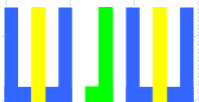


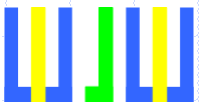
회로 이론/실습

11. 병렬 RC 회로



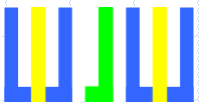
11. 병렬 RC 회로

- 11-1. 목적 및 배경
- 11-2. 소요 부품 및 장비
- 11-3. 유용한 공식
- 11-4. 주파수에 따른 임피던스
- 11-5. 주파수에 따른 위상의 변화
- 11-6. 전압과 전류의 위상



11-1. 목적 및 배경

- ✓ 병렬로 연결된 RC 회로의 특성을 이해한다.
- ✓ 주파수에 따른 임피던스의 변화를 확인한다.
- ✓ 주파수에 따른 위상의 변화를 확인한다.
- ✓ 전압과 전류의 위상변화를 확인한다.



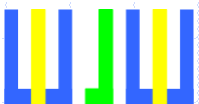
11-2. 소요 부품 및 장비

✓ 부품

- ✓ 저항 (1/4W) : 10 Ω , 1k Ω
- ✓ 캐패시터 : 0.1 μ F

✓ 장비

- ✓ 브레드 보드
- ✓ 디지털 멀티미터 (Digital Multi-Meter)
- ✓ 오실로스코프 (Oscilloscope)
- ✓ 신호발생기 (Function Generator)

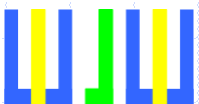


11-3. 유용한 공식

$$Z = \frac{(R \angle 0^\circ)(X_C \angle 90^\circ)}{R - jX_C} = \frac{RX_C \angle (0^\circ - 90^\circ)}{\sqrt{R^2 + X_C^2} \angle -\tan^{-1}\left(\frac{X_C}{R}\right)}$$

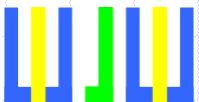
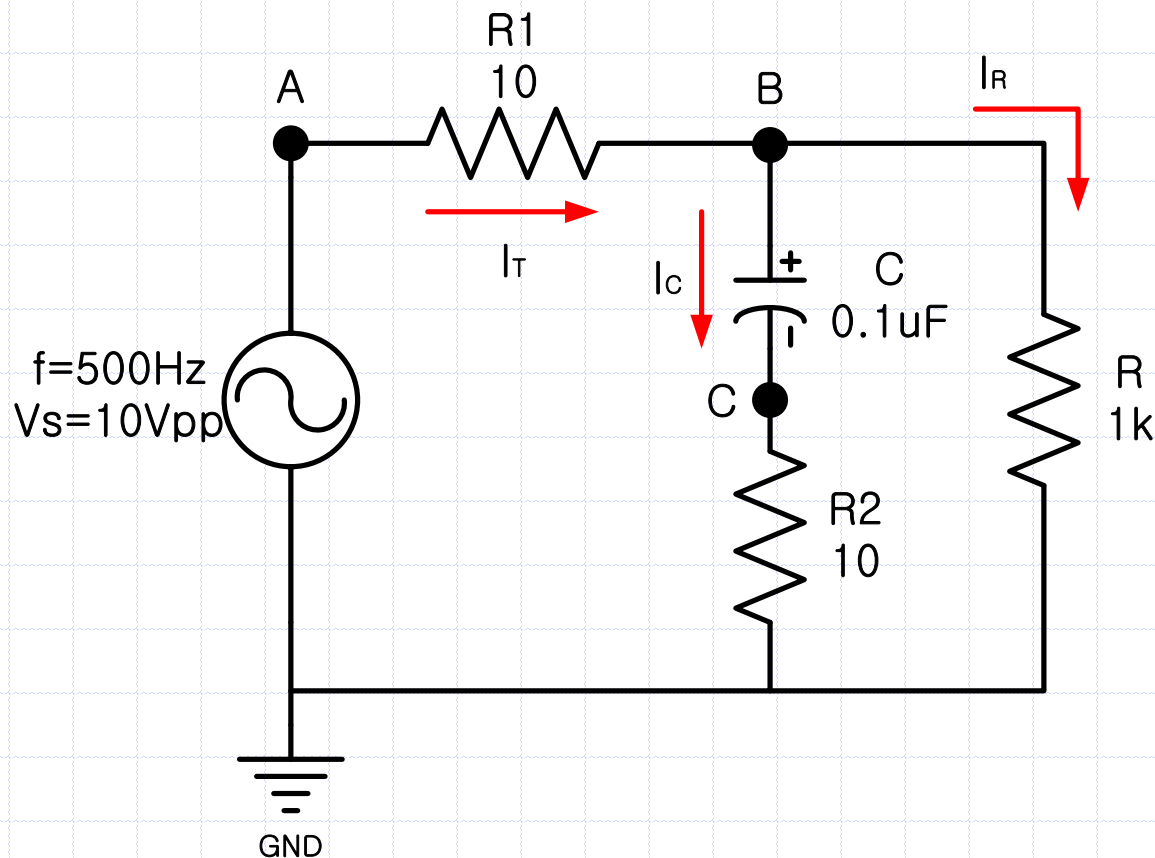
$$|Z| = \frac{RX_C}{\sqrt{R^2 + X_C^2}}$$

$$\theta = -\tan^{-1}\left(\frac{R}{X_C}\right)$$



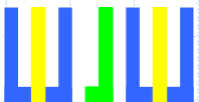
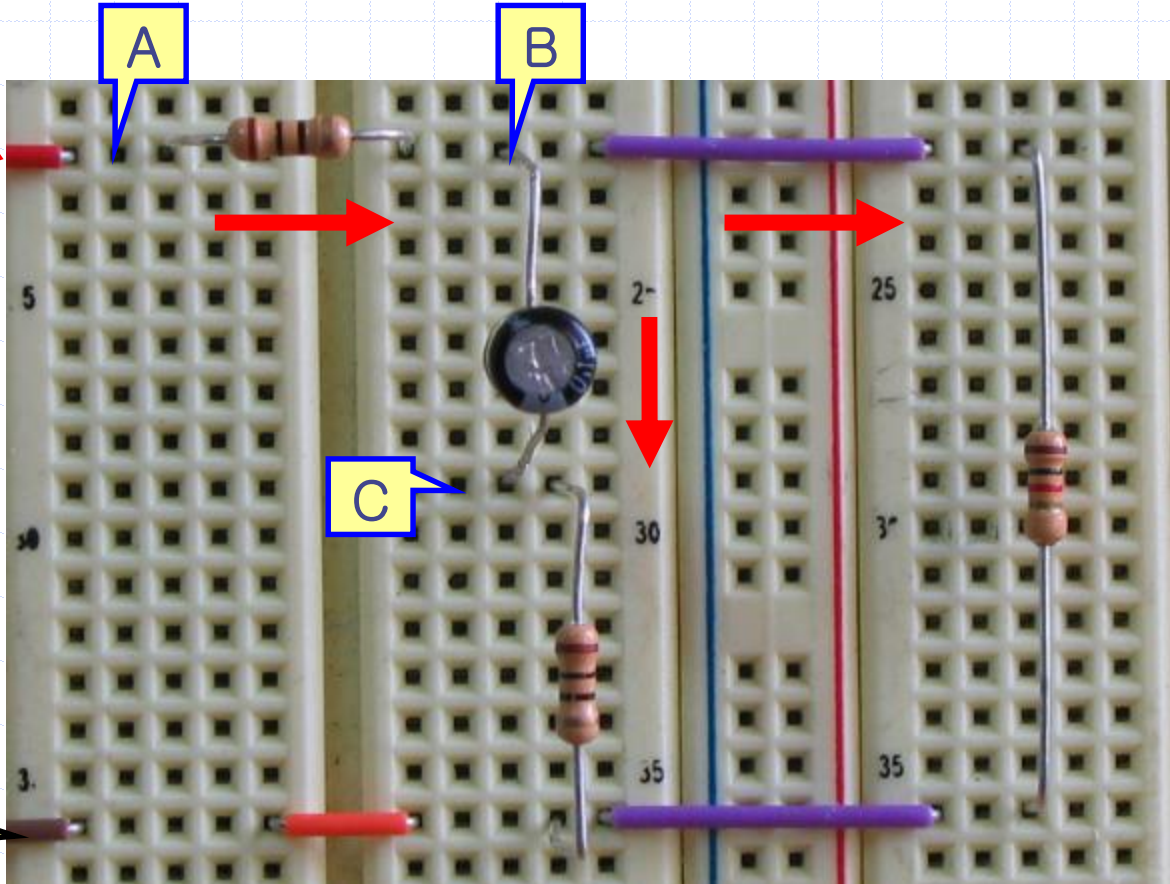
11-4. 주파수에 따른 임피던스

- 다음과 같이 회로를 연결하고, 신호발생기를 조절하여 주파수 500Hz, 10Vpp의 정현파가 나오도록 한다.

