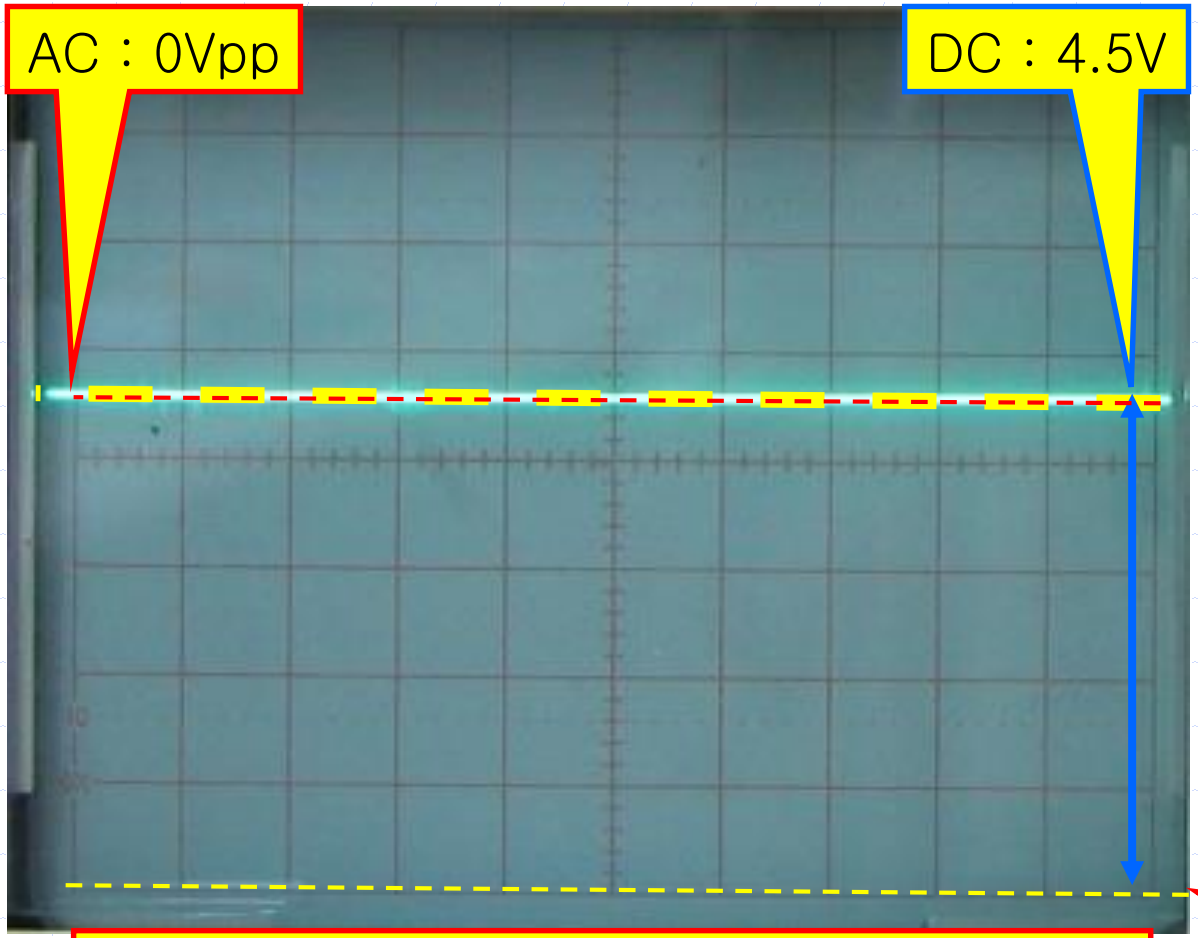
- ✓ AC 측정



CH 1 : 0.5V/DIV, Time : 50uS/DIV

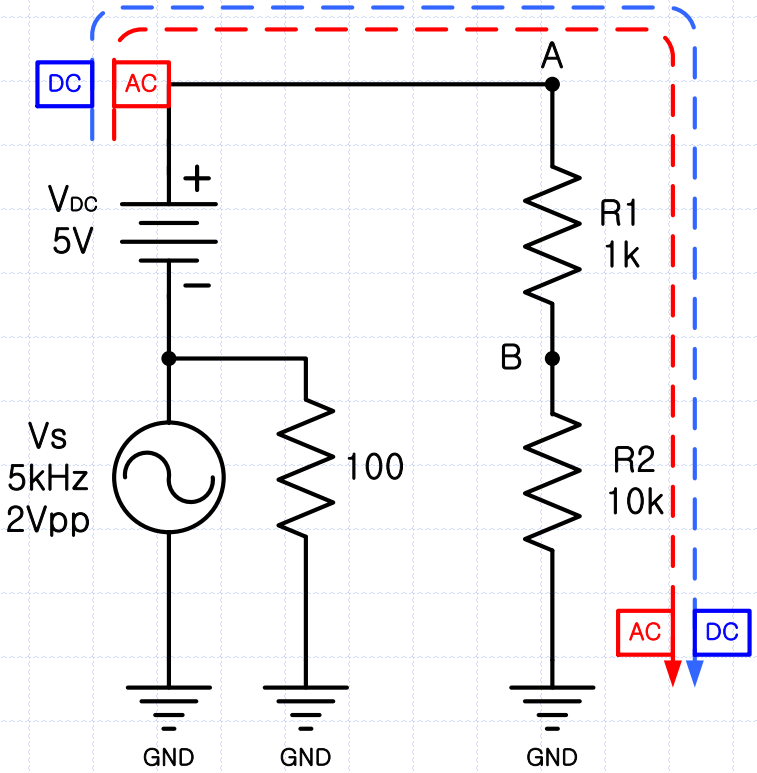
8-7B. 커패시터의 바이패스 특성

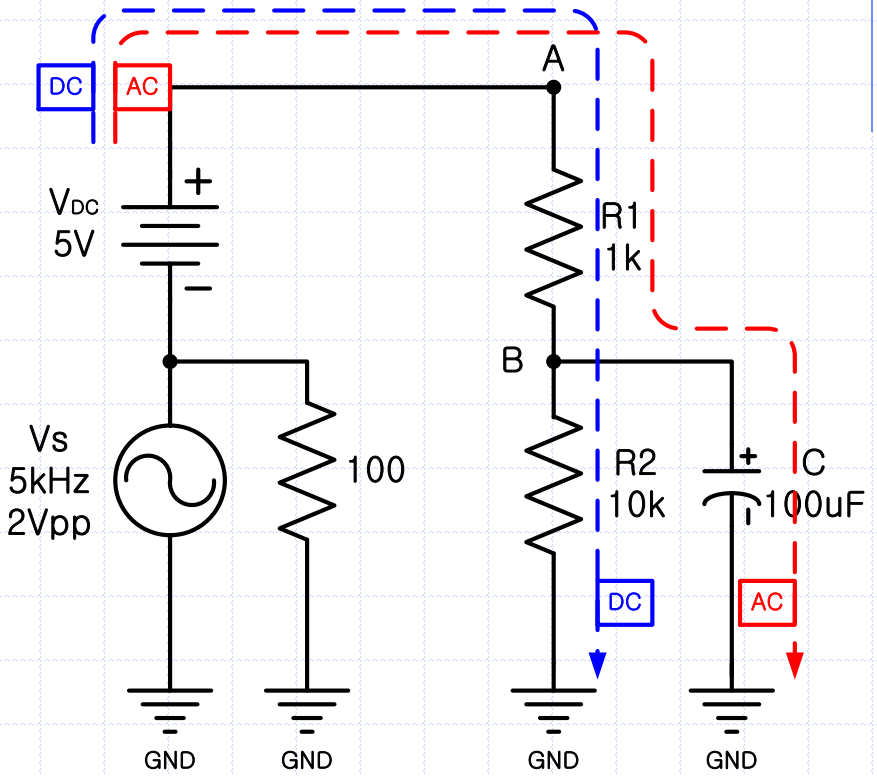
- ✓ AC + DC 측정



8-7C. 커패시터의 바이패스 특성

