회로 이론/실습

15. 병렬 공진 회로

15. 병렬 공진 회로

15-1. 목적 및 배경

- ✓ 병렬 공진 회로의 특성을 이해한다.
- ✓ 주파수에 따른 전압, 전류, 위상의 변화를 확인한다.
- ✓ 주파수에 따른 임피던스 변화를 확인한다.

15-2. 소요 부품 및 장비

- 부품
  - 저항 (1/4W) : 10Ω, 1kΩ
  - 인덕터 : 10mH
  - 캐패시터 : 0.1uF
- 장비
  - 브레드 보드
  - 디지털 멀티미터 (Digital Multi-Meter)
  - 직류 전원 공급 장치 (DC Power Supply)
  - 오실로스코프 (Oscilloscope)
  - 신호 발생기 (Function Generator)

15-3. 유용한 공식

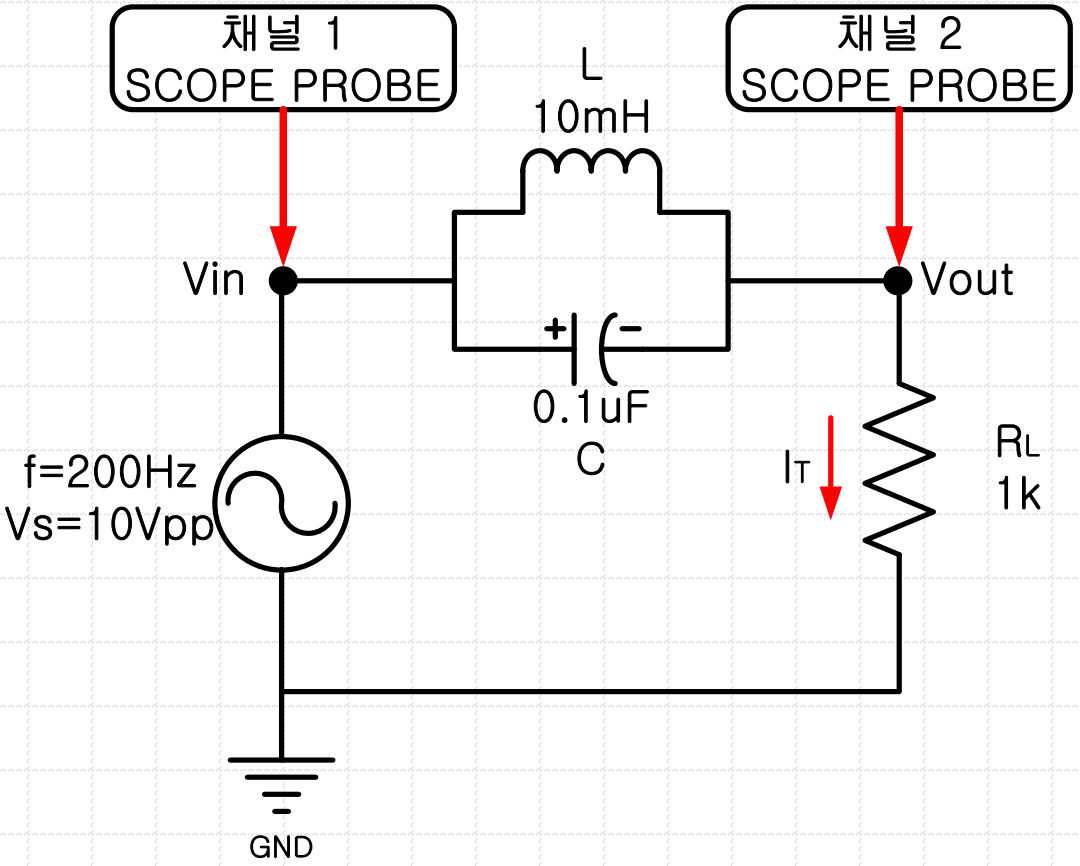
✓ 병렬 공진 회로의 공진 주파수

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$A_v(\text{전압이득}) = \frac{V_{out}}{V_{in}}$$