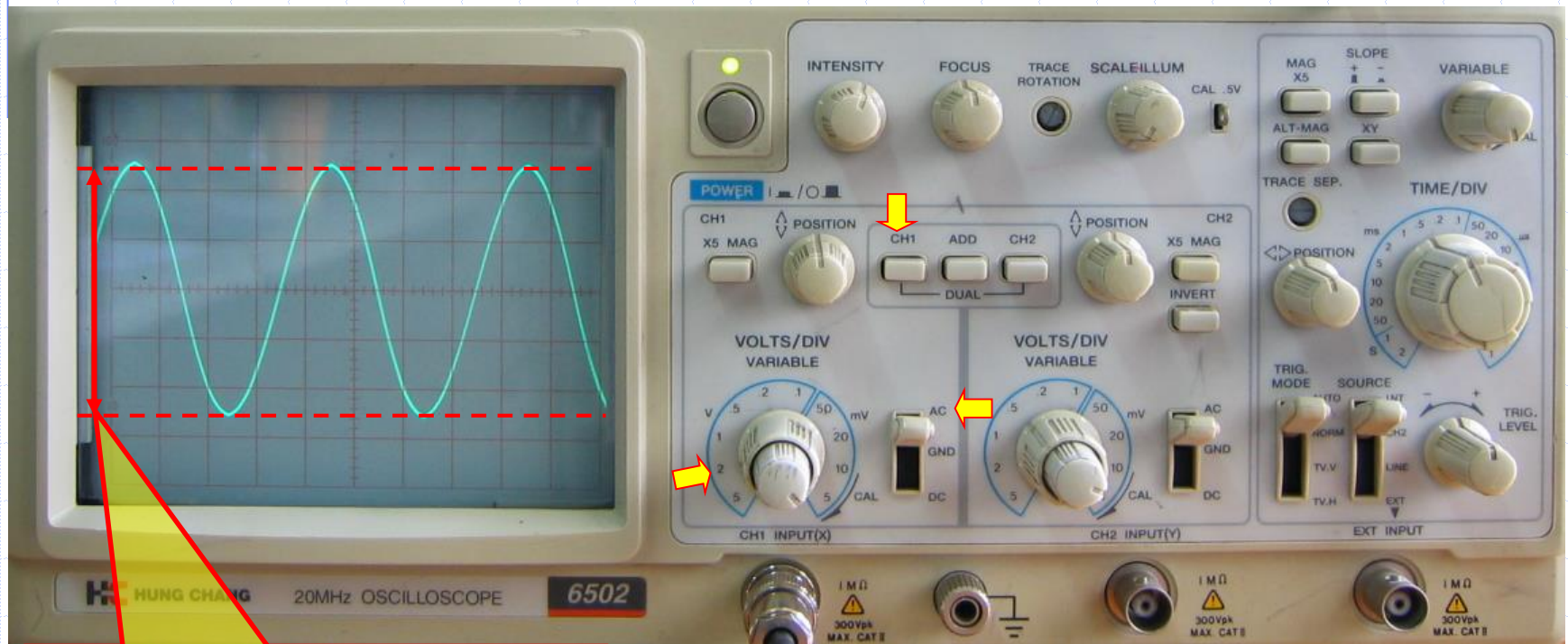
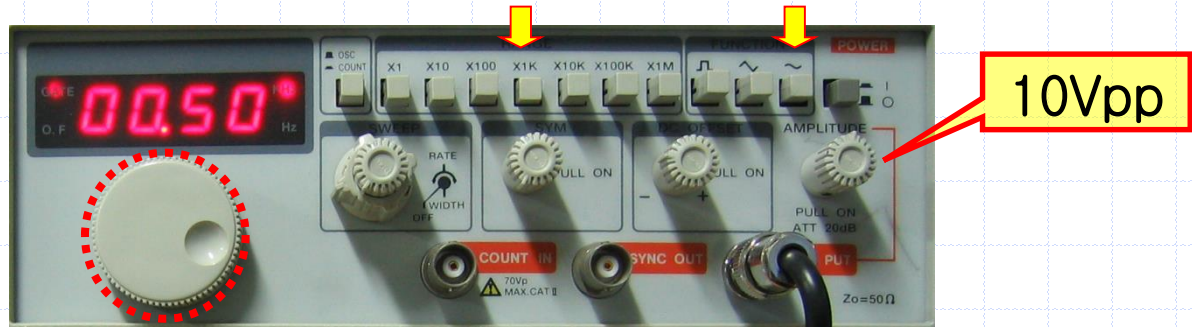


11-4. 주파수에 따른 임피던스

정현파
500Hz
10Vpp



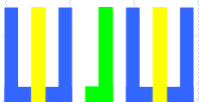
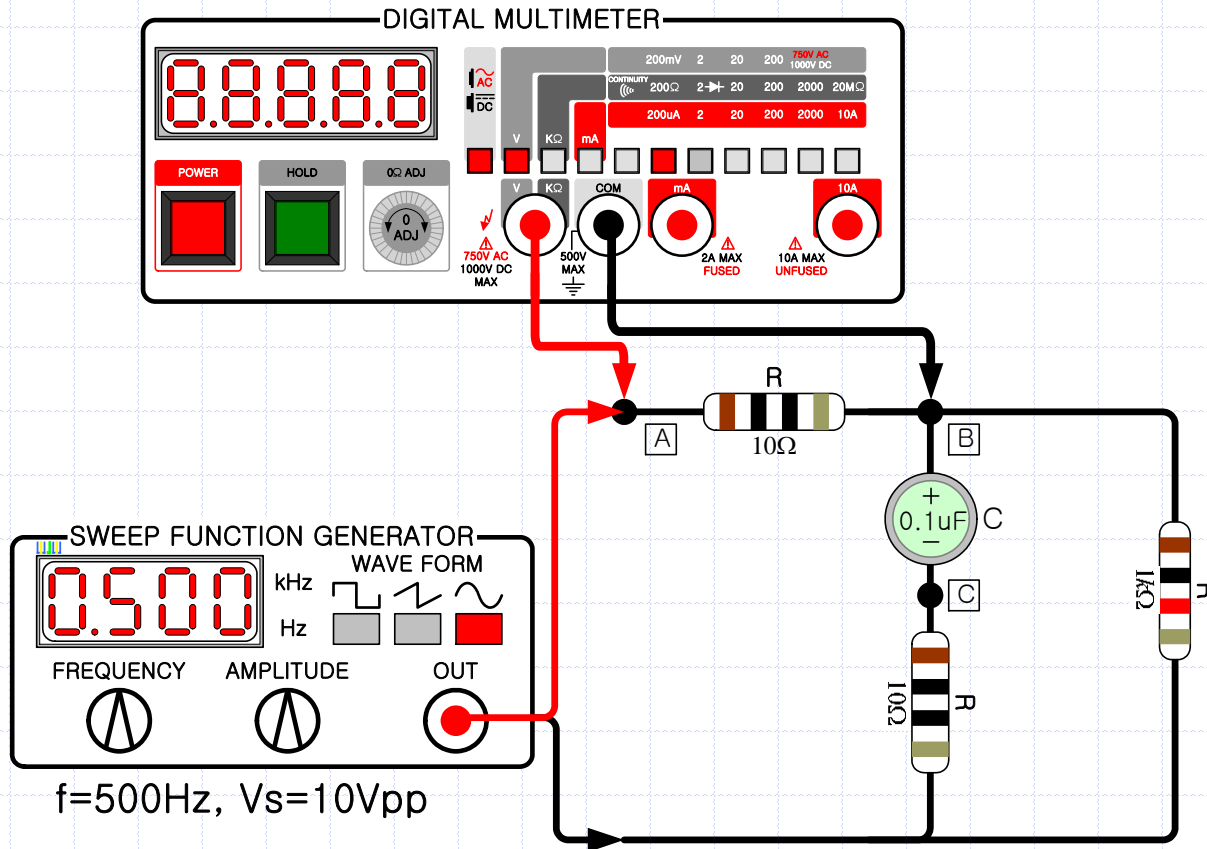
11-4. 주파수에 따른 임피던스



5칸 X 2V/DIV = 10Vpp

11-4. 주파수에 따른 임피던스

- ✓ 디지털 멀티미터를 이용하여 저항 양단의 전압을 측정한다.



11-4. 주파수에 따른 임피던스

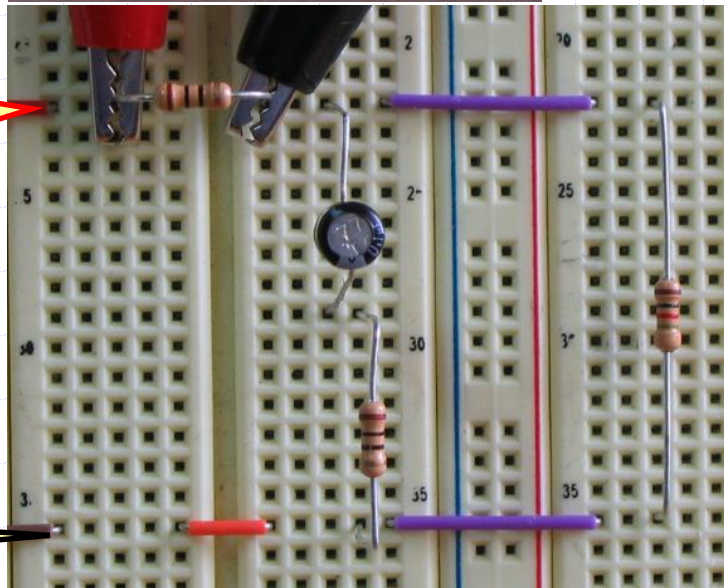
✓ 주파수 : 500Hz

$$V_{R1(rms)} = 35.32mV$$

$$V_{R1(p-p)} = 35.32mV \times 2 \times 1.414 = 99.88mV_{pp}$$

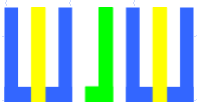


정현파
500Hz
10Vpp



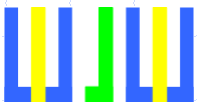
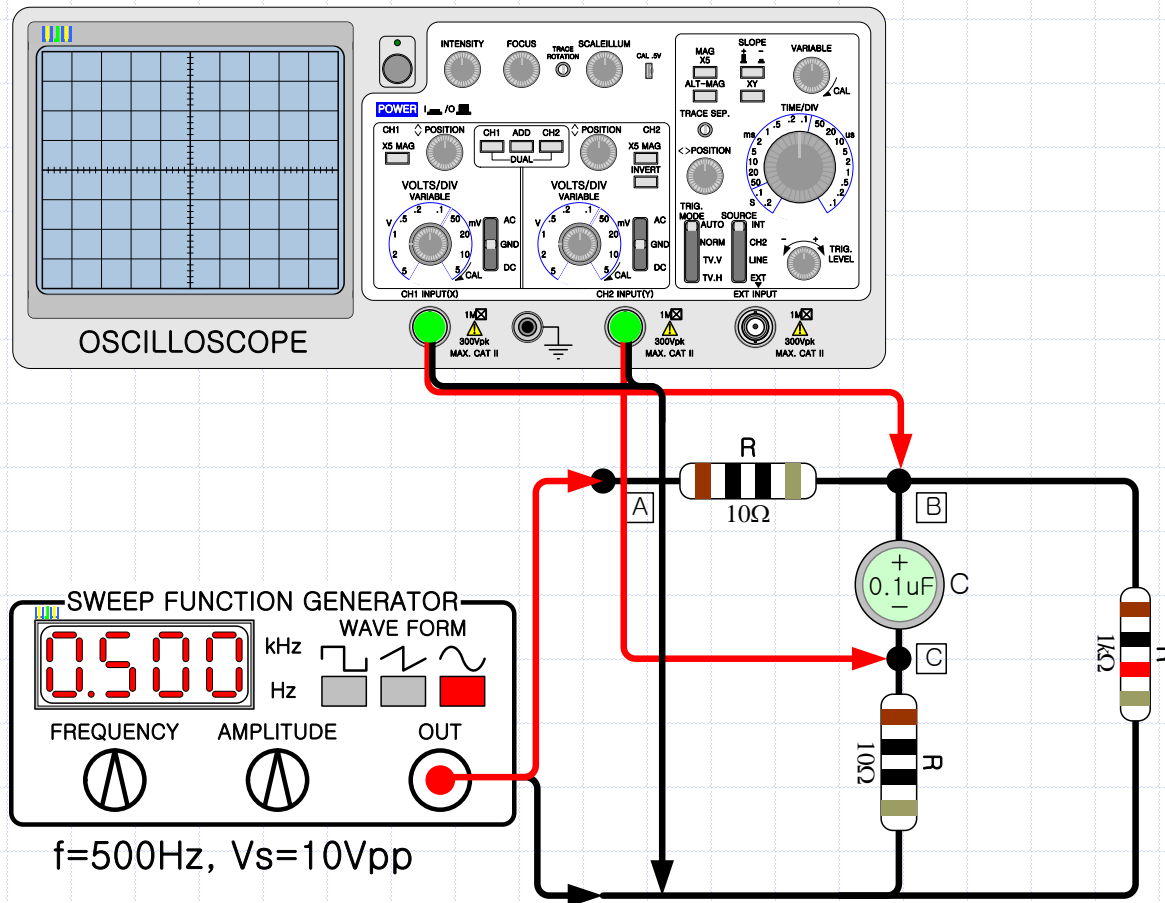
GND

$$\begin{aligned} I_T(\text{실험}) &= \frac{V_{R1}}{R_1} \\ &= \frac{99.88mV_{PP}}{10\Omega} \\ &= 9.988mA_{PP} \end{aligned}$$