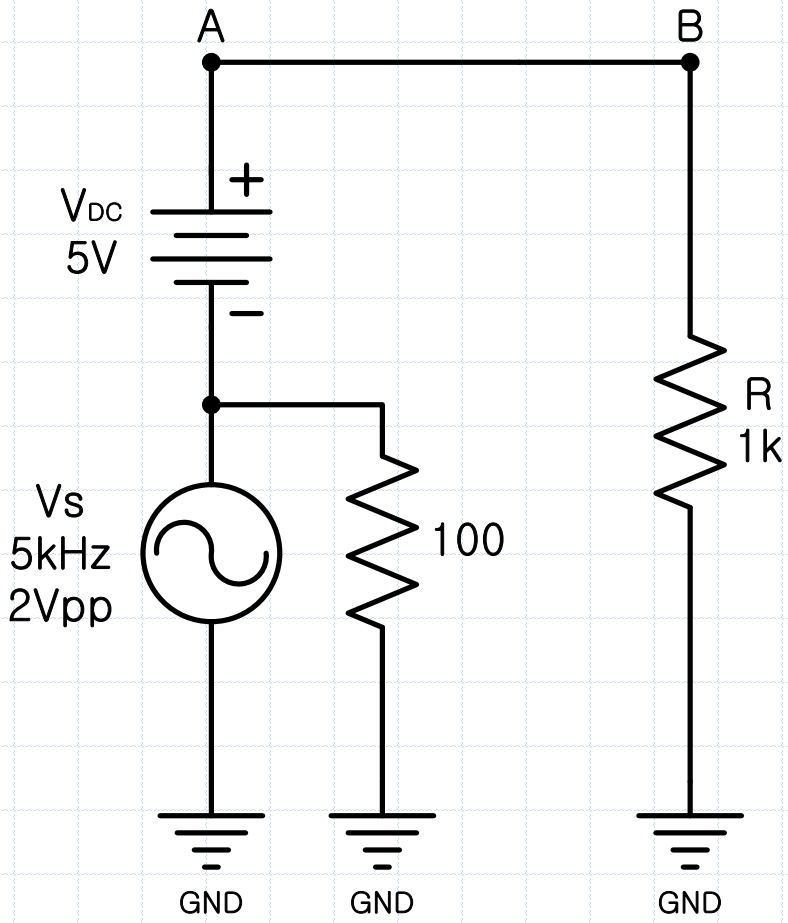
- 커패시터의 병렬 연결 : 바이패스 역할



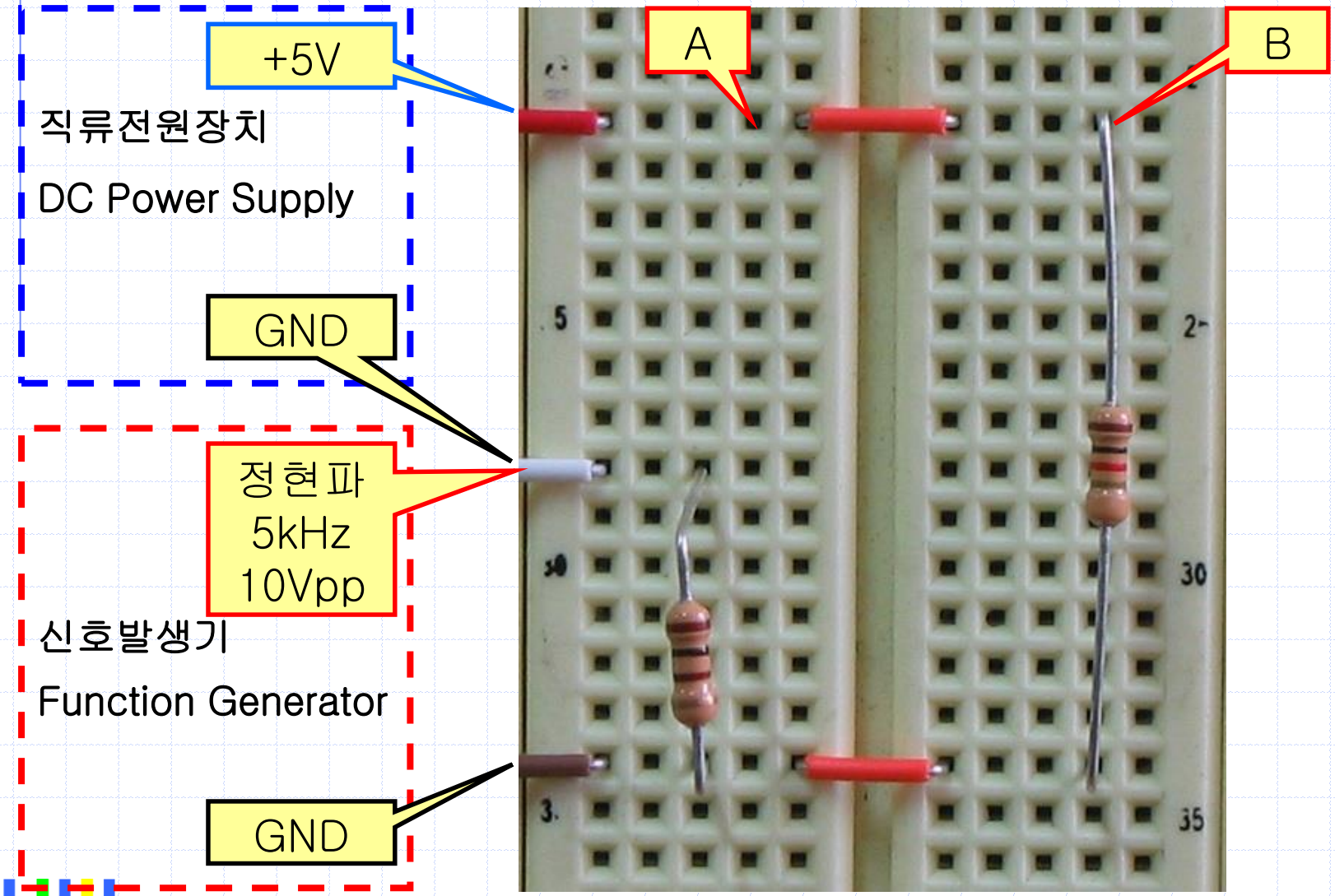


8-8A. 커패시터의 커플링 특성

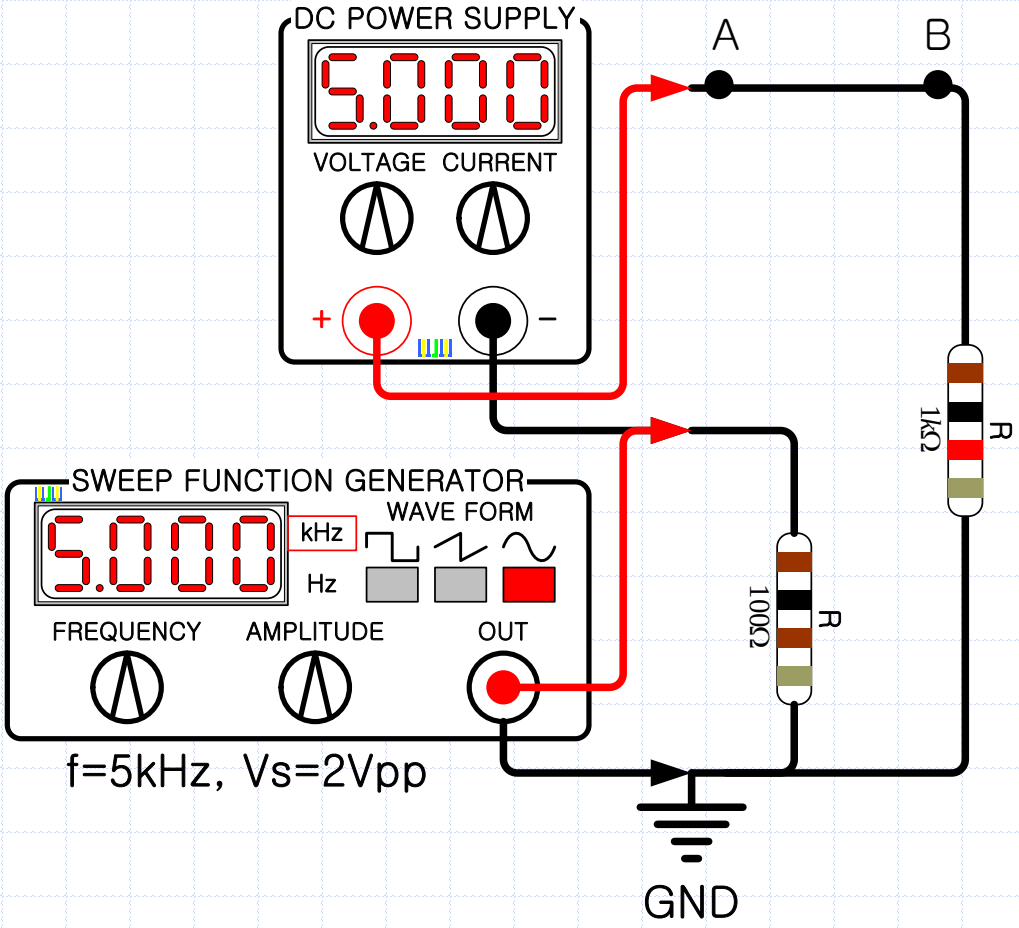
- 회로를 다음과 같이 연결하고, 오실로스코프를 이용하여 각 지점의 전압을 측정한다.