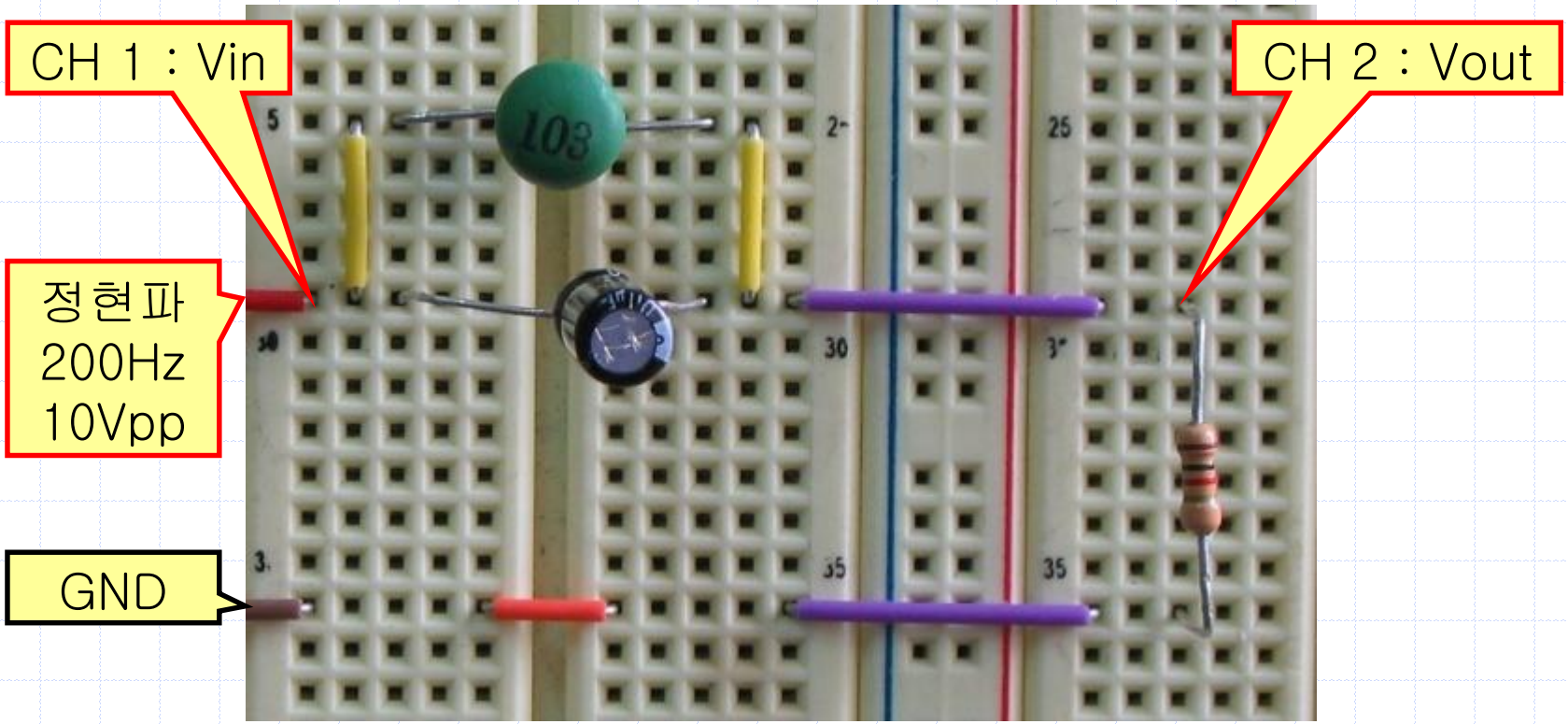
15-4. 주파수에 따른 전압

- 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.



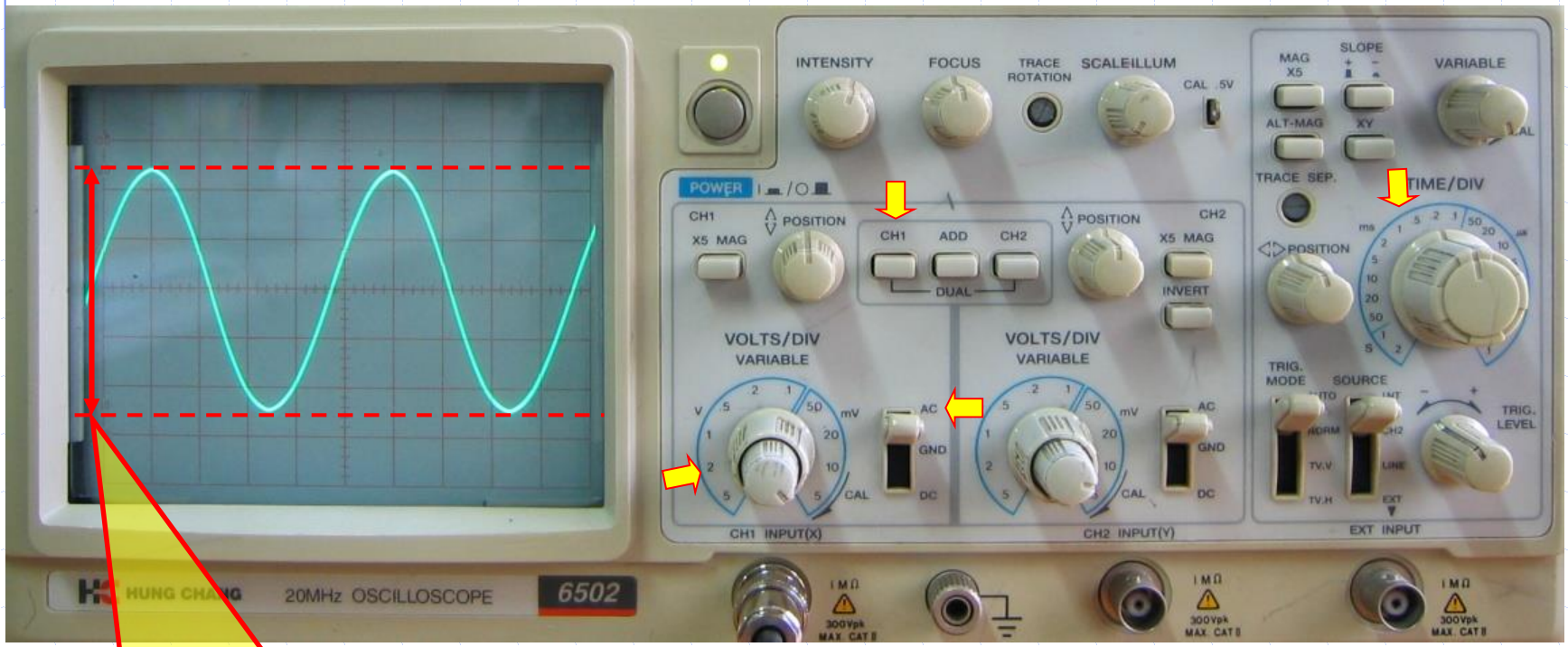
15-4. 주파수에 따른 전압

- ✓ 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.