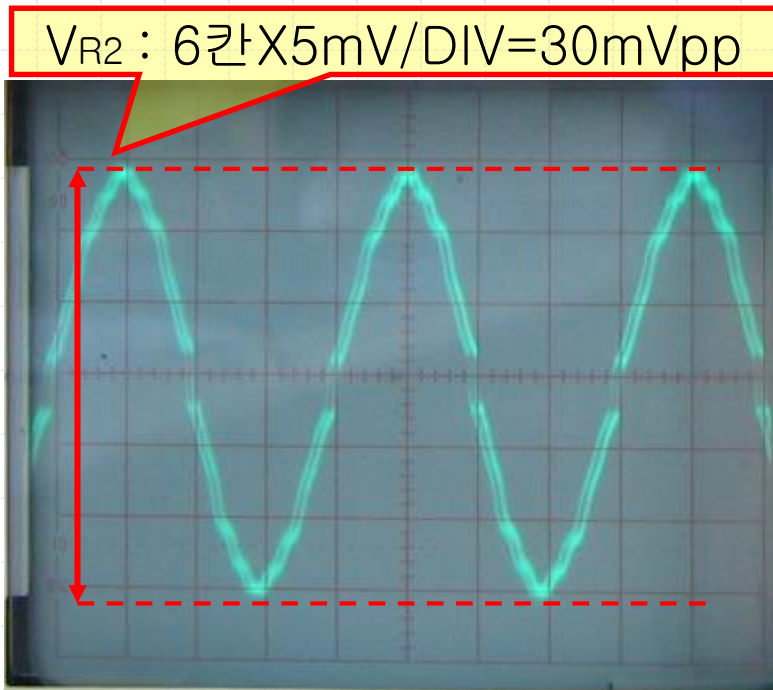
11-4. 주파수에 따른 임피던스

- ✓ 오실로스코프의 CH 1 을 B점과 접지에, CH 2 를 C점과 접지에 연결하여 전압을 측정하라.



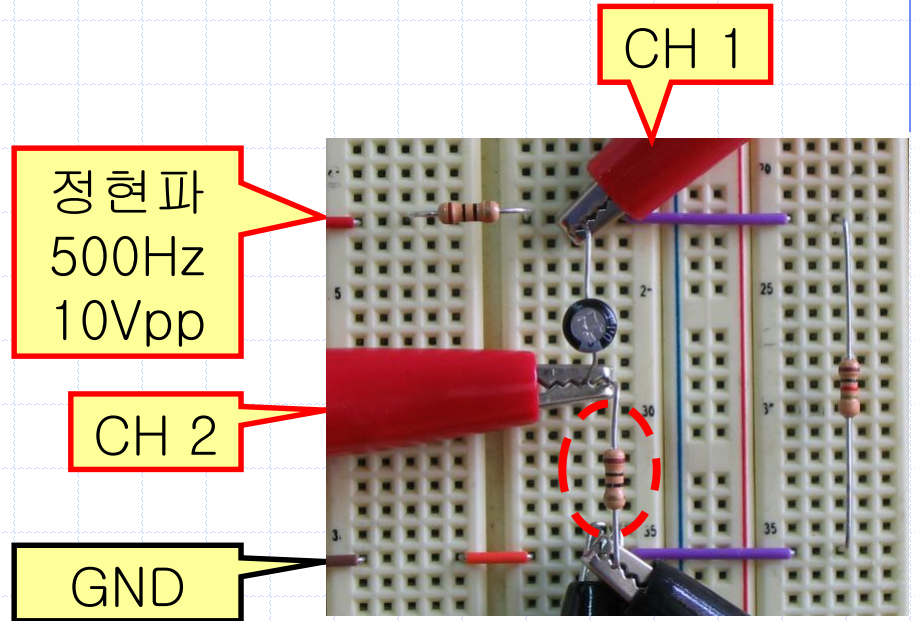
11-4. 주파수에 따른 임피던스

✓ 주파수 : 500Hz, CH 2, V_{R2} 의 전압



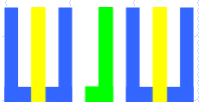
5mV/DIV, 0.5mS/DIV

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{30\text{mV}_{PP}}{10\Omega} = 3\text{mA}_{PP}$$



$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{V_C}{I_C} = \frac{V_R}{I_C} = \frac{10V_{PP}}{3\text{mA}} = 3333.3\Omega$$

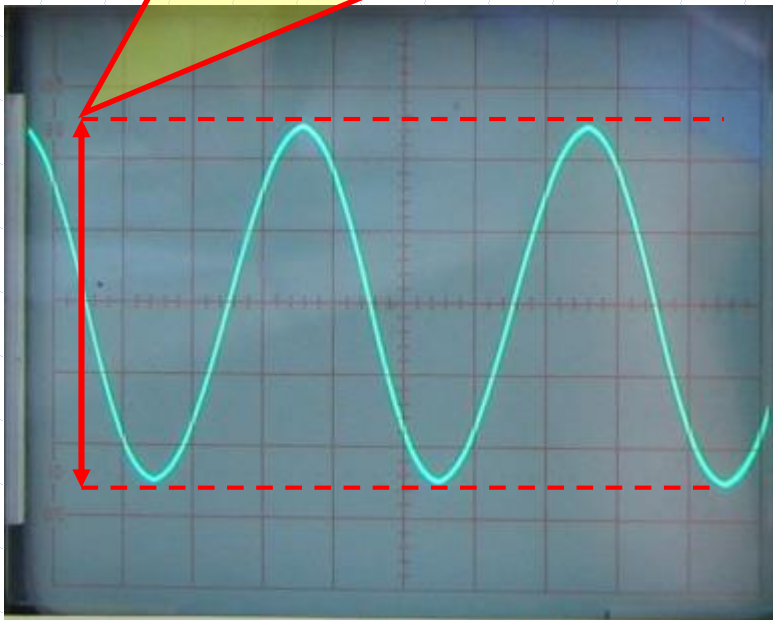
$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10V_{PP}}{9.988\text{mA}_{PP}} = 1001.2\Omega$$



11-4. 주파수에 따른 임피던스

✓ 주파수 : 500Hz, CH 1, V_R 의 전압

V_s, V_C, V_{R2} : 5칸 X 2V/DIV = 10Vpp



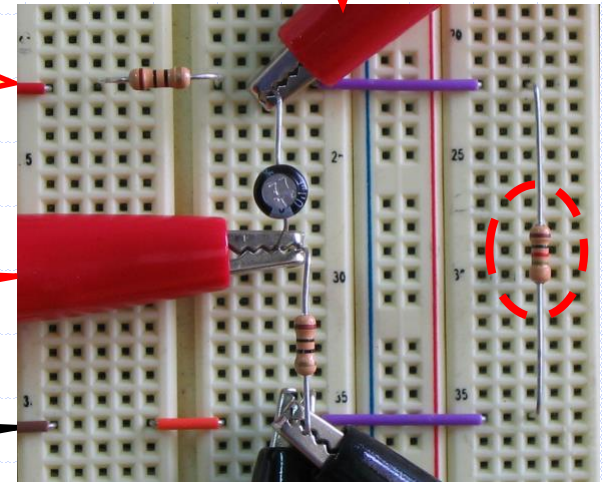
2V/DIV, 0.5mS/DIV

정현파
500Hz
10Vpp

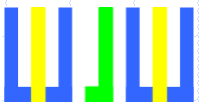
CH 2

GND

CH 1



$$I_R(\text{실험}) = \frac{V_R}{R} = \frac{10V_{PP}}{1k\Omega} = 10mA_{PP}$$



11-4. 주파수에 따른 임피던스

✓ 주파수 : 1kHz

$$V_{R1(rms)} = 38.85mV$$

$$V_{R1(p-p)} = 38.85mV \times 2 \times 1.414 \\ = 109.86mV_{pp}$$



$$I_T(\text{실험}) = \frac{V_{R1}}{R_1} = \frac{109.86mV_{PP}}{10\Omega} = 10.986mA_{PP}$$

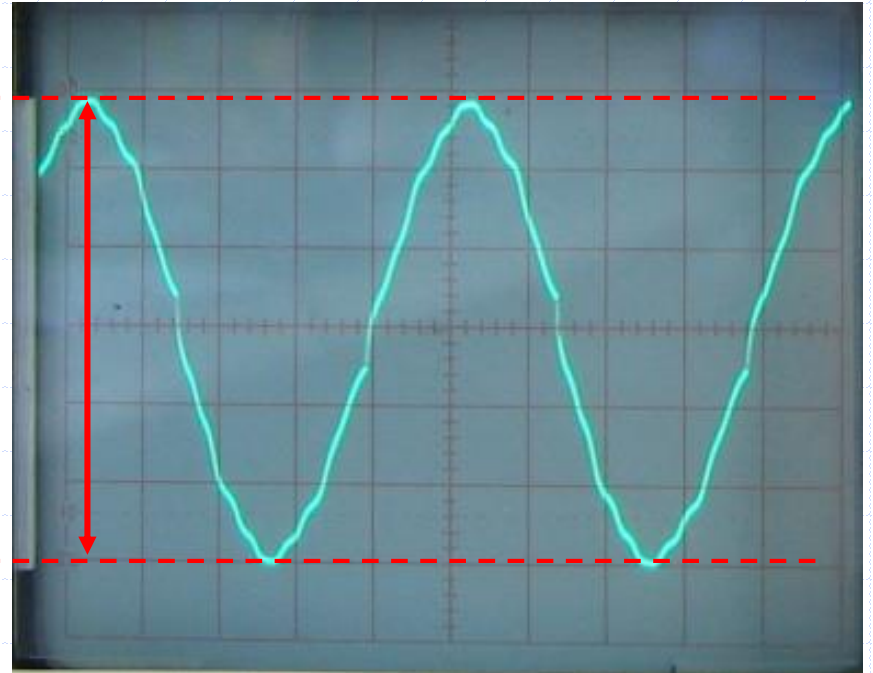
$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10V_{PP}}{10.986mA_{PP}} = 910.25\Omega$$