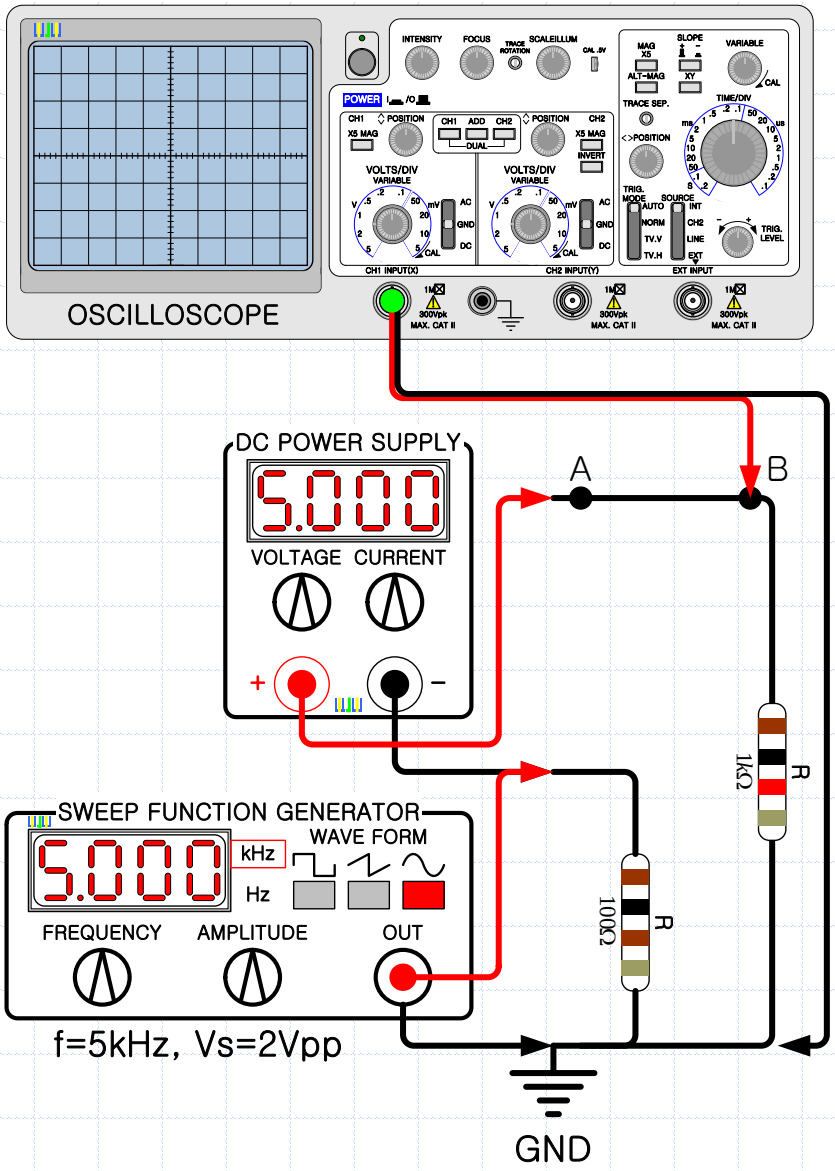
8-8A. 커패시터의 커플링 특성



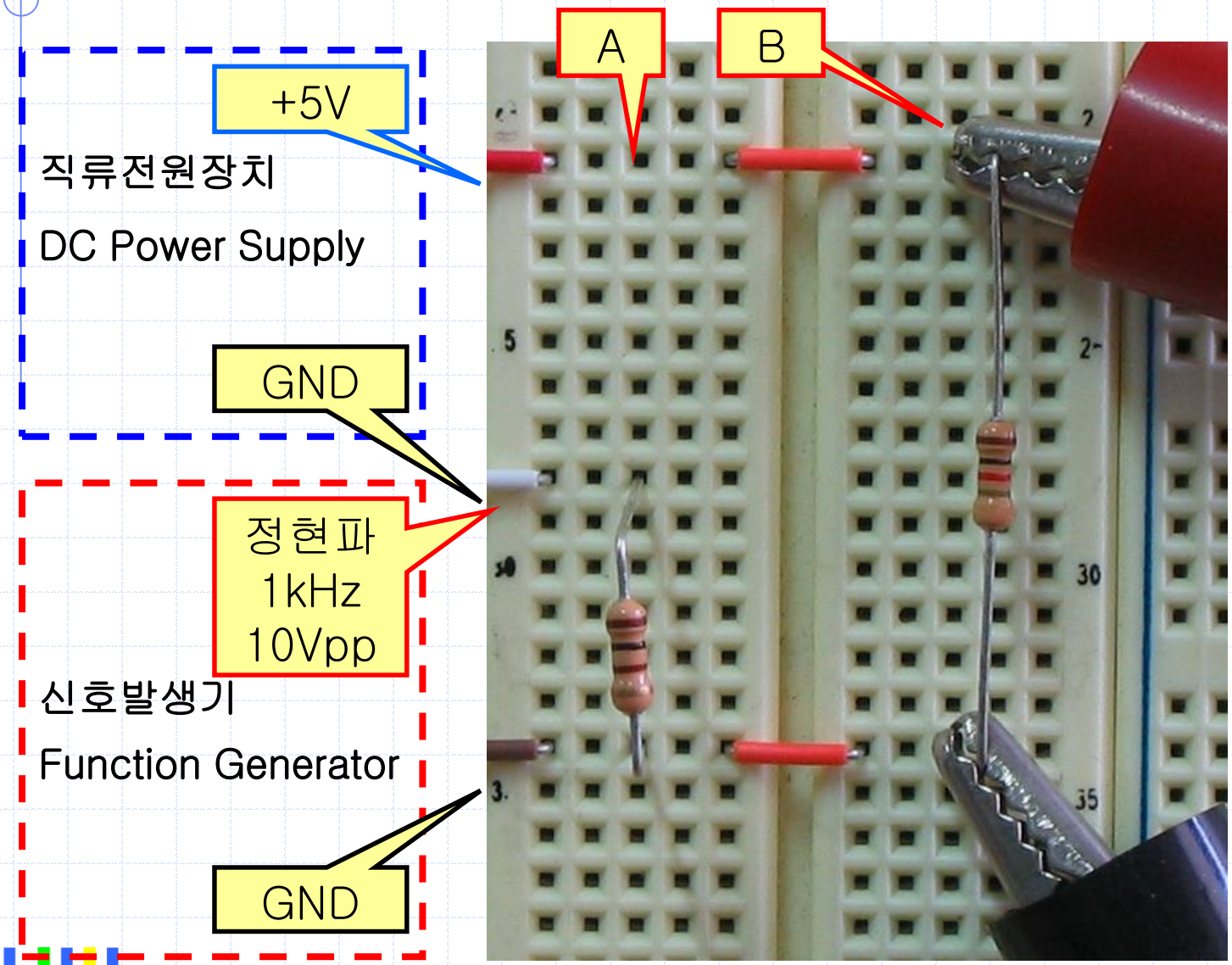
8-8A. 커패시터의 커플링 특성



8-8A. 커패시터의 커플링 특성

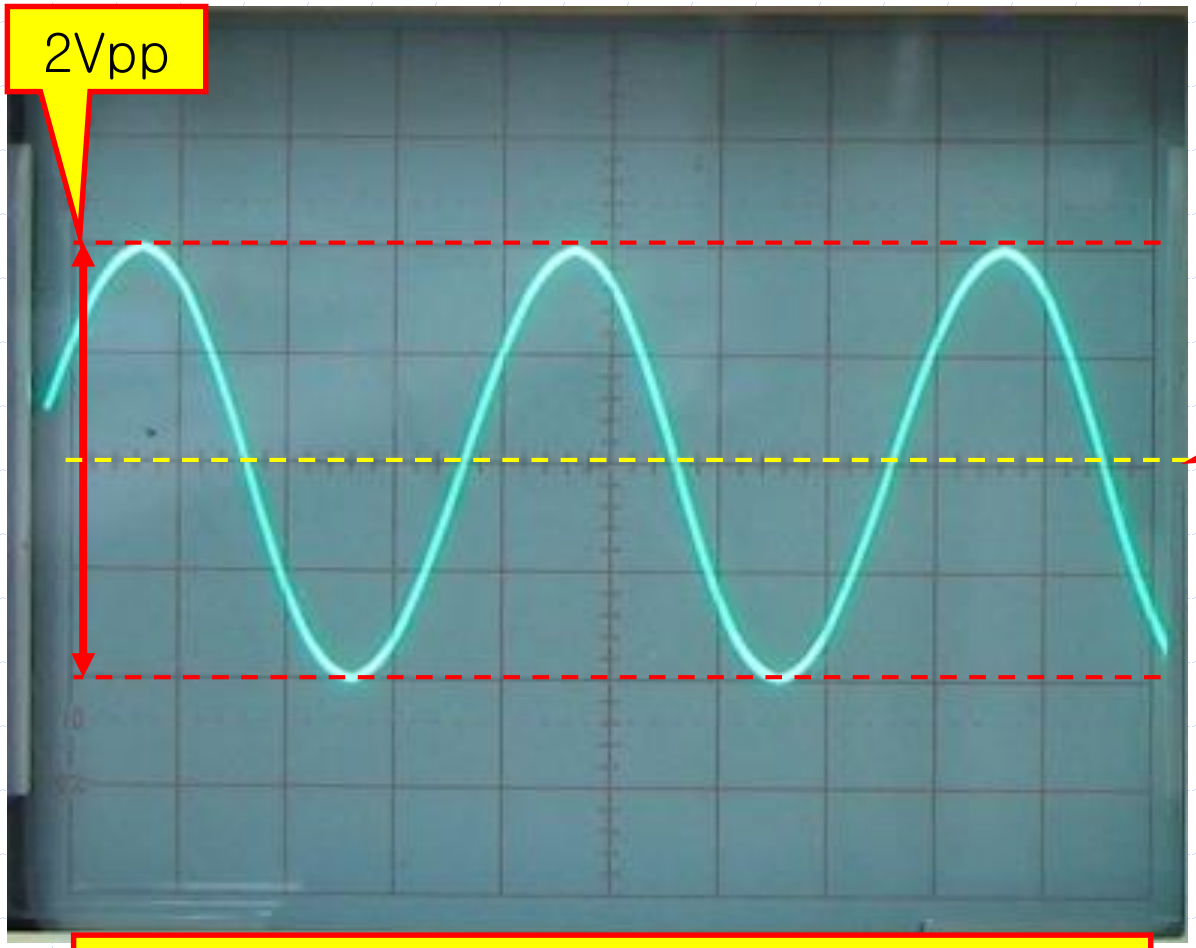


8-8A. 커패시터의 커플링 특성



8-8A. 커패시터의 커플링 특성

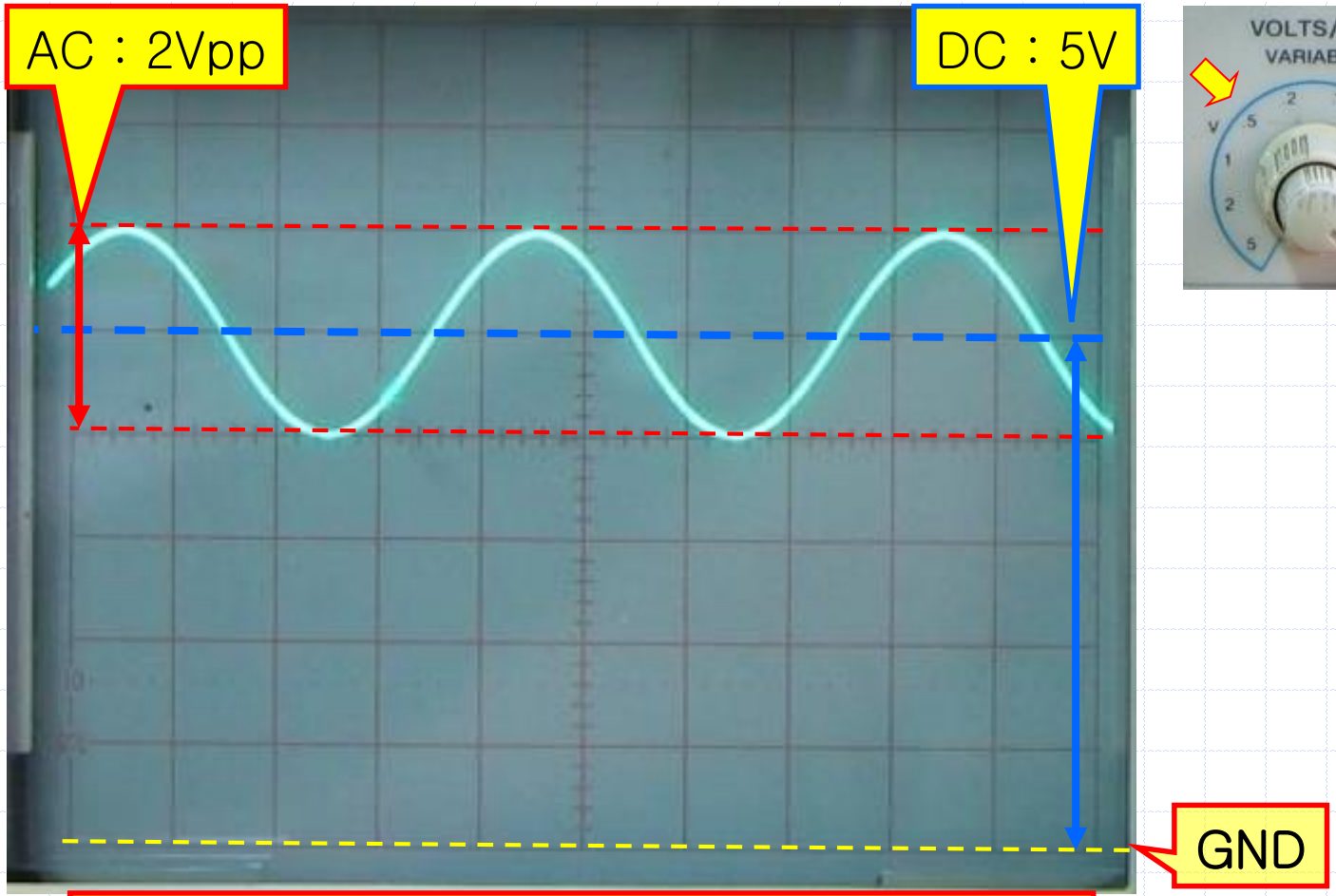
✓ AC 측정