15-4. 주파수에 따른 전압

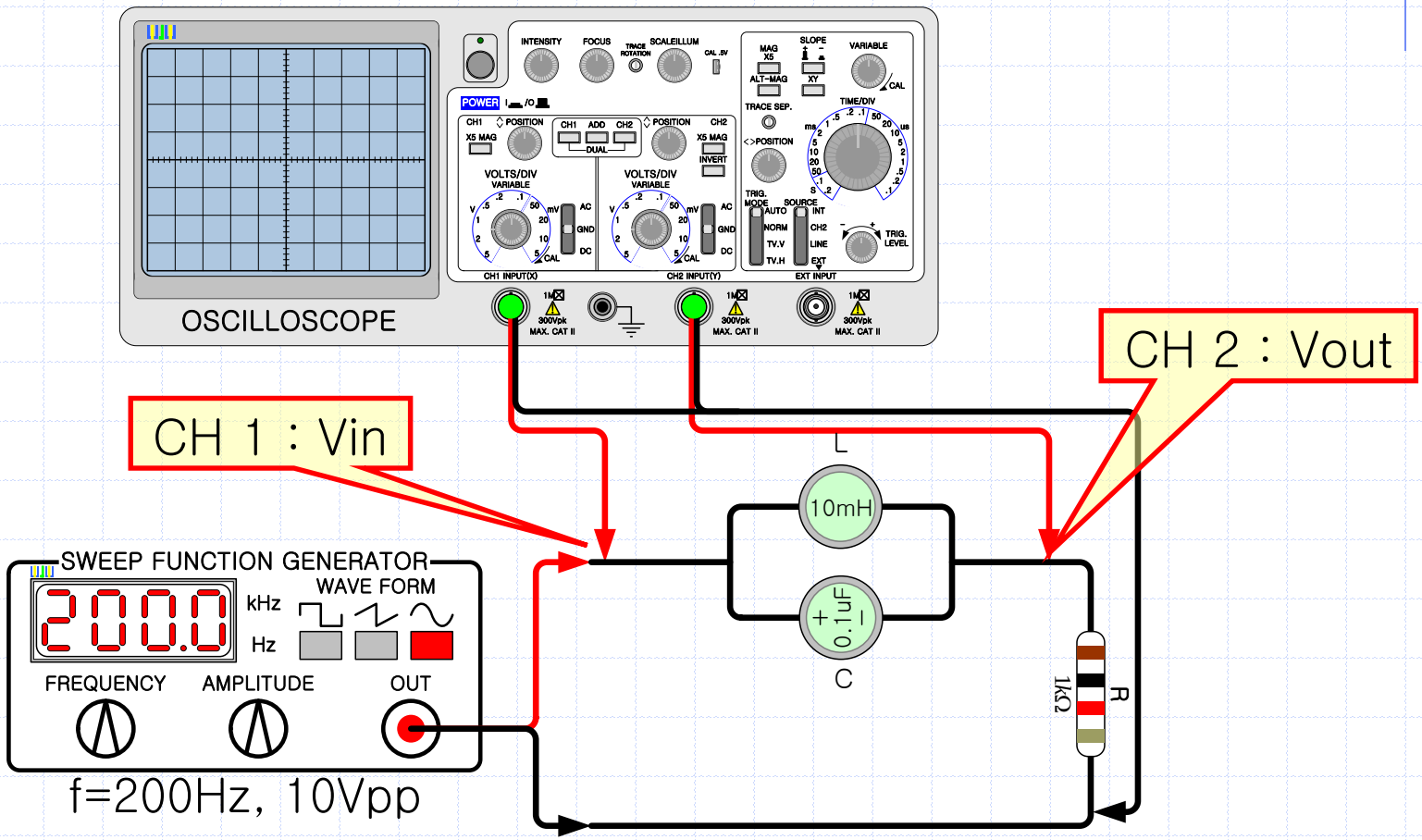
10Vpp



5칸X2V/DIV=10Vpp

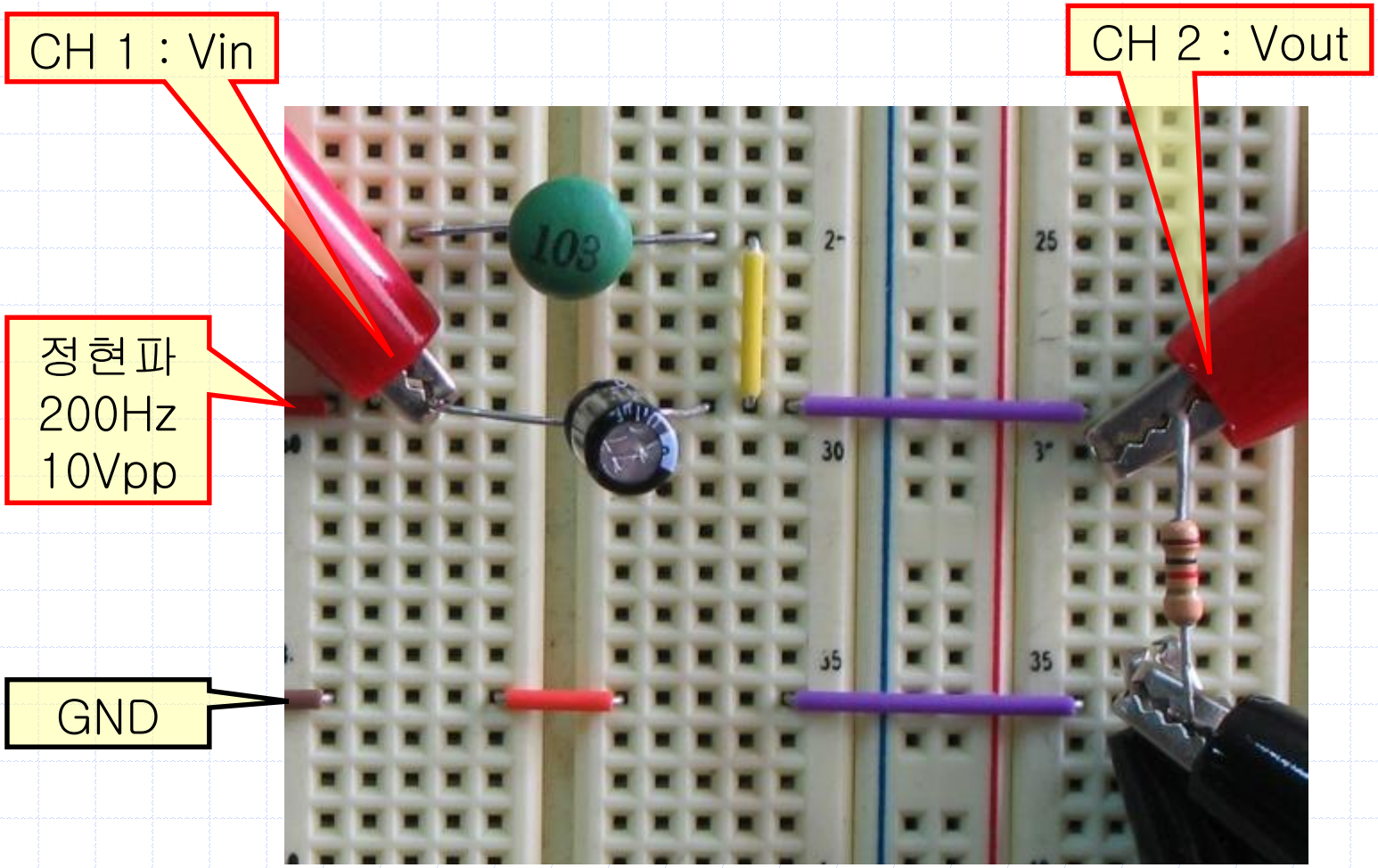
15-4. 주파수에 따른 전압

- 오실로스코프의 CH 1 을 이용하여 입력 전압 (Vin) 을 측정하고, CH 2 는 출력 전압 (Vout) 을 측정한다.