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{60mV_{PP}}{10\Omega} = 6mA_{PP}$$

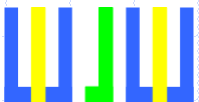
$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{10V_{PP}}{6mA_{PP}} = 1666.67\Omega$$

✓ CH 2, V_{R2} 의 전압

$$V_{R2} : 6\text{칸} \times 10mV/DIV = 60mV_{pp}$$



10mV/DIV, 0.2mS/DIV



11-4. 주파수에 따른 임피던스

✓ 주파수 : 1.5kHz

$$V_{R1(rms)} = 43.91\text{mV}$$

$$V_{R1(p-p)} = 43.91\text{mV} \times 2 \times 1.414 \\ = 124.18\text{mV}_{pp}$$



$$I_T(\text{실험}) = \frac{V_{R1}}{R_1} = \frac{124.18\text{mV}_{PP}}{10\Omega} = 12.418\text{mA}_{PP}$$

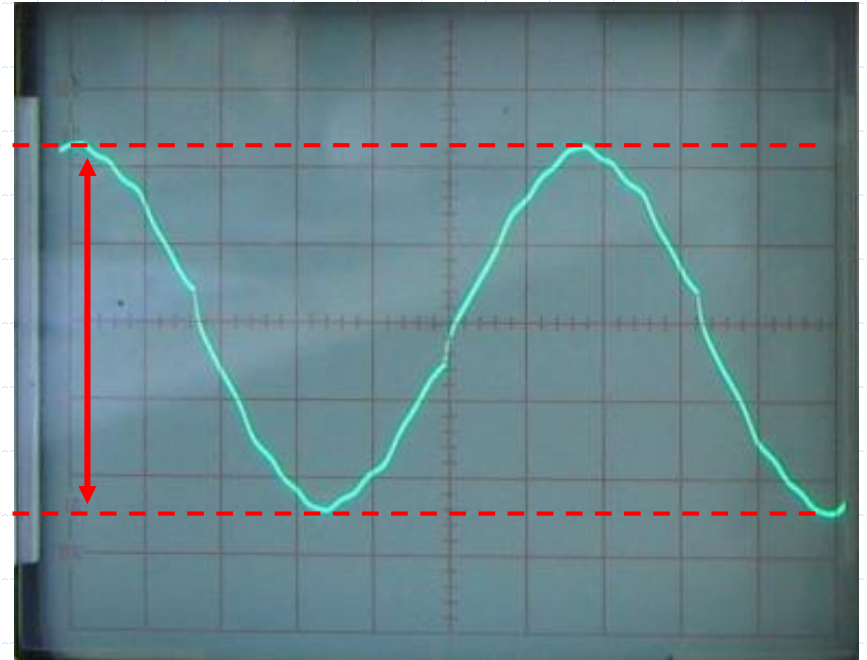
$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10V_{PP}}{12.418\text{mA}_{PP}} = 805.53\Omega$$

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{96\text{mV}_{PP}}{10\Omega} = 9.6\text{mA}_{PP}$$

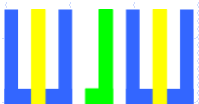
$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{10V_{PP}}{9.6\text{mA}_{PP}} = 1041.67\Omega$$

✓ CH 2, V_{R2} 의 전압

$$V_{R2} : 4.8\text{칸} \times 20\text{mV/DIV} = 96\text{mV}_p$$



20mV/DIV, 0.1mS/DIV



11-4. 주파수에 따른 임피던스

✓ 주파수 : 2kHz

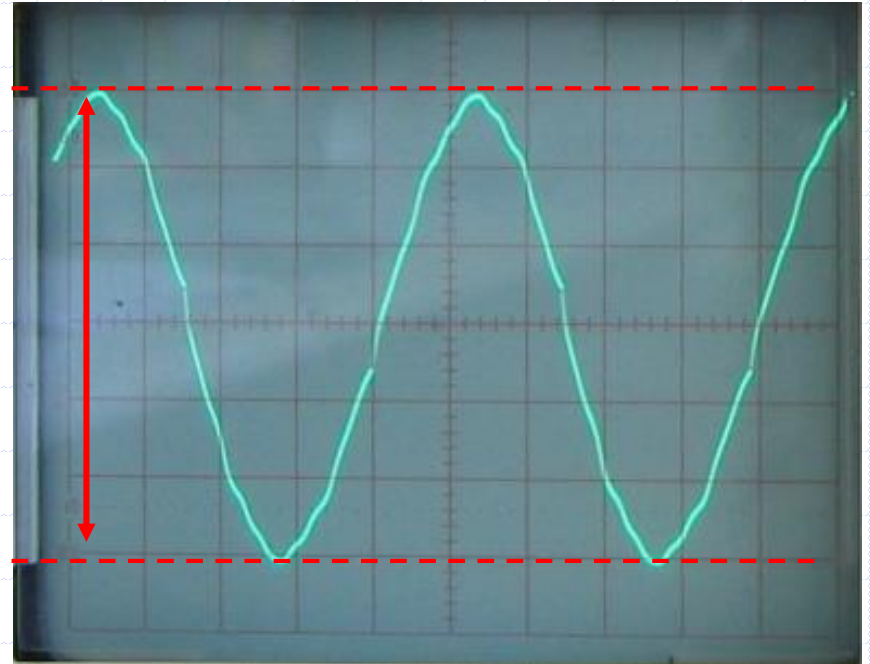
$$V_{R1(rms)} = 49.97mV$$

$$V_{R1(p-p)} = 49.97mV \times 2 \times 1.414 \\ = 141.32mV_{pp}$$



✓ CH 2, V_{R2} 의 전압

$$V_{R2} : 6.1 \text{ 칸} \times 20mV/DIV = 122mV_{pp}$$



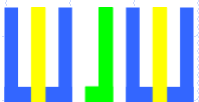
$$I_T(\text{실험}) = \frac{V_{R1}}{R_1} = \frac{141.32mV_{PP}}{10\Omega} = 14.132mA_{PP}$$

$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10V_{PP}}{14.132mA_{PP}} = 707.61\Omega$$

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{122mV_{PP}}{10\Omega} = 12.2mA_{PP}$$

$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{10V_{PP}}{12.2mA_{PP}} = 819.67\Omega$$

20mV/DIV, 0.1mS/DIV



11-4. 주파수에 따른 임피던스

✓ 주파수 : 4kHz

$$V_{R1(rms)} = 79.29\text{mV}$$

$$V_{R1(p-p)} = 79.29\text{mV} \times 2 \times 1.414 \\ = 204.44\text{mVpp}$$



✓ CH 2, V_{R2} 의 전압

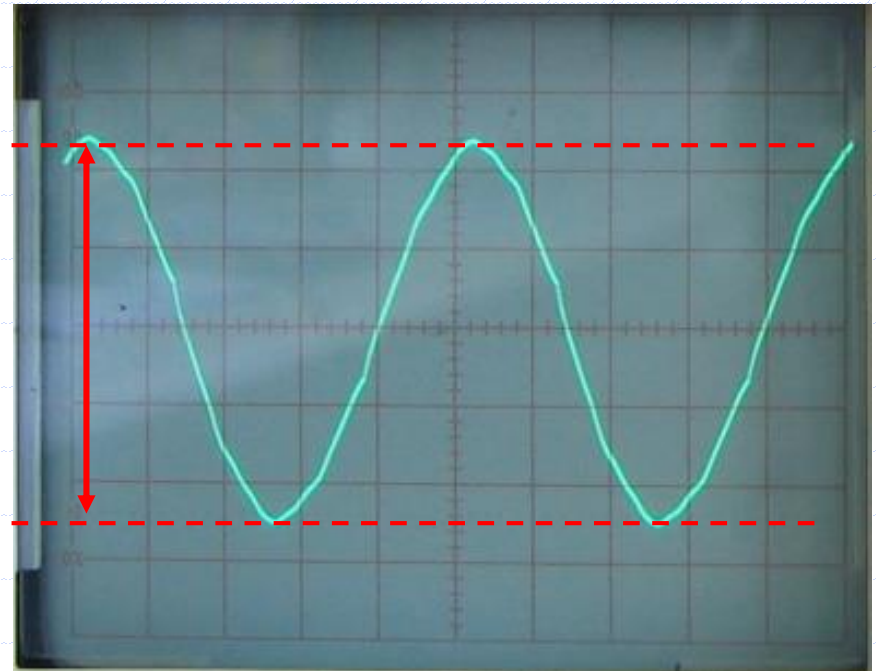
$$V_{R2} : 4.9\text{칸} \times 50\text{mV/DIV} = 245\text{mVpp}$$

$$I_T(\text{실험}) = \frac{V_{R1}}{R_1} = \frac{204.44\text{mV}_{PP}}{10\Omega} = 20.444\text{mA}_{PP}$$

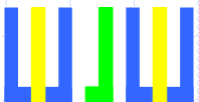
$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10\text{V}_{PP}}{20.444\text{mA}_{PP}} = 489.14\Omega$$

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{245\text{mV}_{PP}}{10\Omega} = 24.5\text{mA}_{PP}$$

$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{10\text{V}_{PP}}{24.5\text{mA}_{PP}} = 408.16\Omega$$