CH 1 : 0.5V/DIV, Time : 50uS/DIV

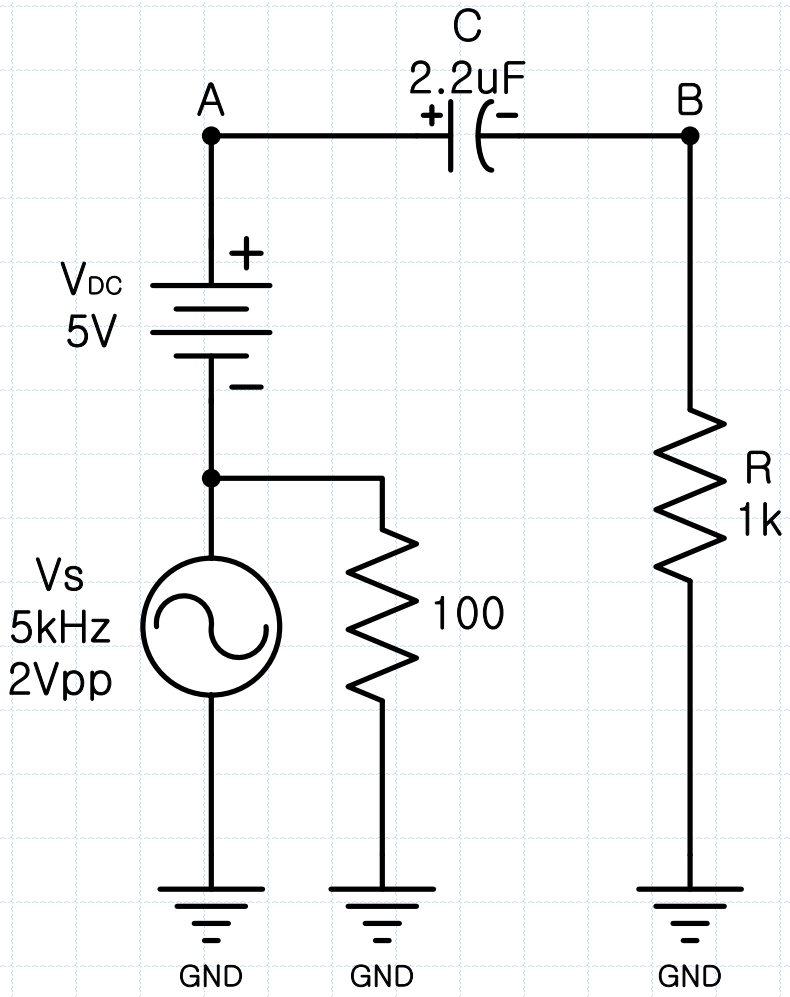
8-8A. 커패시터의 커플링 특성

- ✓ AC + DC 측정

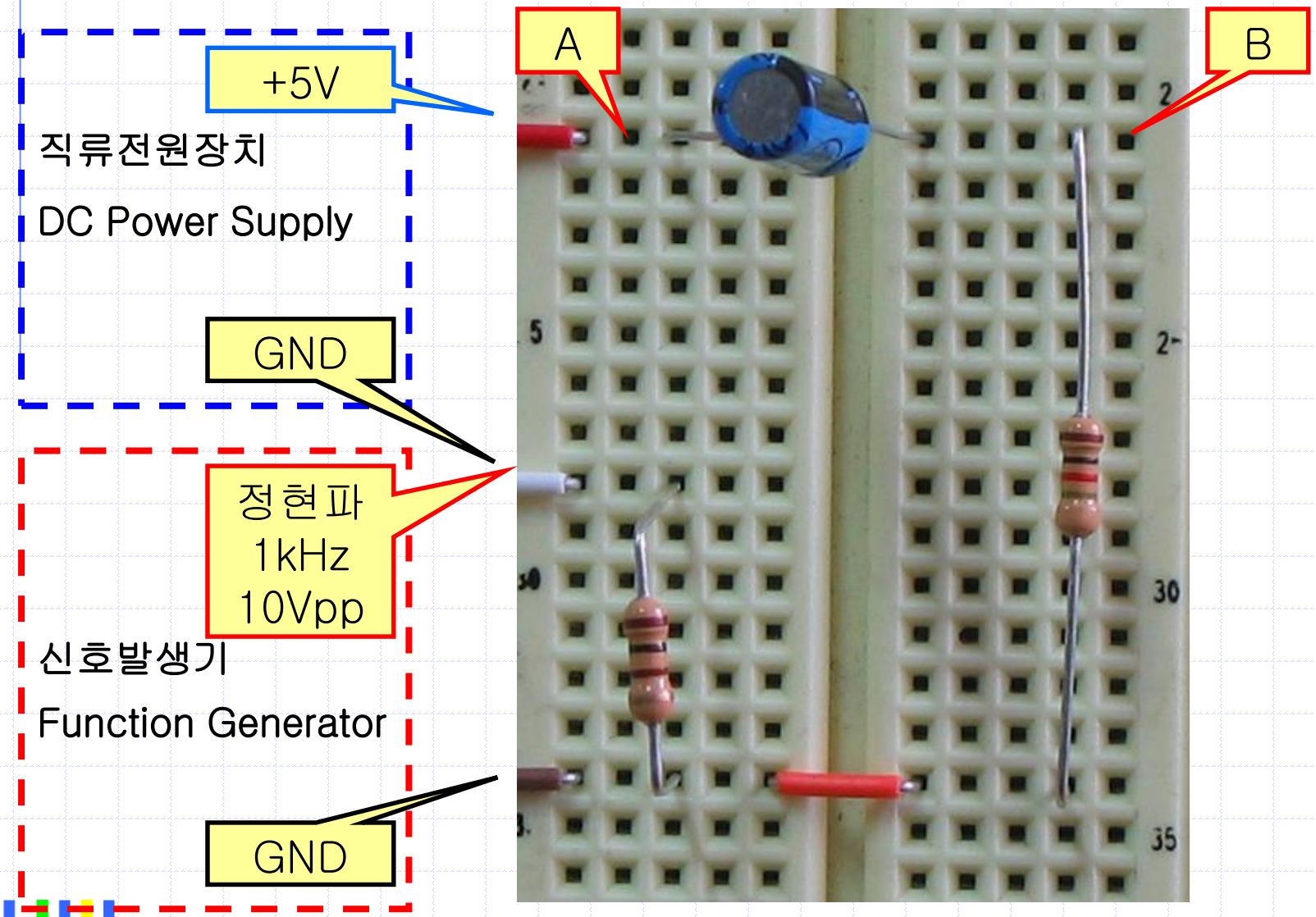


8-8B. 커패시터의 커플링 특성

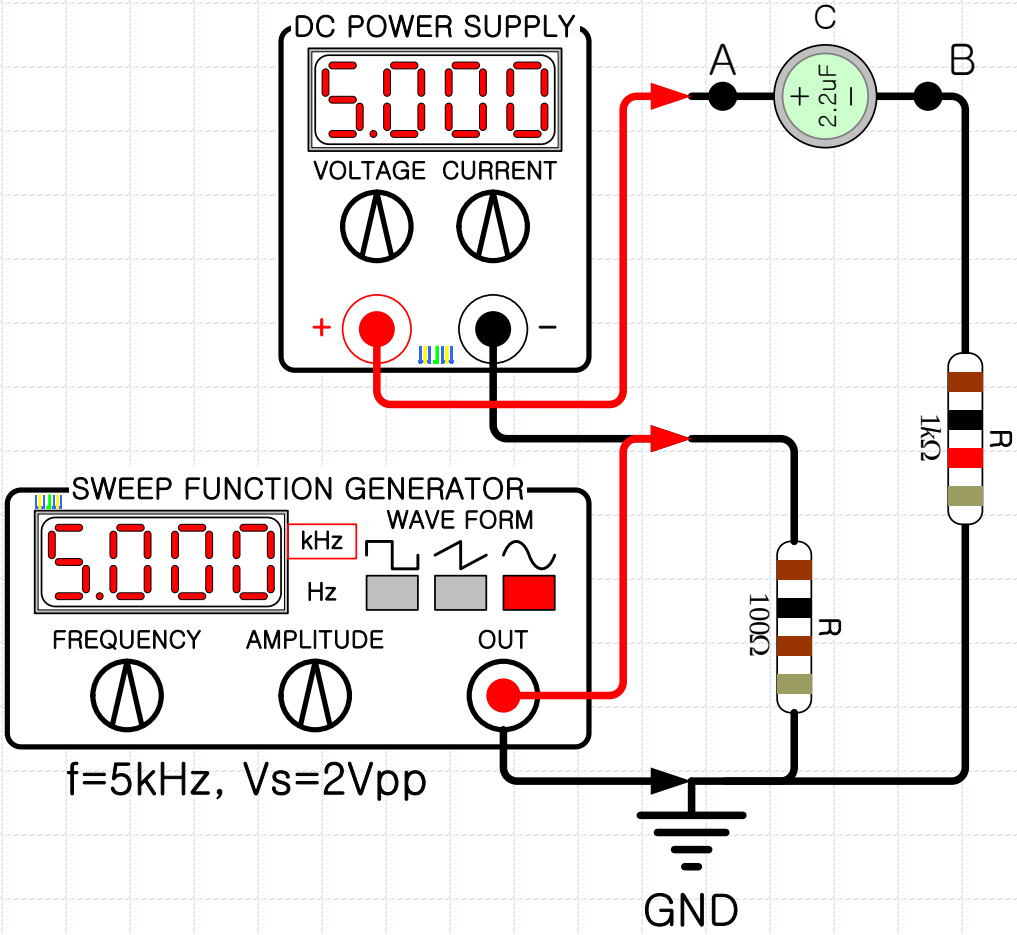
- 앞의 회로에 커패시터를 다음과 같이 연결하고, 오실로스코프를 이용하여 각 지점의 전압을 측정한다.