15-4. 주파수에 따른 전압

- ✓ 주파수 : 200Hz

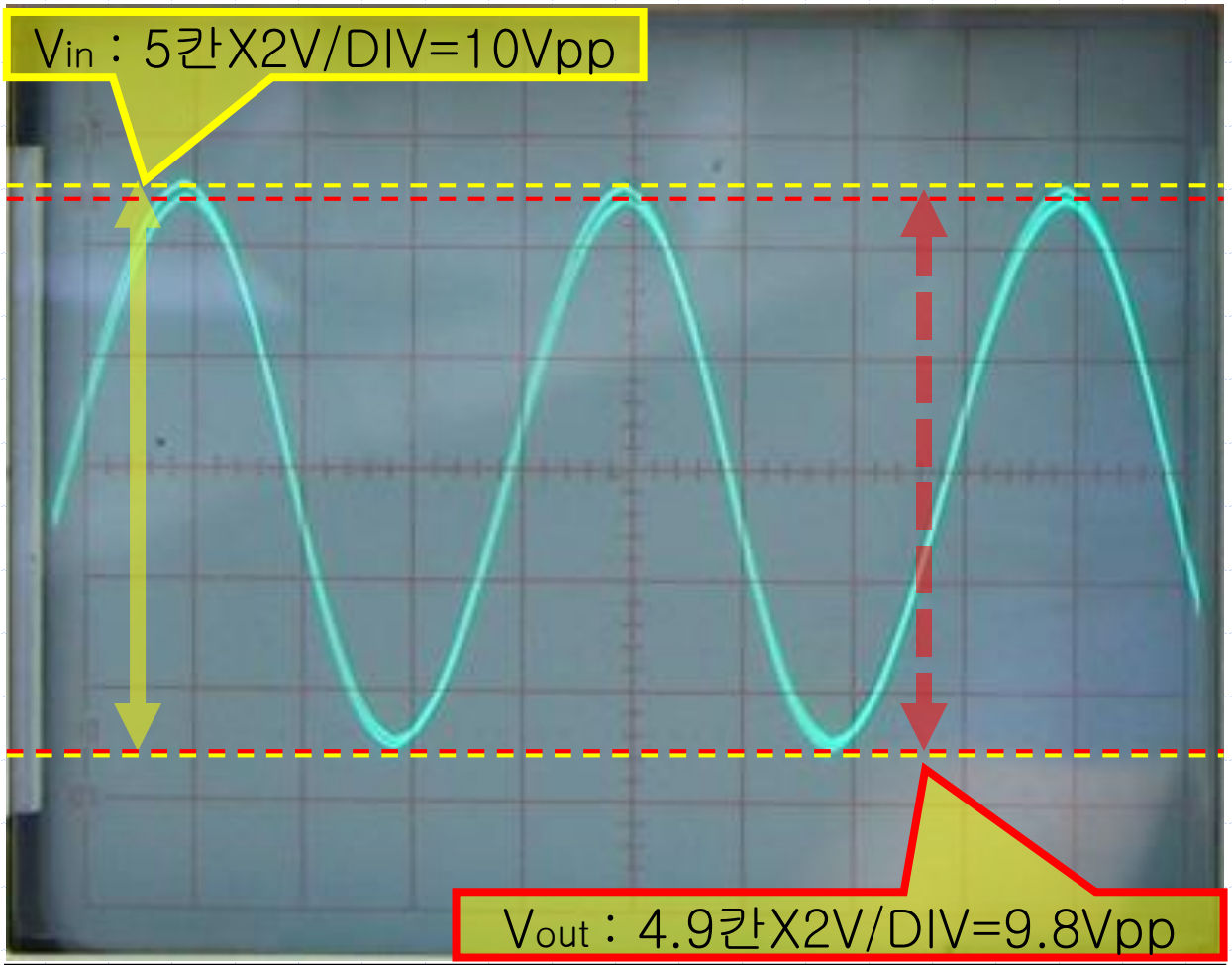


15-4. 주파수에 따른 전압

- ✓ 주파수 : 200Hz