50mV/DIV, 0.1mS/DIV



11-4. 주파수에 따른 임피던스

✓ 주파수 : 8kHz

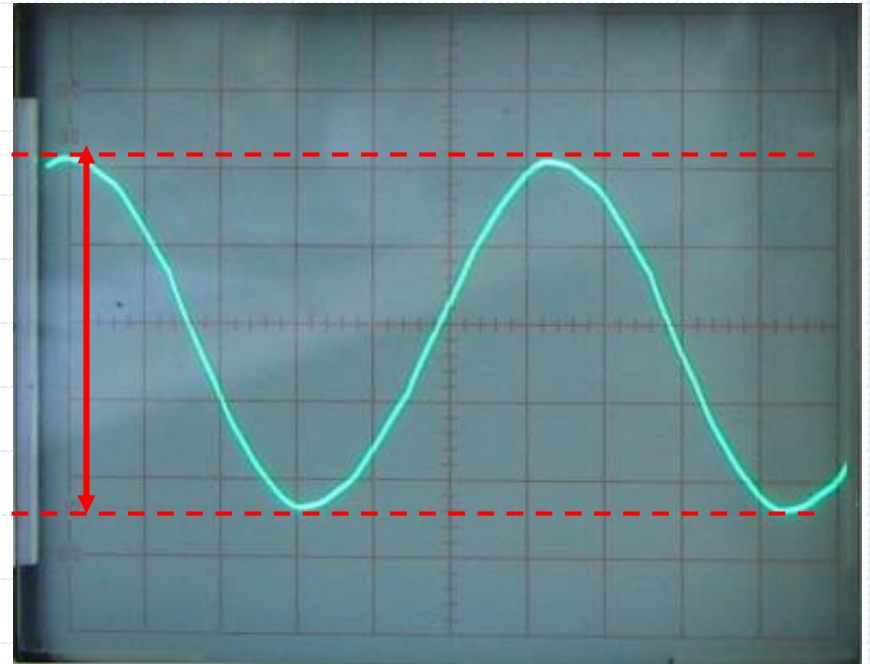
$$V_{R1(rms)} = 138.94mV$$

$$V_{R1(p-p)} = 138.94mV \times 2 \times 1.414 \\ = 392.92mV_{pp}$$



✓ CH 2, V_{R2} 의 전압

$$V_{R2} : 4.4칸 \times 0.1V/DIV = 440mV_{pp}$$



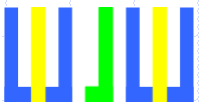
0.1V/DIV, 0.1mS/DIV

$$I_T(\text{실험}) = \frac{V_{R1}}{R_1} = \frac{392.92mV_{PP}}{10\Omega} = 39.292mA_{PP}$$

$$|Z|(\text{실험}) = \frac{V_S}{I_T} = \frac{10V_{PP}}{39.292mA_{PP}} = 254.50\Omega$$

$$I_C(\text{실험}) = \frac{V_{R2}}{R_2} = \frac{440mV_{PP}}{10\Omega} = 44mA_{PP}$$

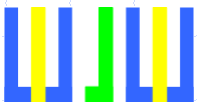
$$X_C(\text{실험}) = \frac{V_S}{I_C} = \frac{10V_{PP}}{44mA_{PP}} = 227.27\Omega$$



11-4. 주파수에 따른 임피던스

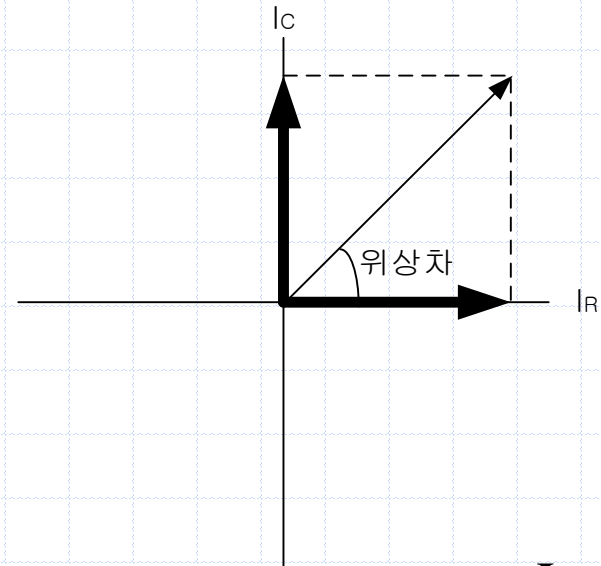
✓ 측정값의 비교

주파수	V_{R1} (mVpp)		I_T (mApp)		V_{R2} (mVpp)		I_C (mApp)		V_R (Vpp)		I_R (mApp)		X_C (Ω)		$ Z $ (Ω)	
	실험	이론	실험	이론	실험	이론	실험	이론	실험	이론	실험	이론	실험	이론	실험	이론
500Hz	99.88	105	9.99	10.5	30	30	3	3	10	10	10	10	3333	3183	1001	954
1kHz	109.86	118	10.99	11.8	60	63	6	6.3	10	10	10	10	1667	1592	910	847
1.5kHz	124.18	137	12.42	13.7	96	94	9.6	9.4	10	10	10	10	1042	1061	806	728
2kHz	141.32	161	14.13	16.1	122	126	12.2	12.6	10	10	10	10	820	796	708	623
4kHz	204.44	270	20.44	27	245	251	24.5	25.1	10	10	10	10	408	398	489	370
8kHz	392.92	513	39.29	51.3	440	503	44	50.3	10	10	10	10	227	199	255	195



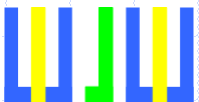
11-5. 주파수에 따른 위상의 변화

주파수	I _C 와 I _R 의 위상차 (도)	
	실험 8.	계산값
500 Hz	16.7	17.44
1 kHz	30.96	32.13
1.5 kHz	43.83	43.3
2 kHz	50.66	51.48
4 kHz	67.8	68.3
8 kHz	77.2	78.75



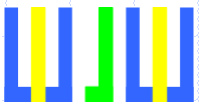
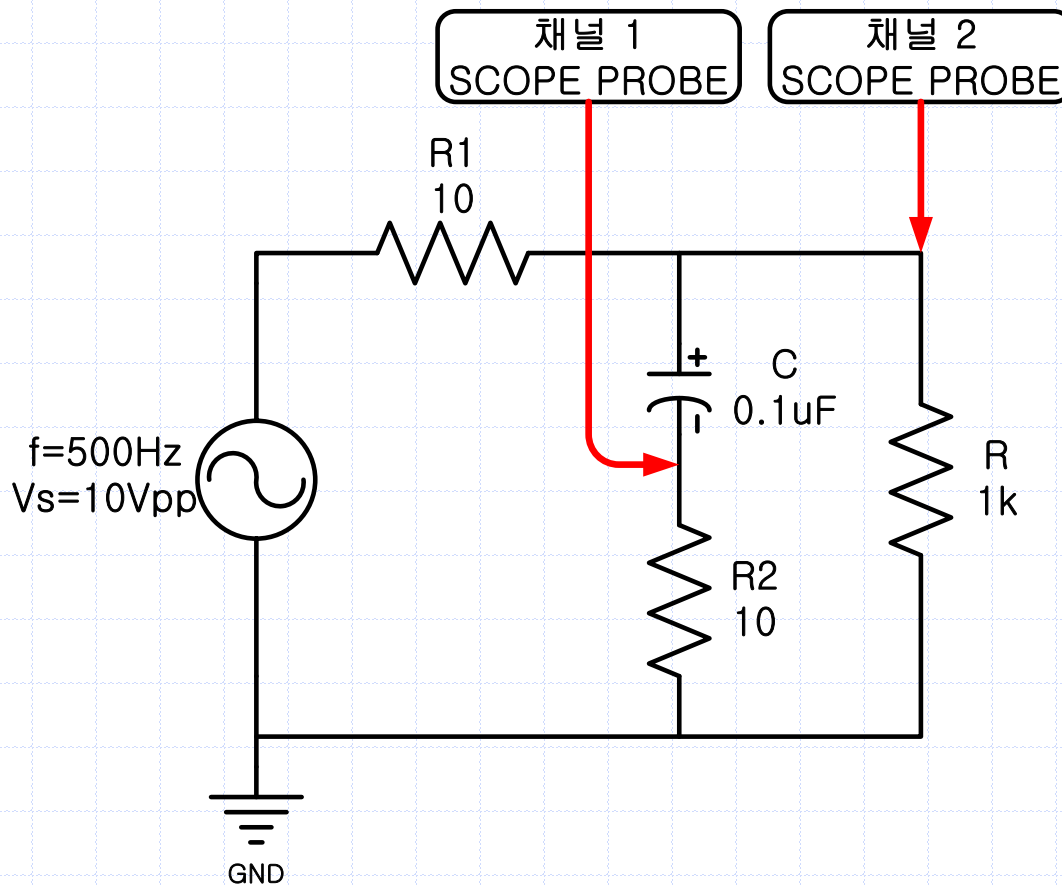
$$\text{위상차(실험 8.)} = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

$$\text{위상차(계산값)} = \tan^{-1}\left(\frac{R}{X_C}\right)$$

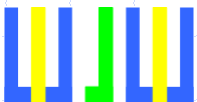
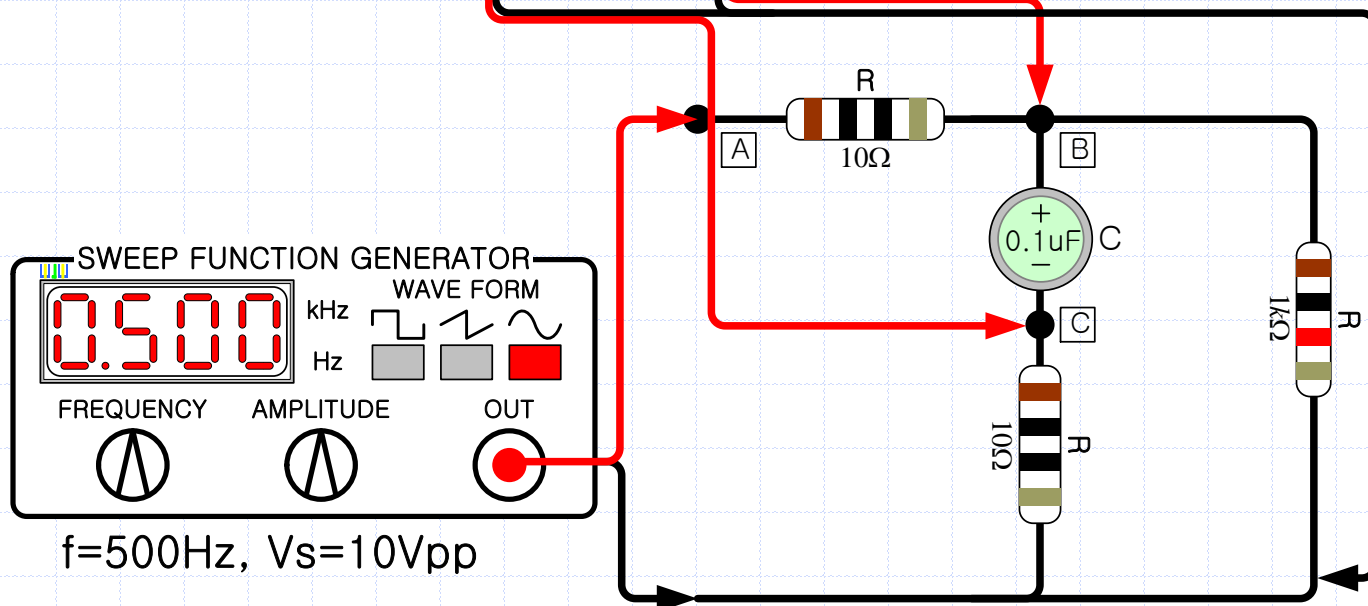
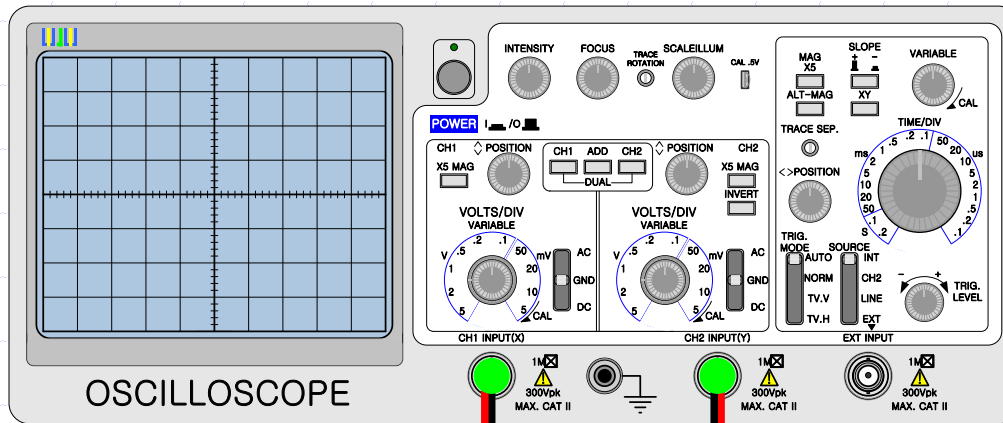