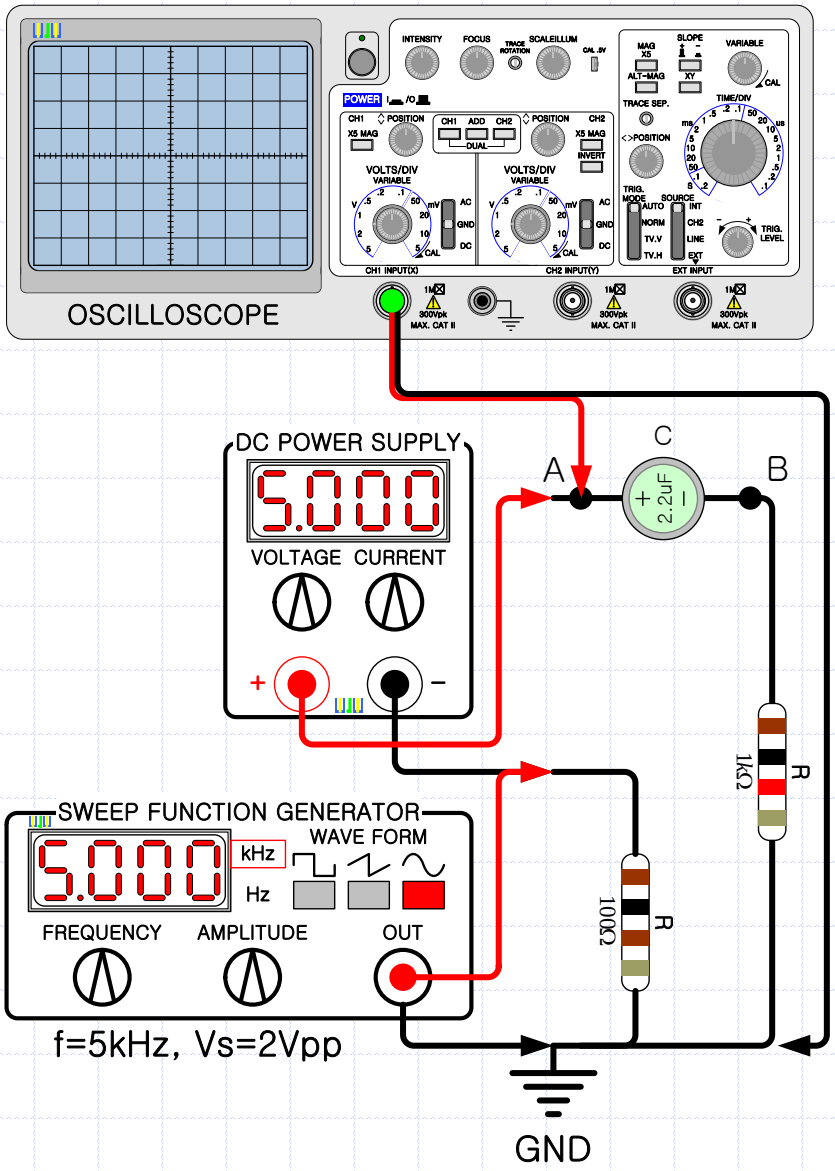
8-8B. 커패시터의 커플링 특성



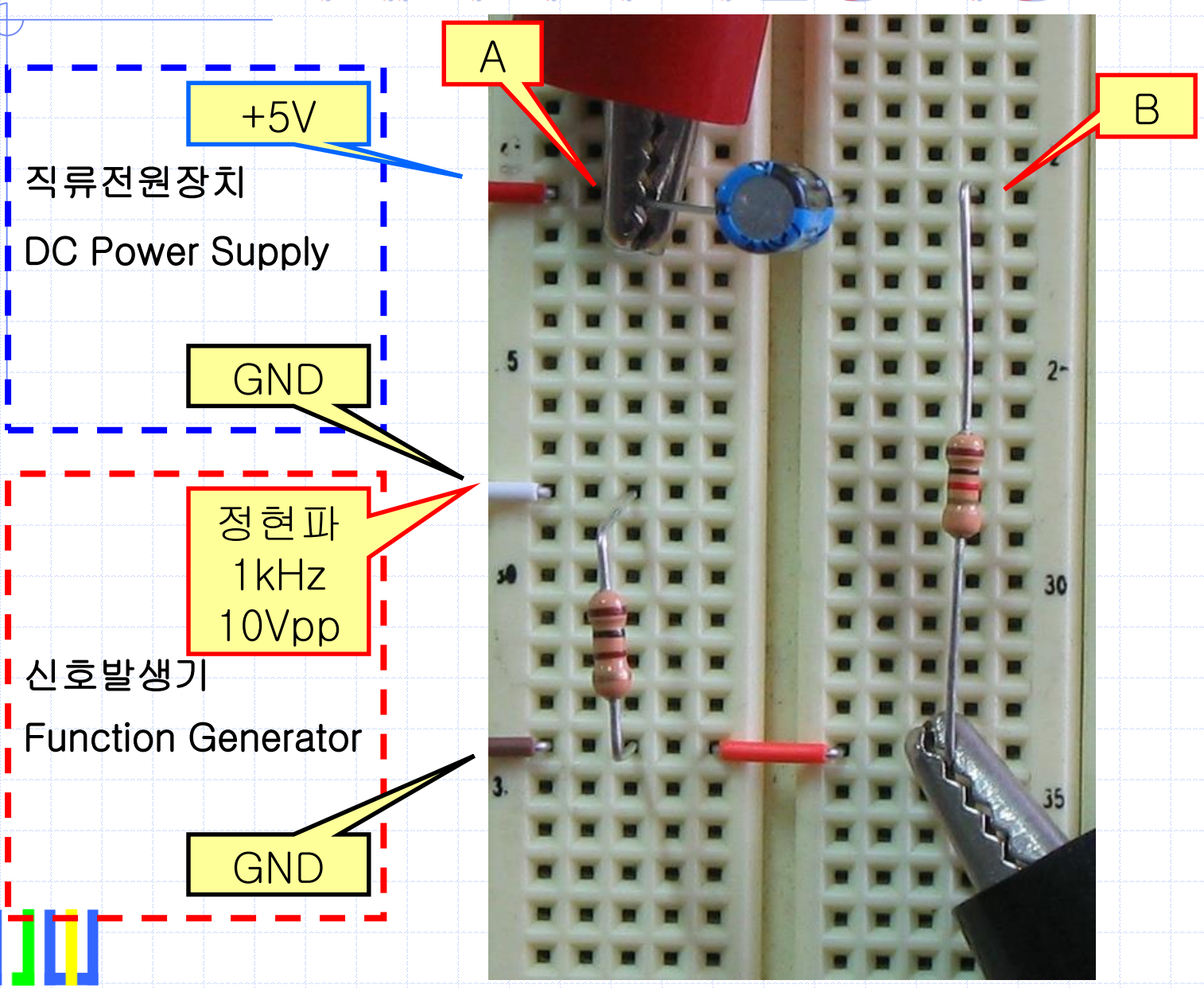
8-8B. 커패시터의 커플링 특성



8-8B. 커패시터의 커플링 특성

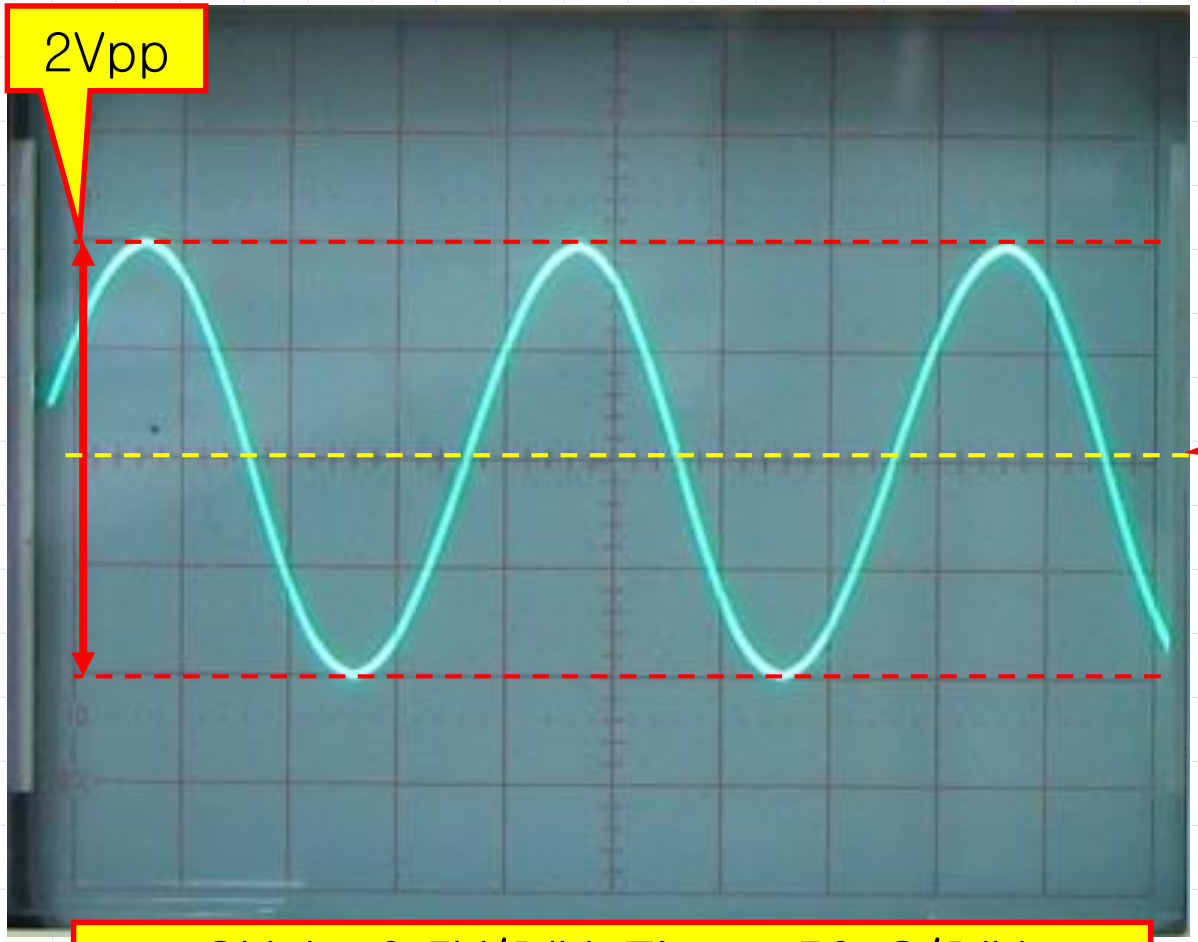


8-8B. 커패시터의 커플링 특성



8-8B. 커패시터의 커플링 특성