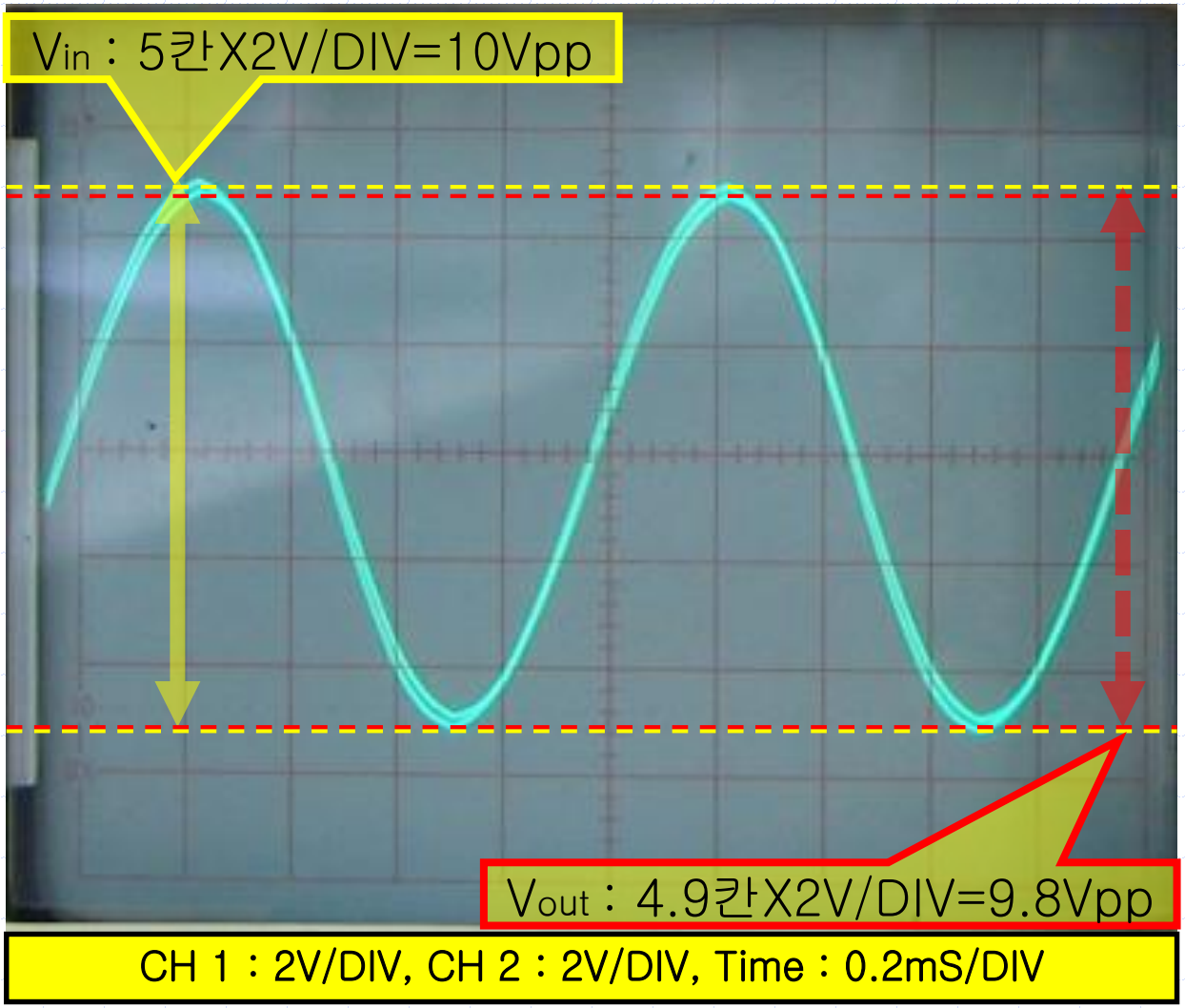
15-4. 주파수에 따른 전압

- ✓ 주파수 : 500Hz



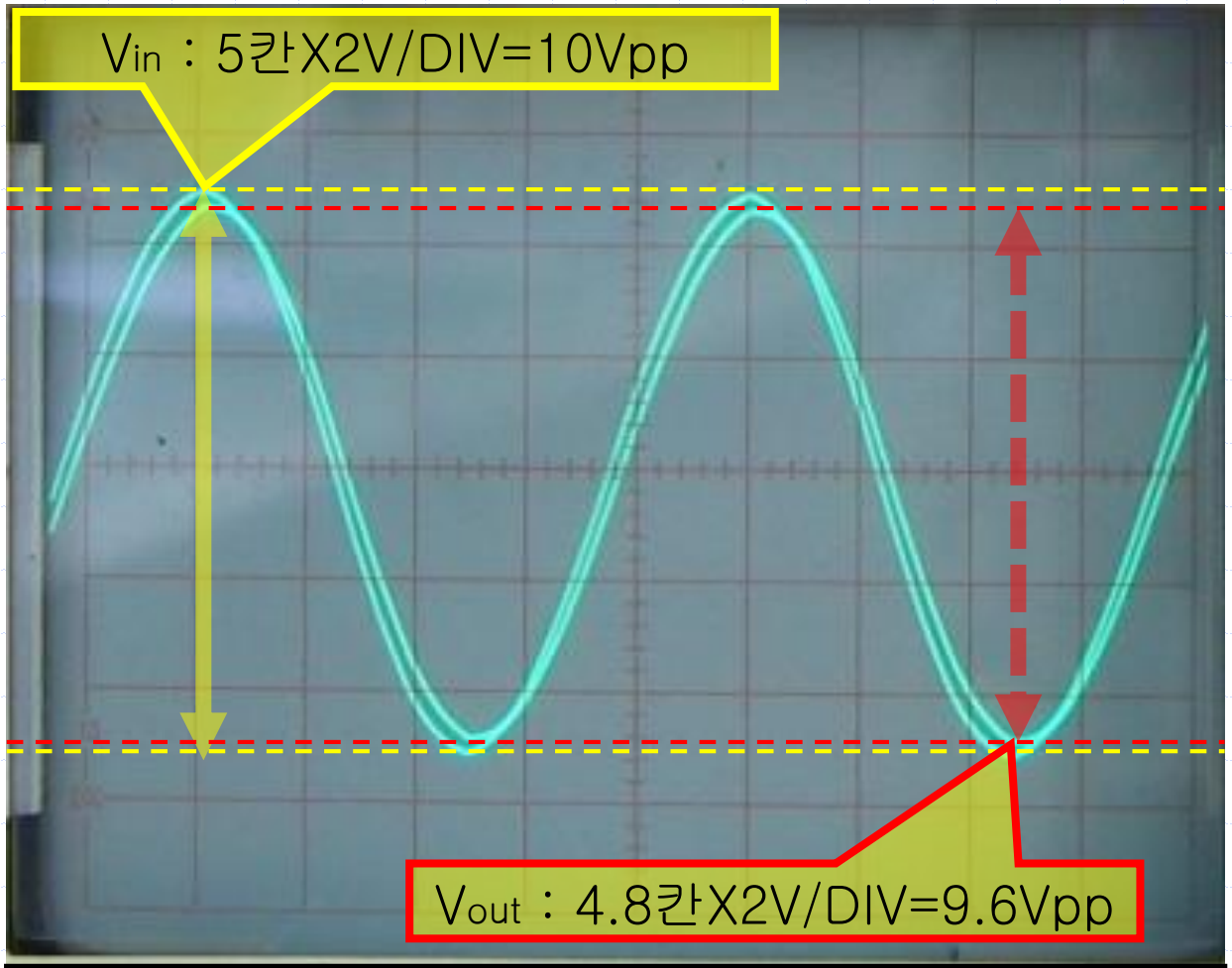