11-6. 전압과 전류의 위상

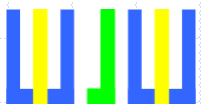
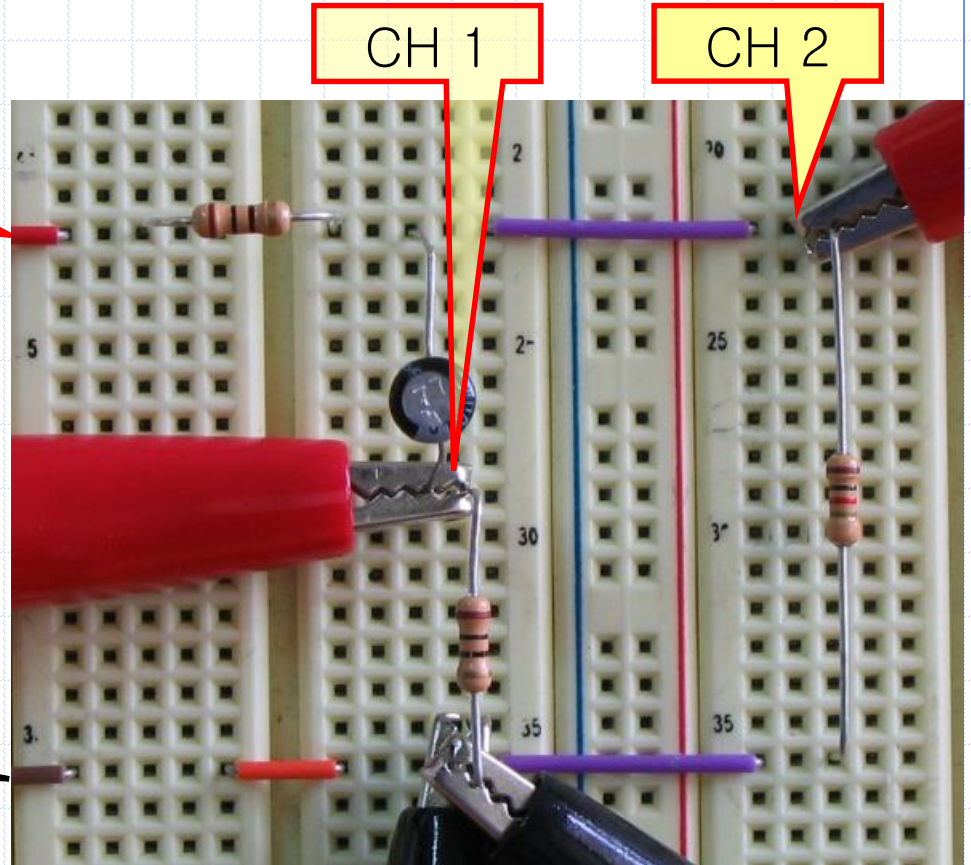
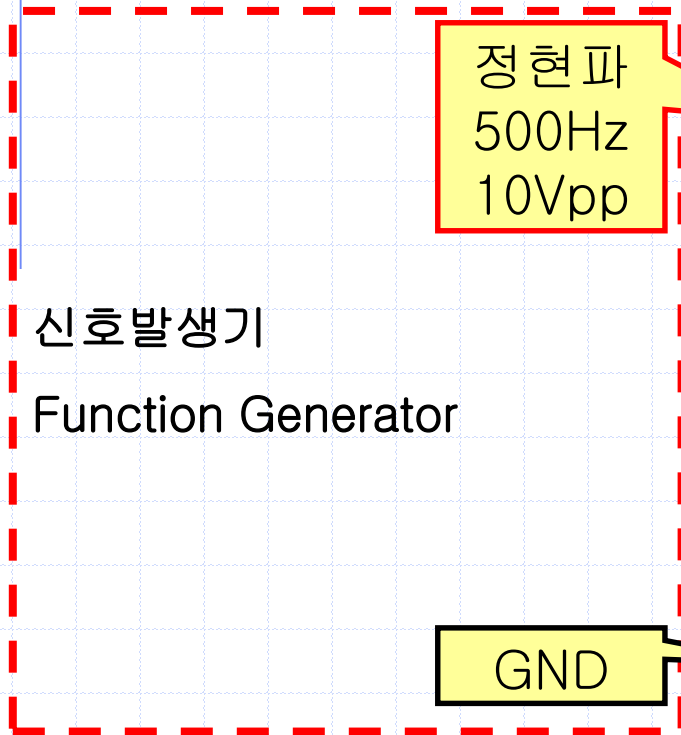
- 다음과 같이 회로를 연결하고, 신호발생기를 조절하여 주파수 500Hz, 10Vpp 의 정현파가 나오도록 한다.



11-6. 전압과 전류의 위상

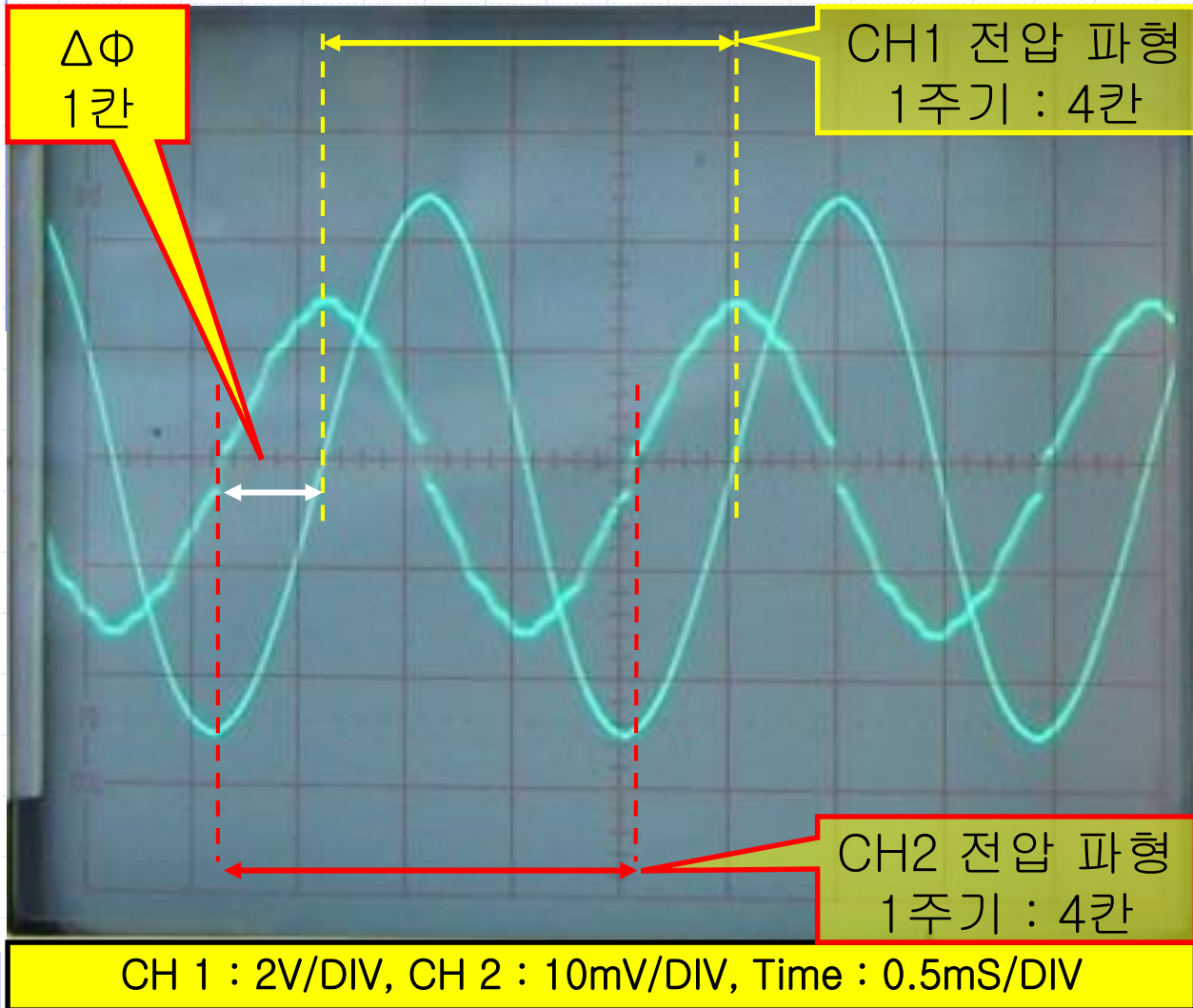


11-6. 전압과 전류의 위상



11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 500Hz)