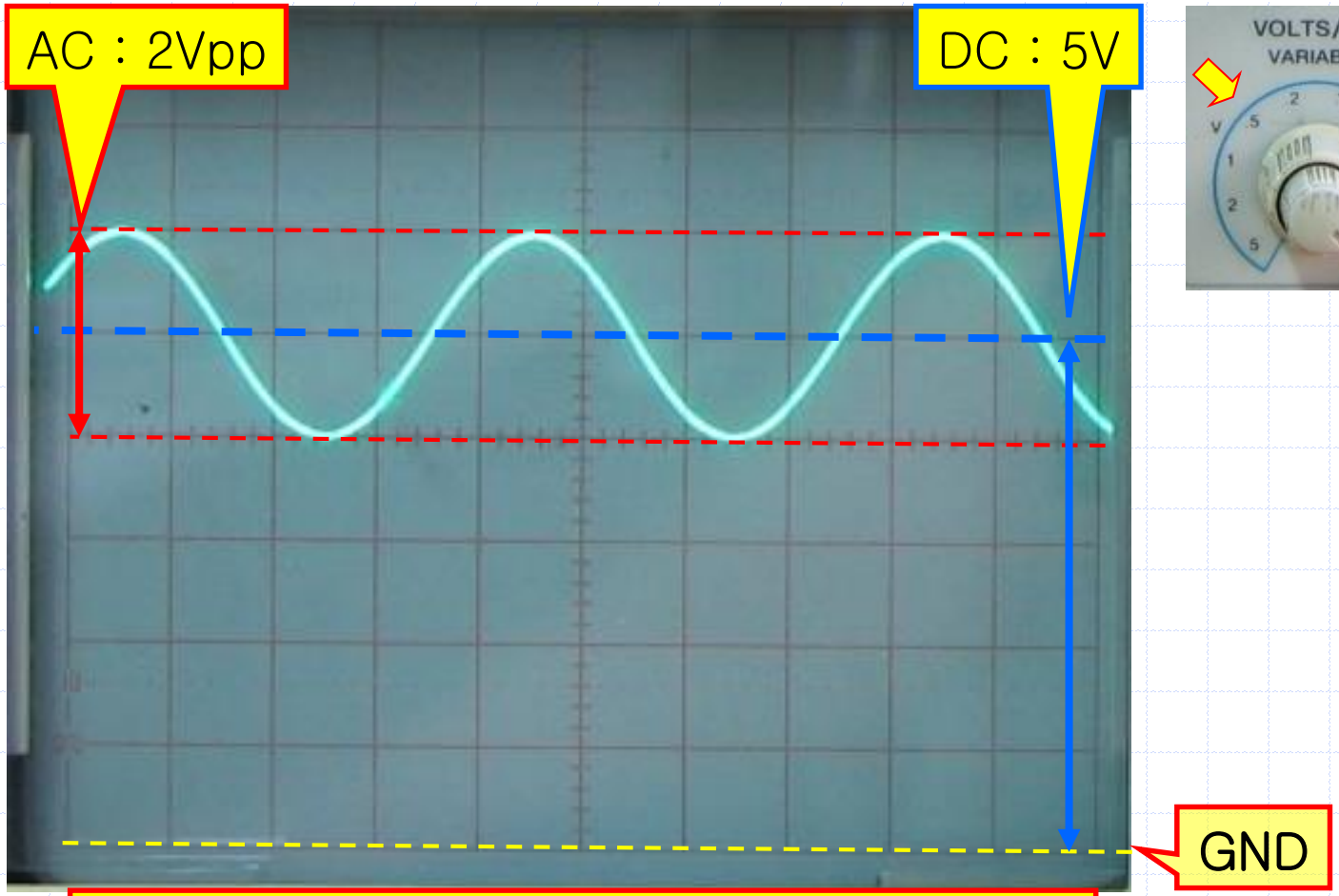
- ✓ AC 측정



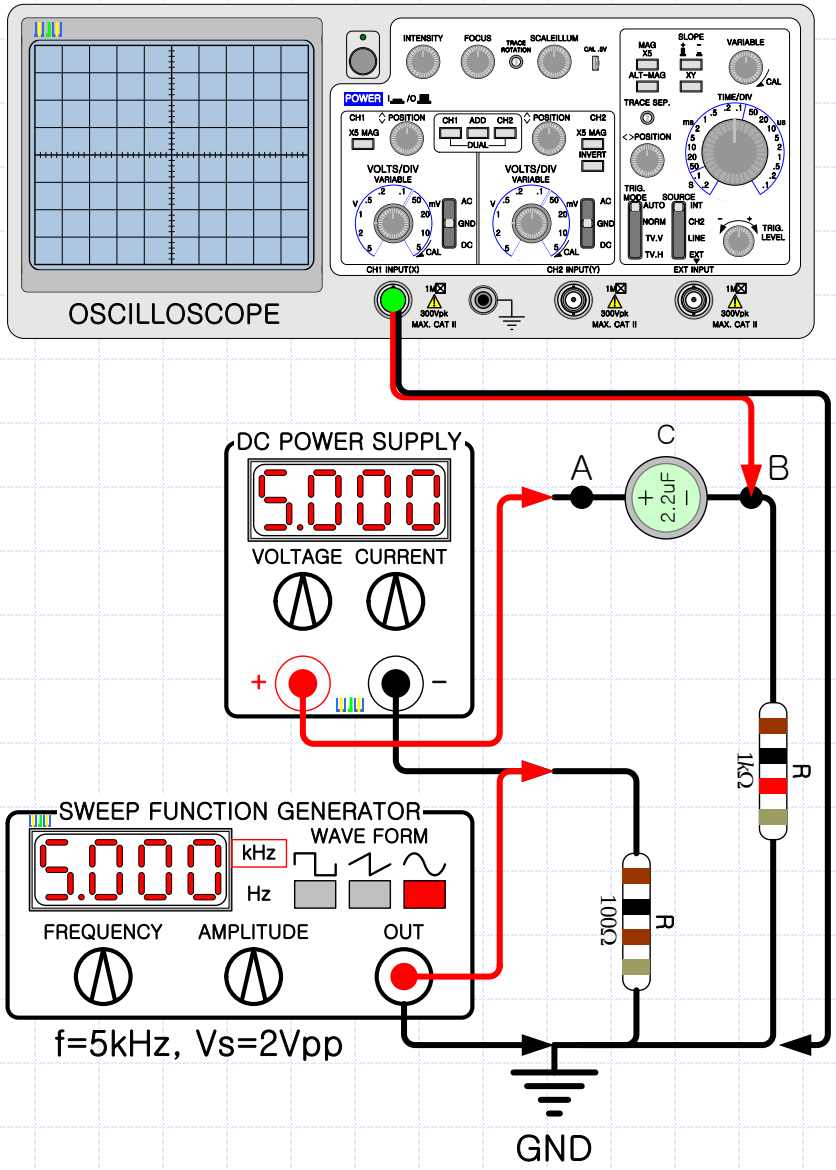
CH 1 : 0.5V/DIV, Time : 50uS/DIV

8-8B. 커패시터의 커플링 특성

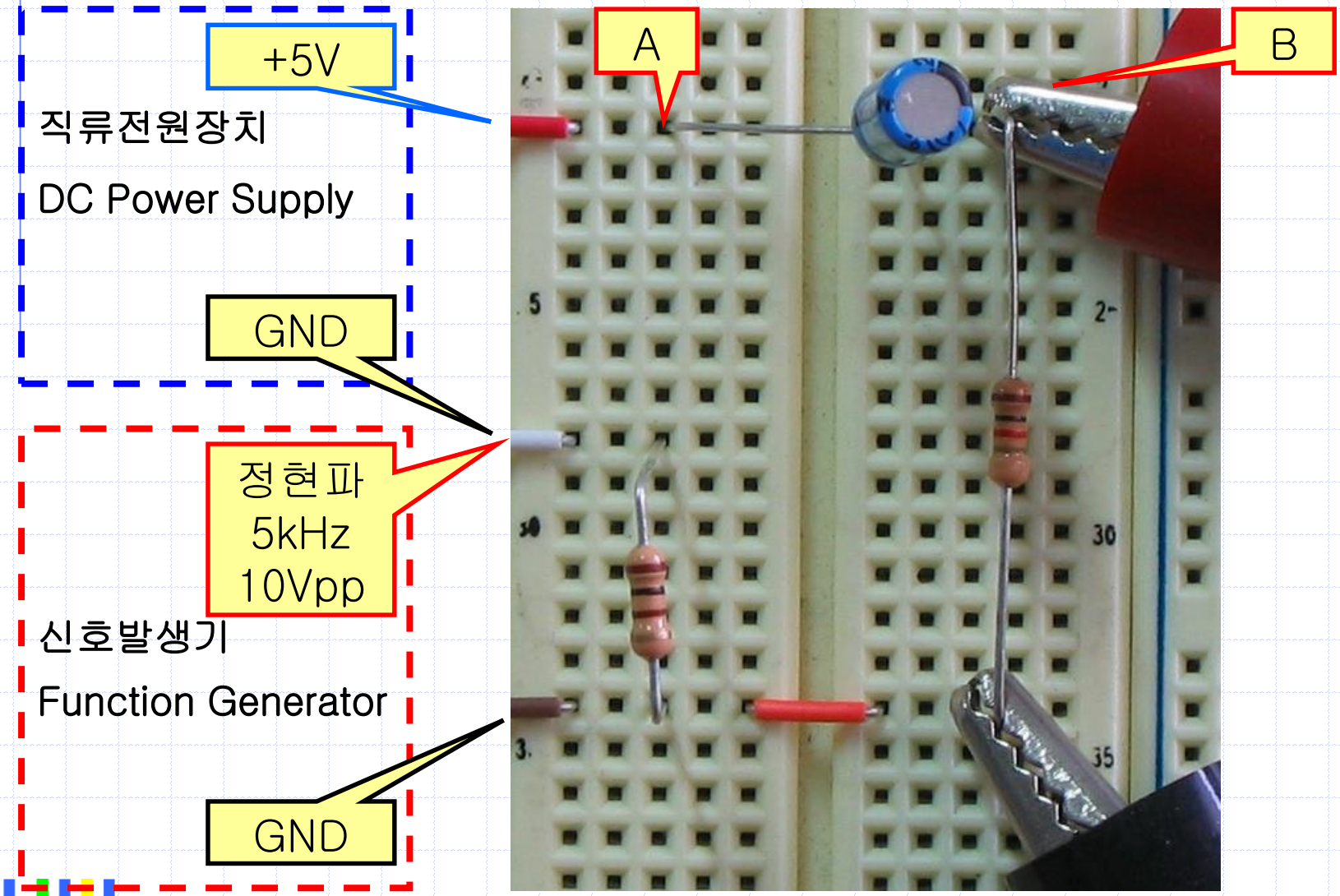
✓ AC + DC 측정



8-8B. 커패시터의 커플링 특성