15-4. 주파수에 따른 전압

- ✓ 주파수 : 1kHz



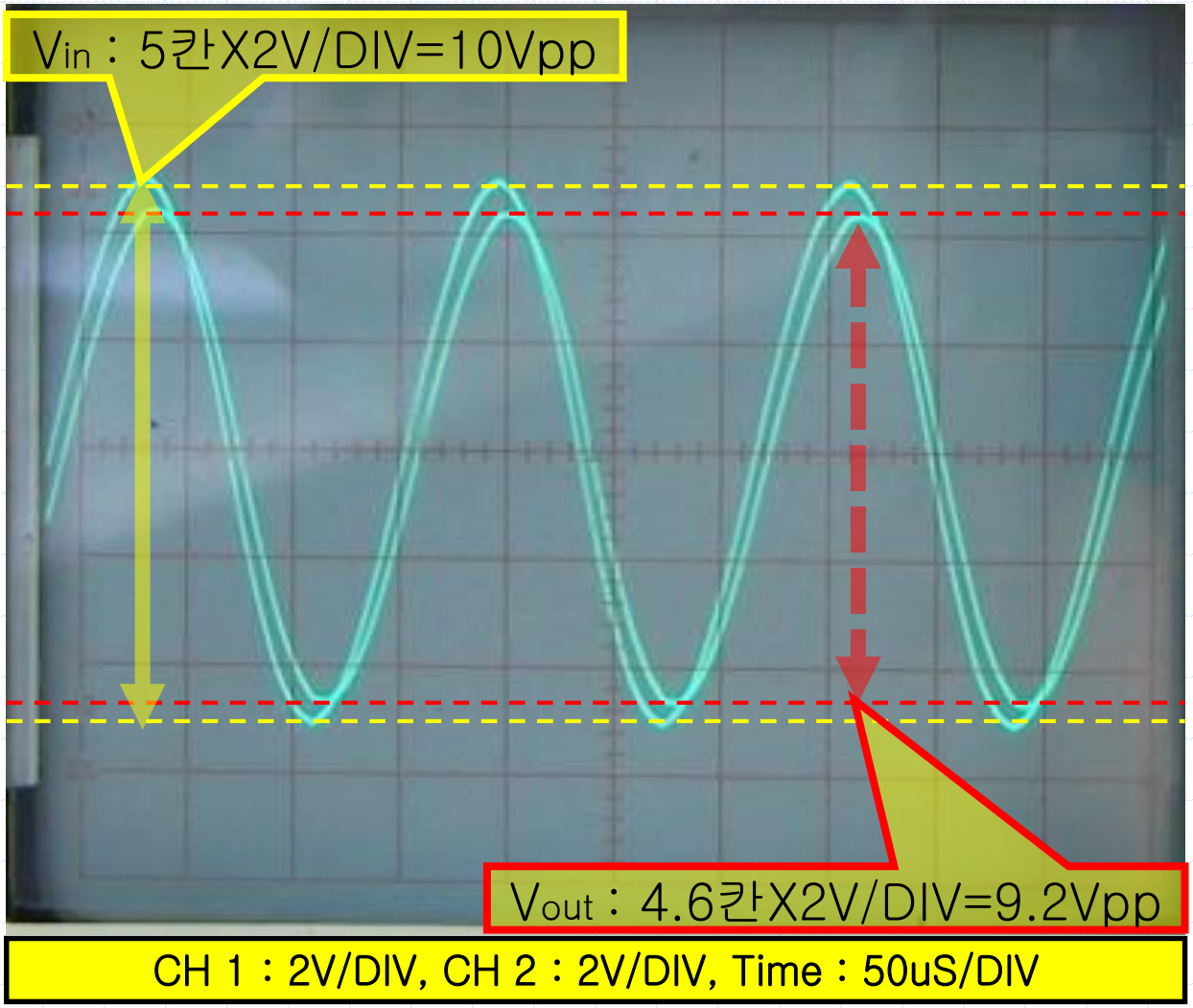
15-4. 주파수에 따른 전압

- ✓ 주파수 : 2kHz