$$1T = 4\text{칸} \times 0.5\text{mSec} \\ = 2\text{mSec}$$

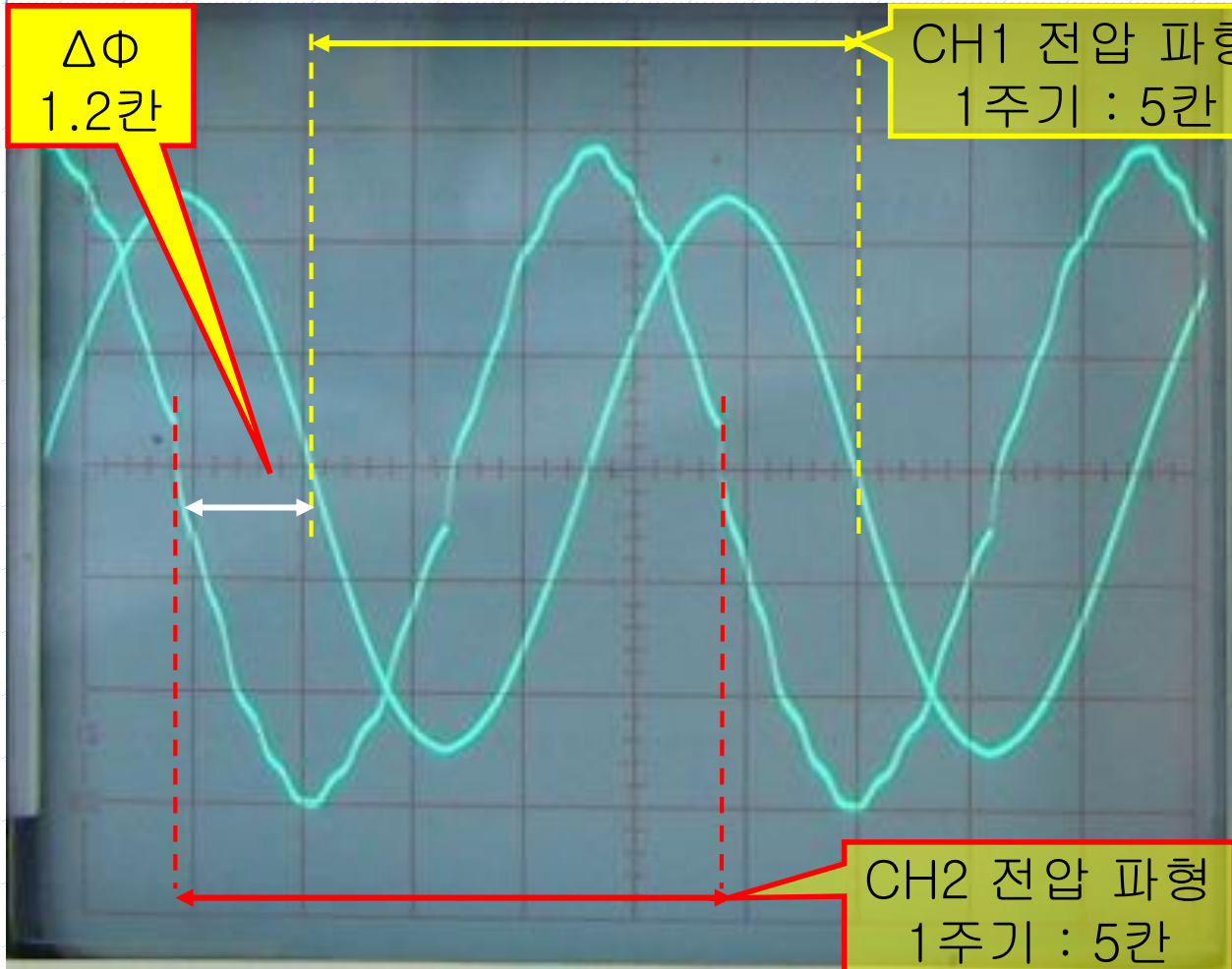
$$\Delta t = 1\text{칸} \times 0.5\text{mSec} \\ = 0.5\text{mSec}$$

$$2\text{mSec} : 0.5\text{mSec} \\ = 360^\circ : \Delta\theta$$

$$\Delta\theta = 90^\circ$$

11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 1kHz)



$$1T = 5\text{칸} \times 0.2\text{mSec} = 1\text{mSec}$$

$$\Delta t = 1.2\text{칸} \times 0.2\text{mSec} = 0.24\text{mSec}$$

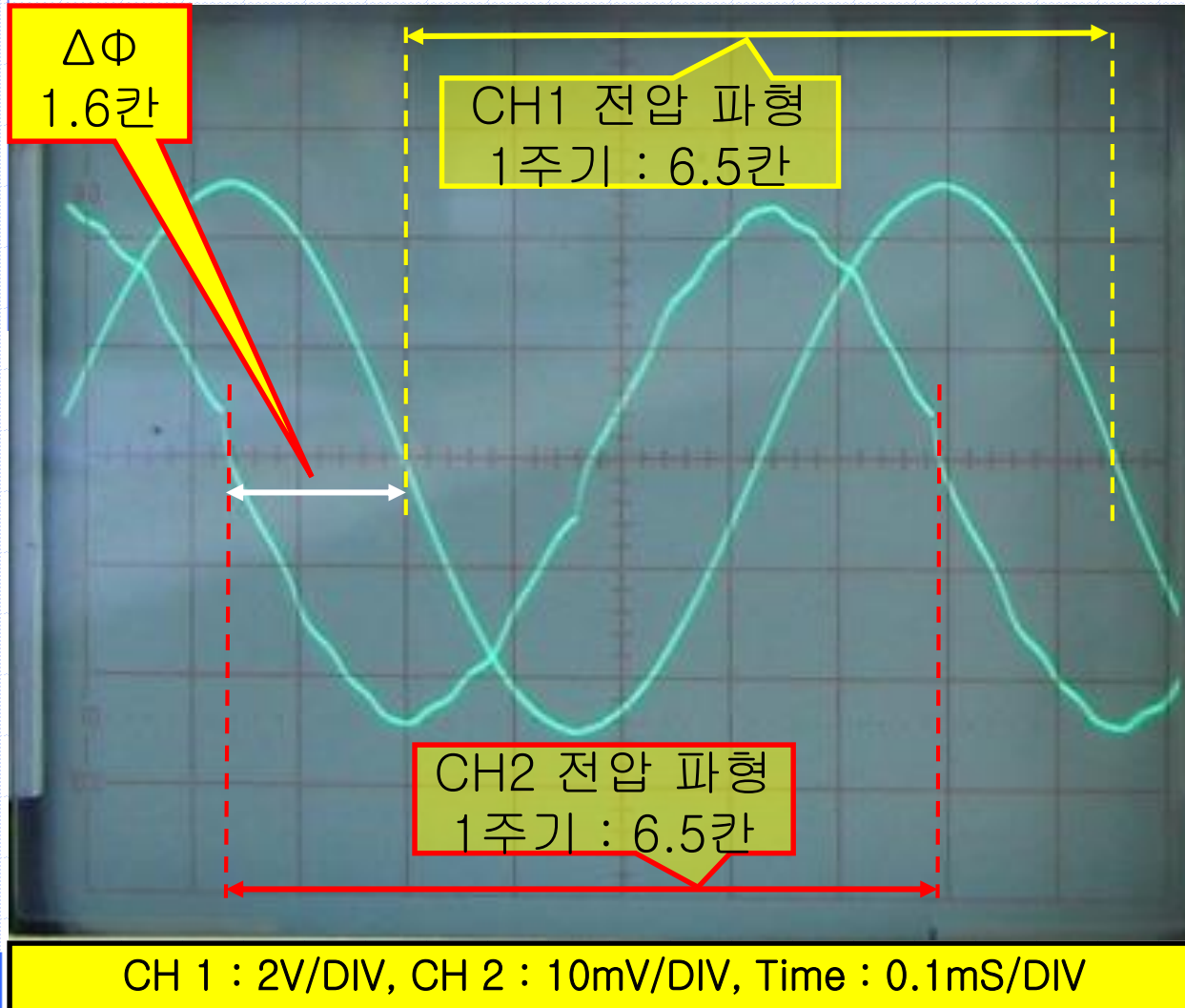
$$1\text{mSec} : 0.24\text{mSec} = 360^\circ : \Delta\theta$$

$$\Delta\theta = 86.4^\circ$$

CH 1 : 2V/DIV, CH 2 : 10mV/DIV, Time : 0.2mS/DIV

11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 1.5kHz)



$$1T = 6.5\text{칸} \times 0.1\text{mSec} = 0.65\text{mSec}$$

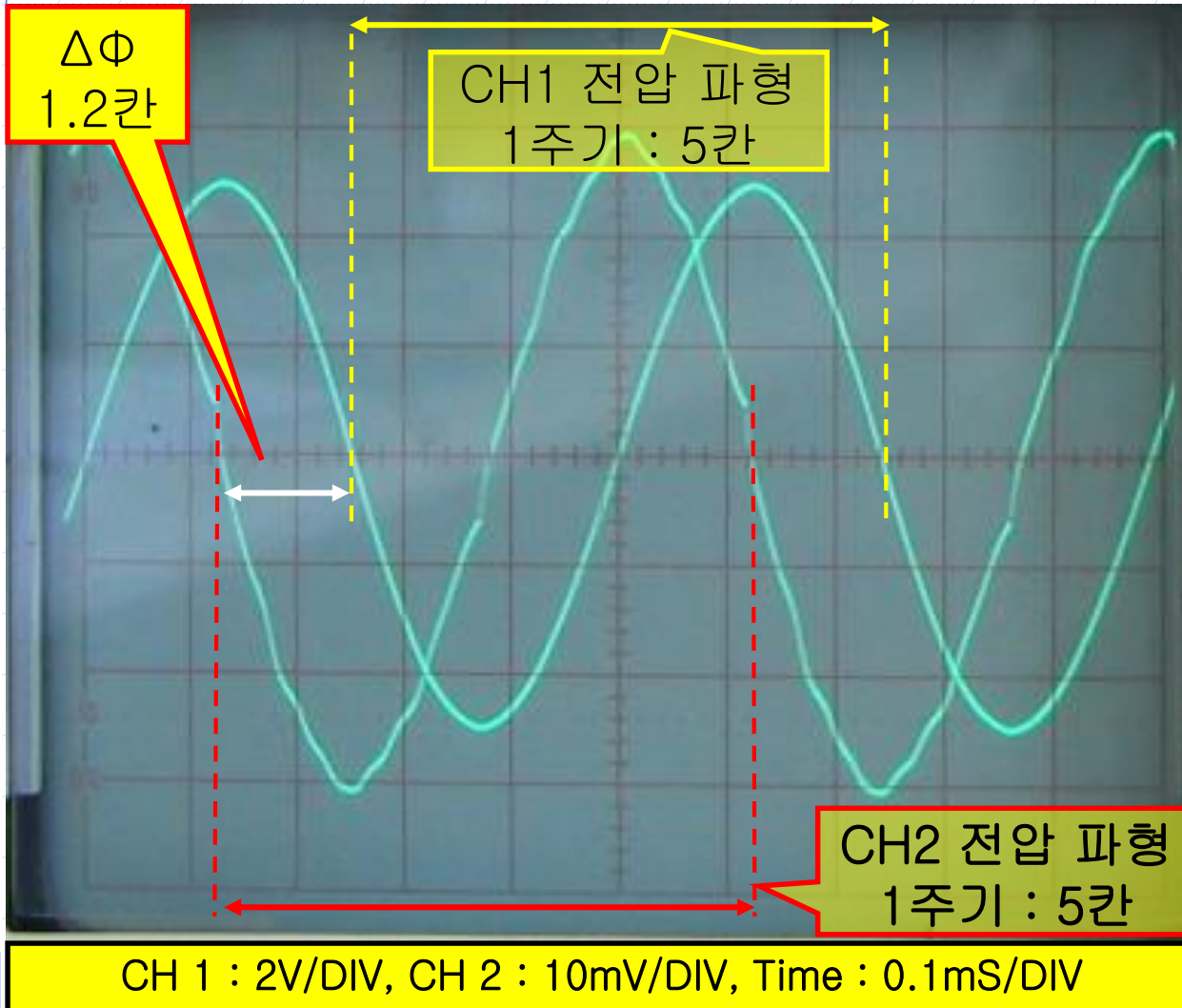
$$\Delta t = 1.6\text{칸} \times 0.1\text{mSec} = 0.16\text{mSec}$$