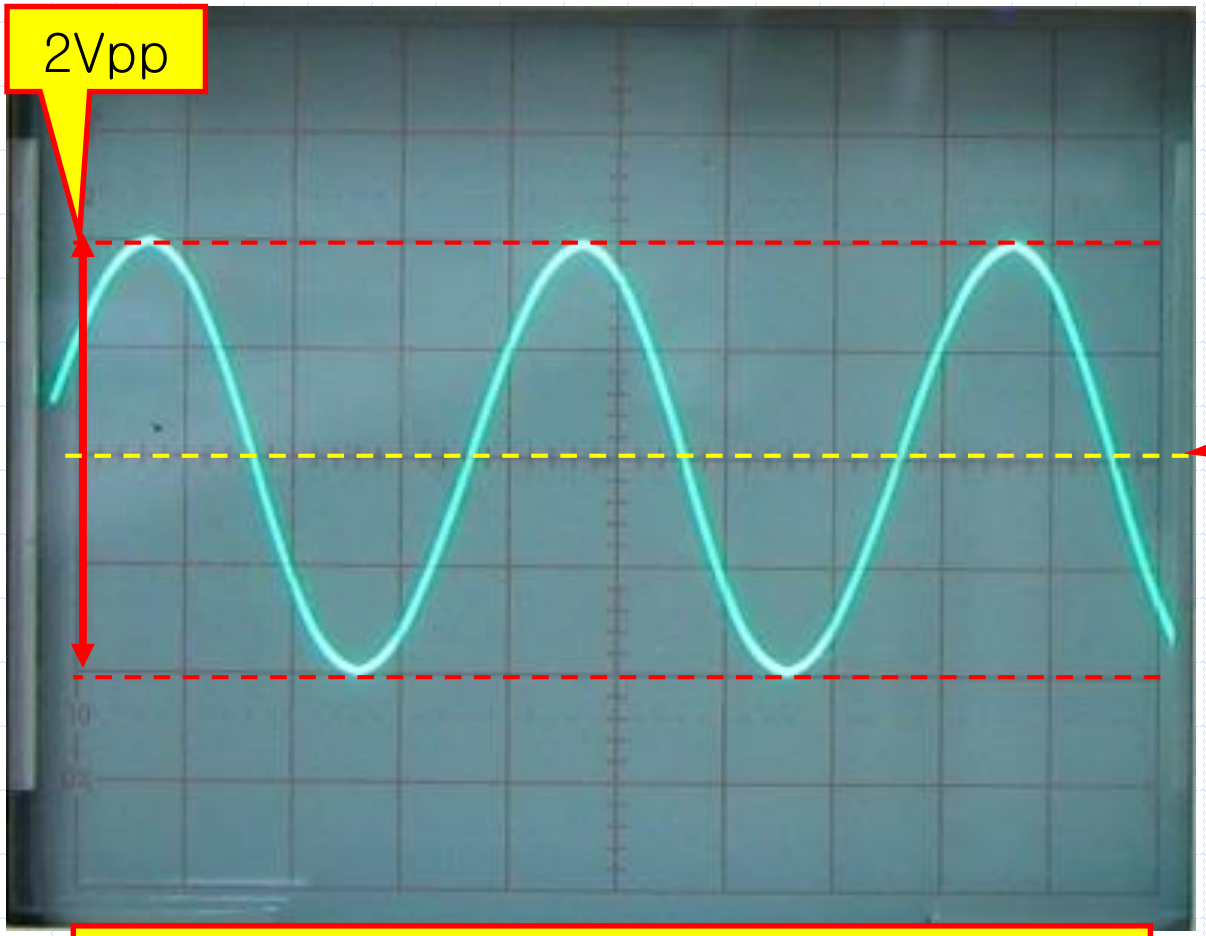


8-8B. 커패시터의 커플링 특성



8-8B. 커패시터의 커플링 특성

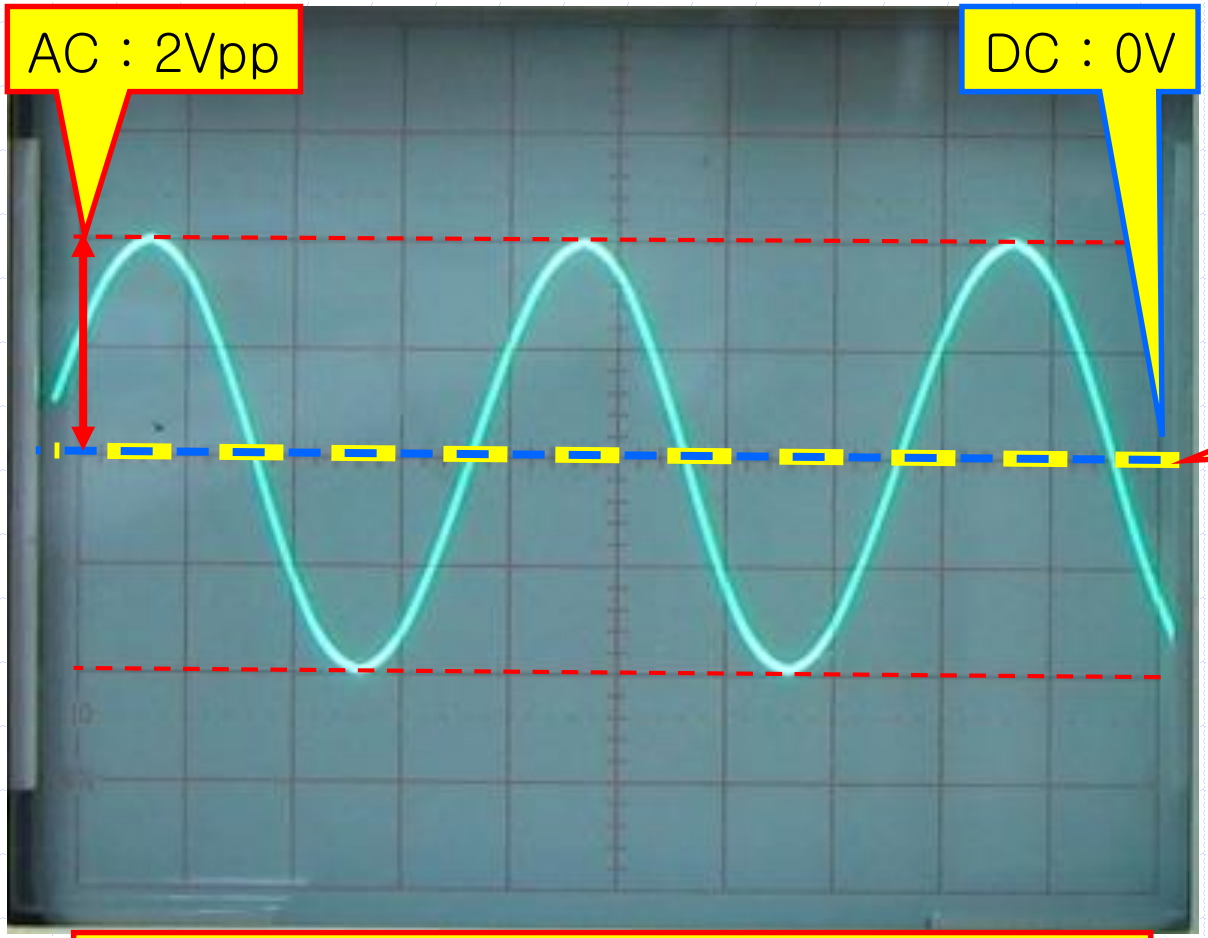
✓ AC 측정



CH 1 : 0.5V/DIV, Time : 50uS/DIV

8-8B. 커패시터의 커플링 특성

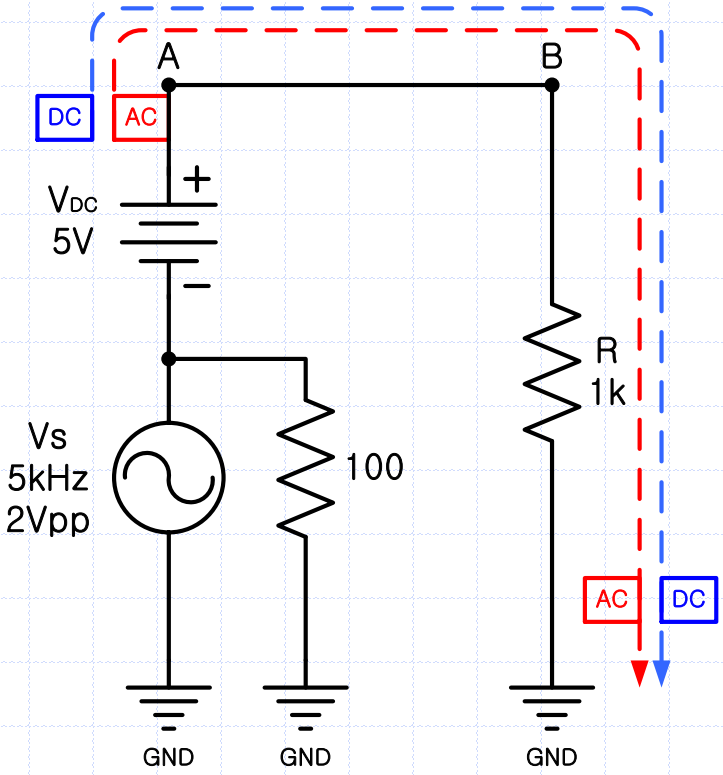
✓ AC + DC 측정