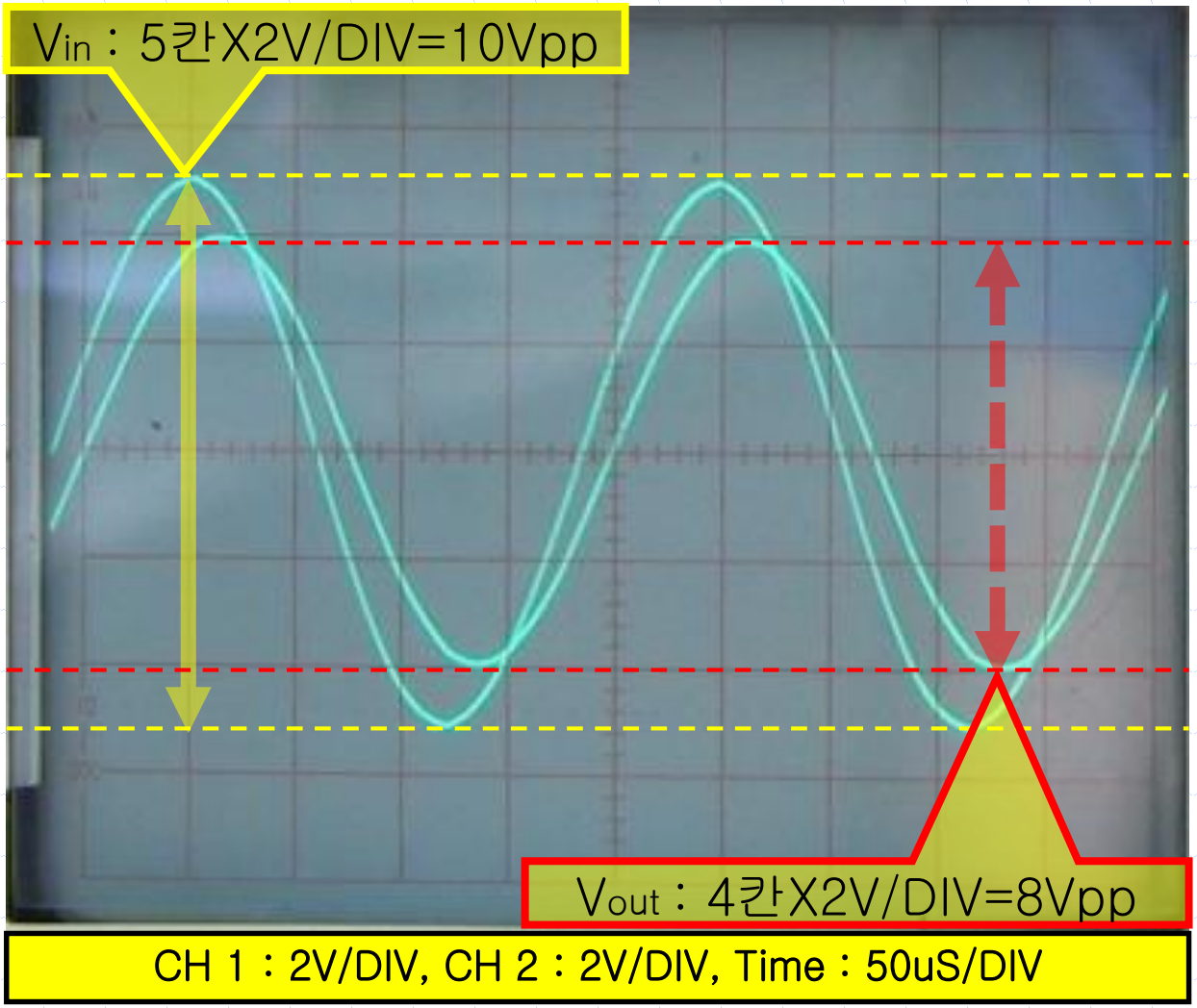
15-4. 주파수에 따른 전압

- ✓ 주파수 : 3kHz



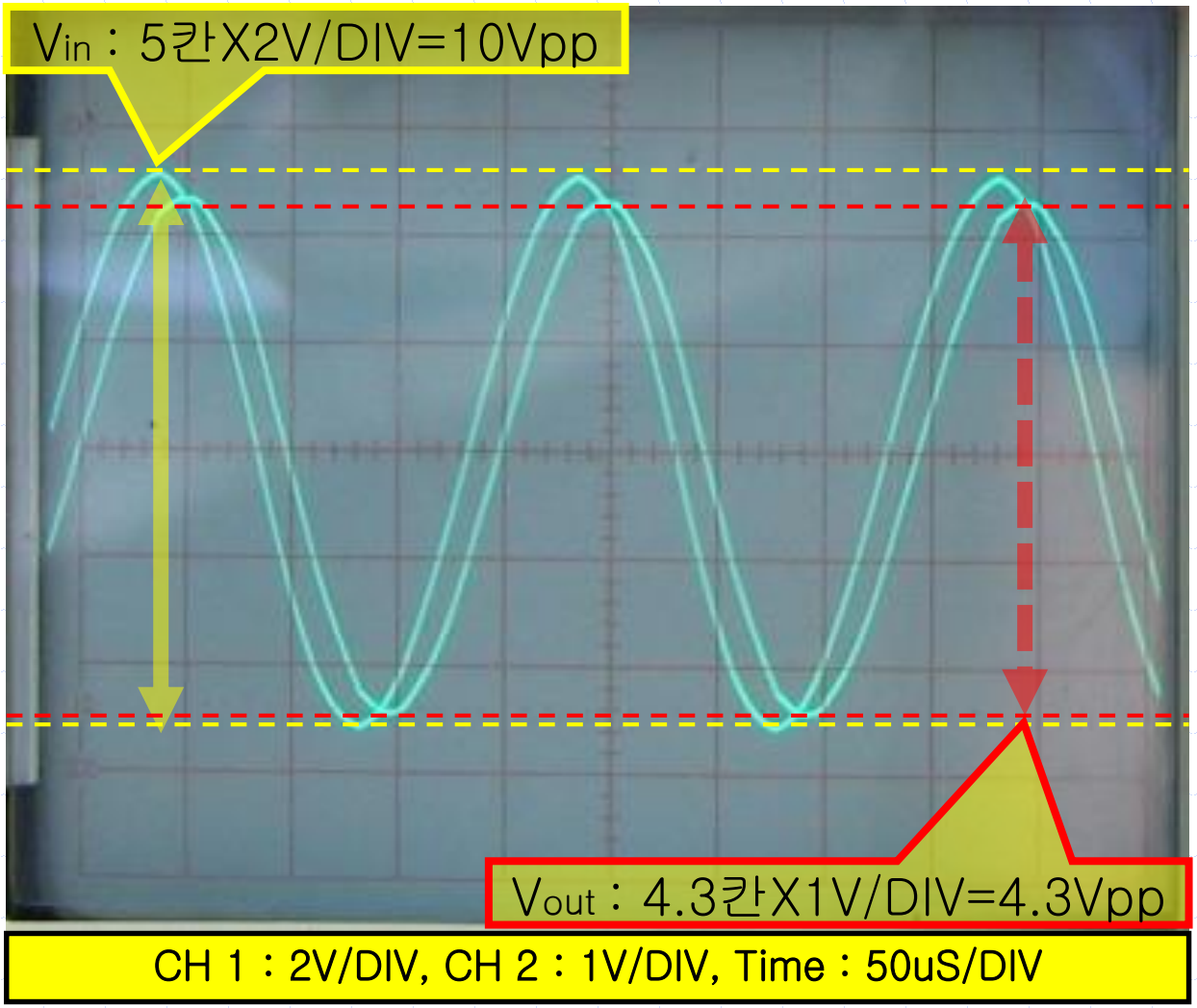