$$0.65\text{mSec} : 0.16\text{mSec} = 360^\circ : \Delta\theta$$

$$\Delta\theta = 88.62^\circ$$

11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 2kHz)



$$1T = 5\text{칸} \times 0.1\text{mSec} \\ = 0.5\text{mSec}$$

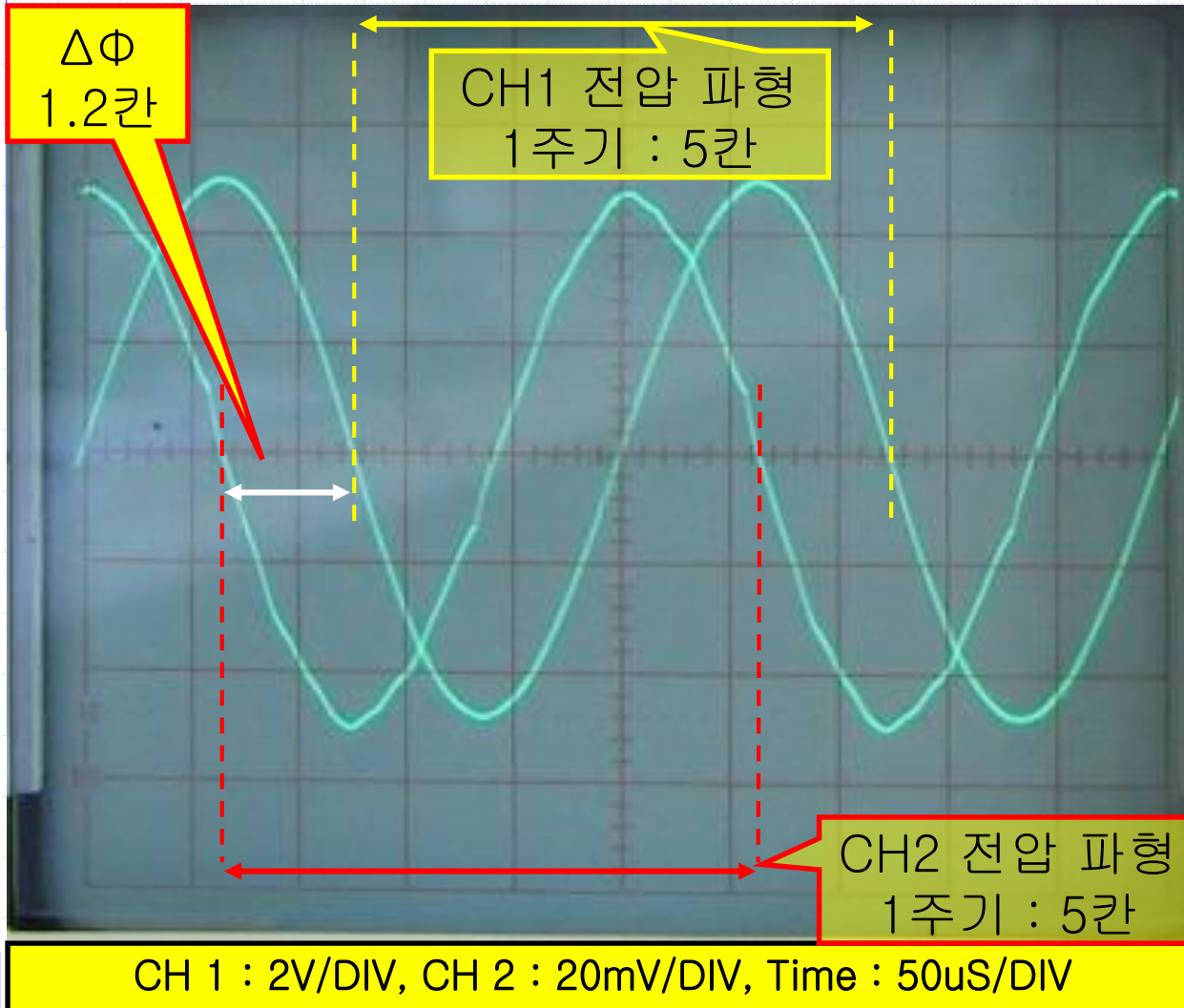
$$\Delta t = 1.2\text{칸} \times 0.1\text{mSec} \\ = 0.12\text{mSec}$$

$$0.5\text{mSec} : 0.12\text{mSec} \\ = 360^\circ : \Delta\theta$$

$$\Delta\theta = 86.4^\circ$$

11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 4kHz)



$$1T = 5\text{칸} \times 50\mu\text{Sec} = 250\mu\text{Sec}$$

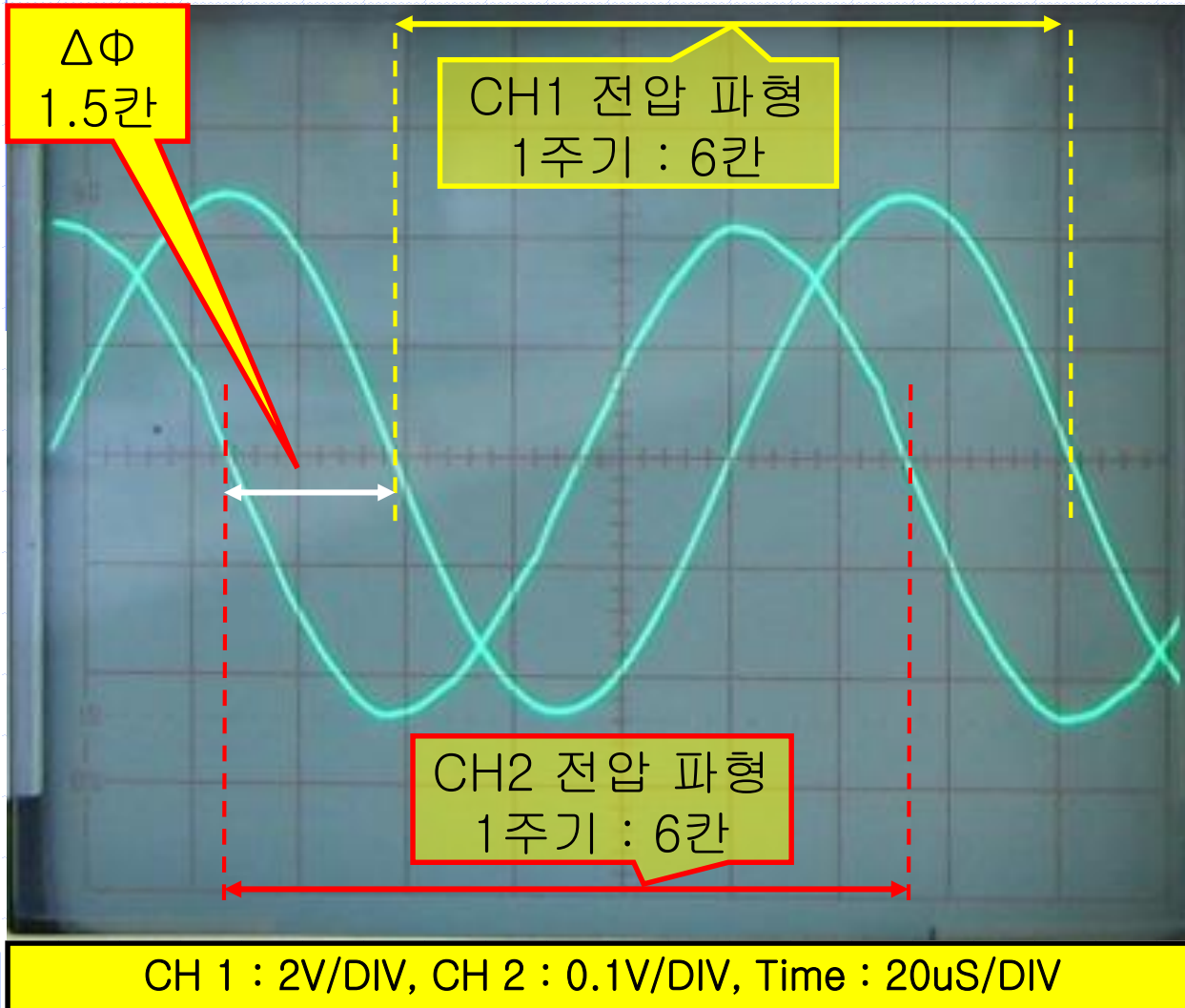
$$\Delta t = 1.2\text{칸} \times 50\mu\text{Sec} = 60\mu\text{Sec}$$

$$250\mu\text{Sec} : 60\mu\text{Sec} = 360^\circ : \Delta\theta$$

$$\Delta\theta = 86.4^\circ$$

11-6. 전압과 전류의 위상

✓ 위상차를 측정하라. (주파수 : 8kHz)



$$1T = 6\text{칸} \times 20\mu\text{Sec} \\ = 120\mu\text{Sec}$$

$$\Delta t = 1.5\text{칸} \times 20\mu\text{Sec} \\ = 30\mu\text{Sec}$$

$$120\mu\text{Sec} : 30\mu\text{Sec} \\ = 360^\circ : \Delta\theta$$

$$\Delta\theta = 90^\circ$$

11-6. 전압과 전류의 위상

주파수	실험 9.	계산값
500 Hz	90 도	90 도
1 kHz	86.4 도	90 도
1.5 kHz	88.62 도	90 도
2 kHz	86.4 도	90 도
4 kHz	86.4 도	90 도
8 kHz	90도	90 도