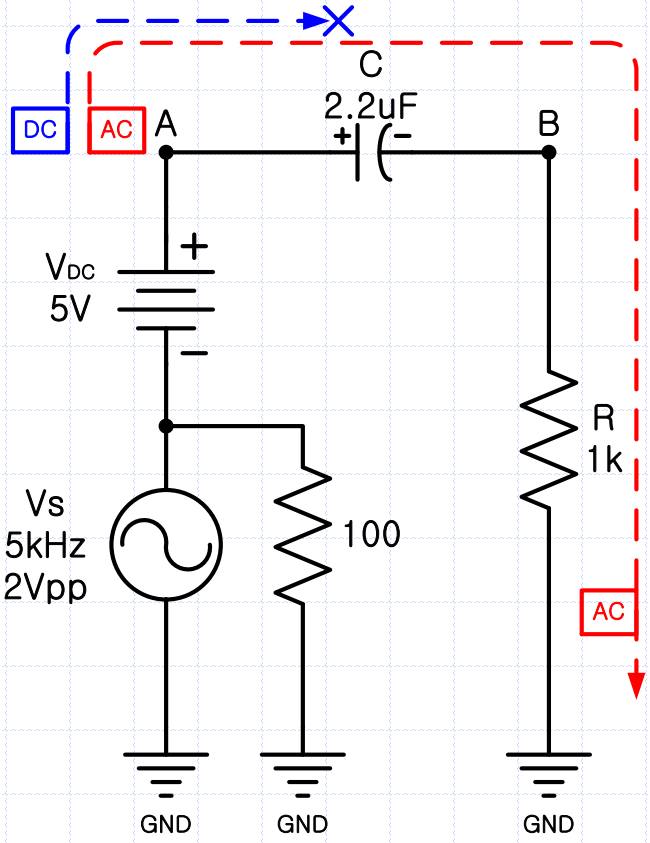


CH 1 : 0.5V/DIV, Time : 50uS/DIV

8-8C. 커패시터의 커플링 특성

- ✓ 커패시터의 직렬 연결 : 결합 역할 (DC 차단)

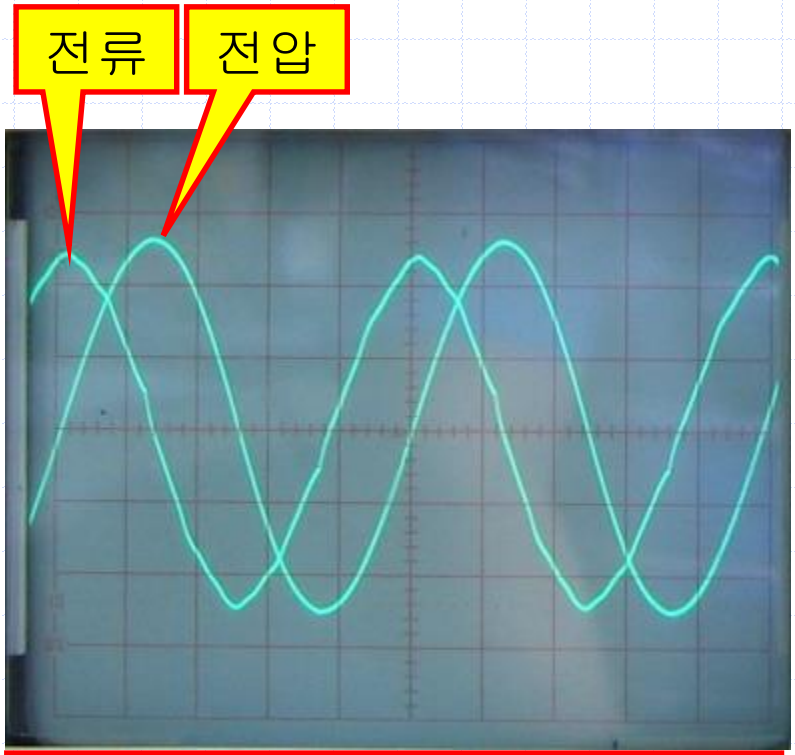




8-9. 위상차

- ✓ 인덕터와 캐패시터의 전압과 전류의 위상차

인덕터인 경우 전압이 빠름



캐패시터인 경우 전류가 빠름