15-4. 주파수에 따른 전압

- ✓ 주파수 : 4kHz



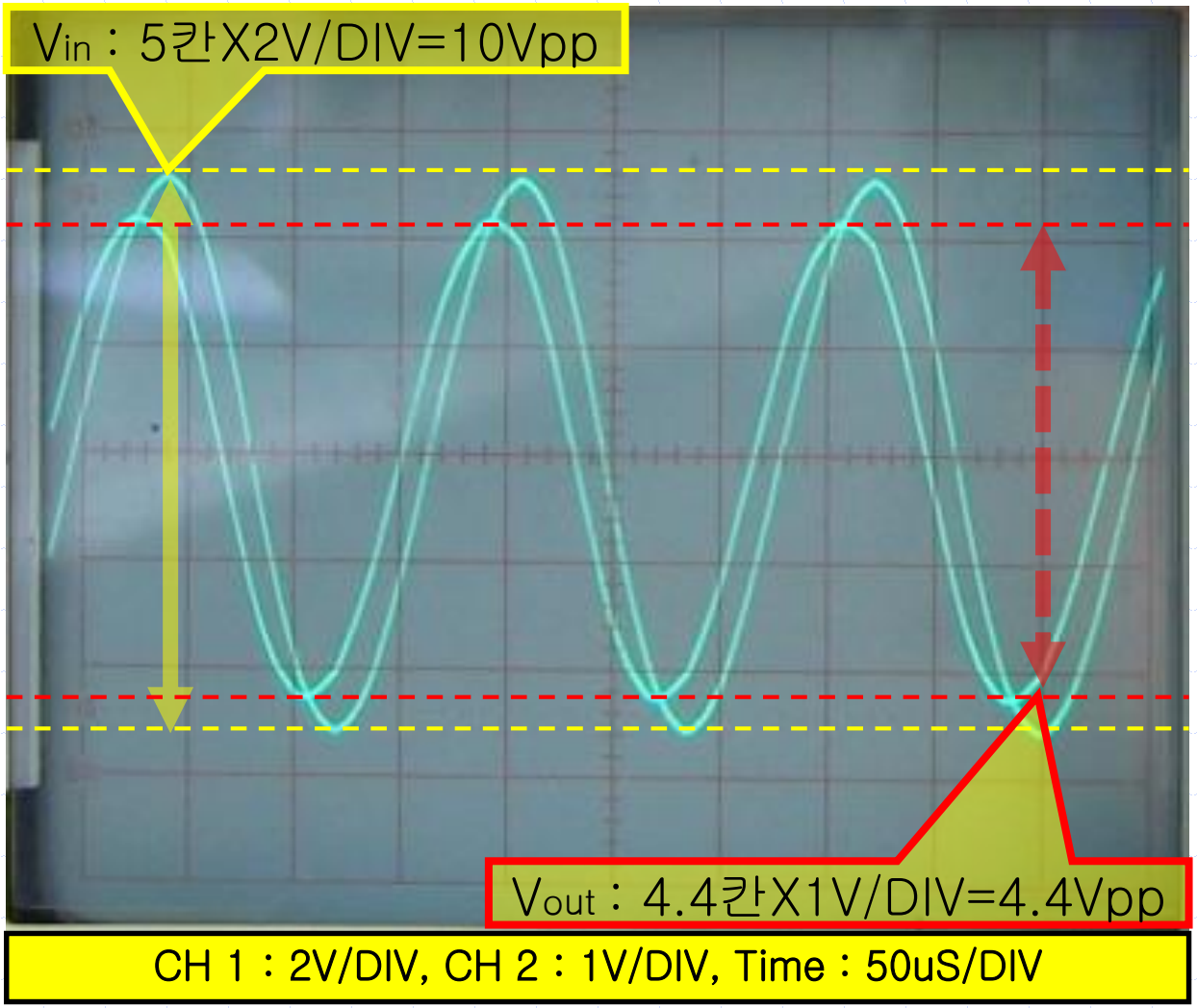
15-4. 주파수에 따른 전압

- ✓ 주파수 : 5kHz



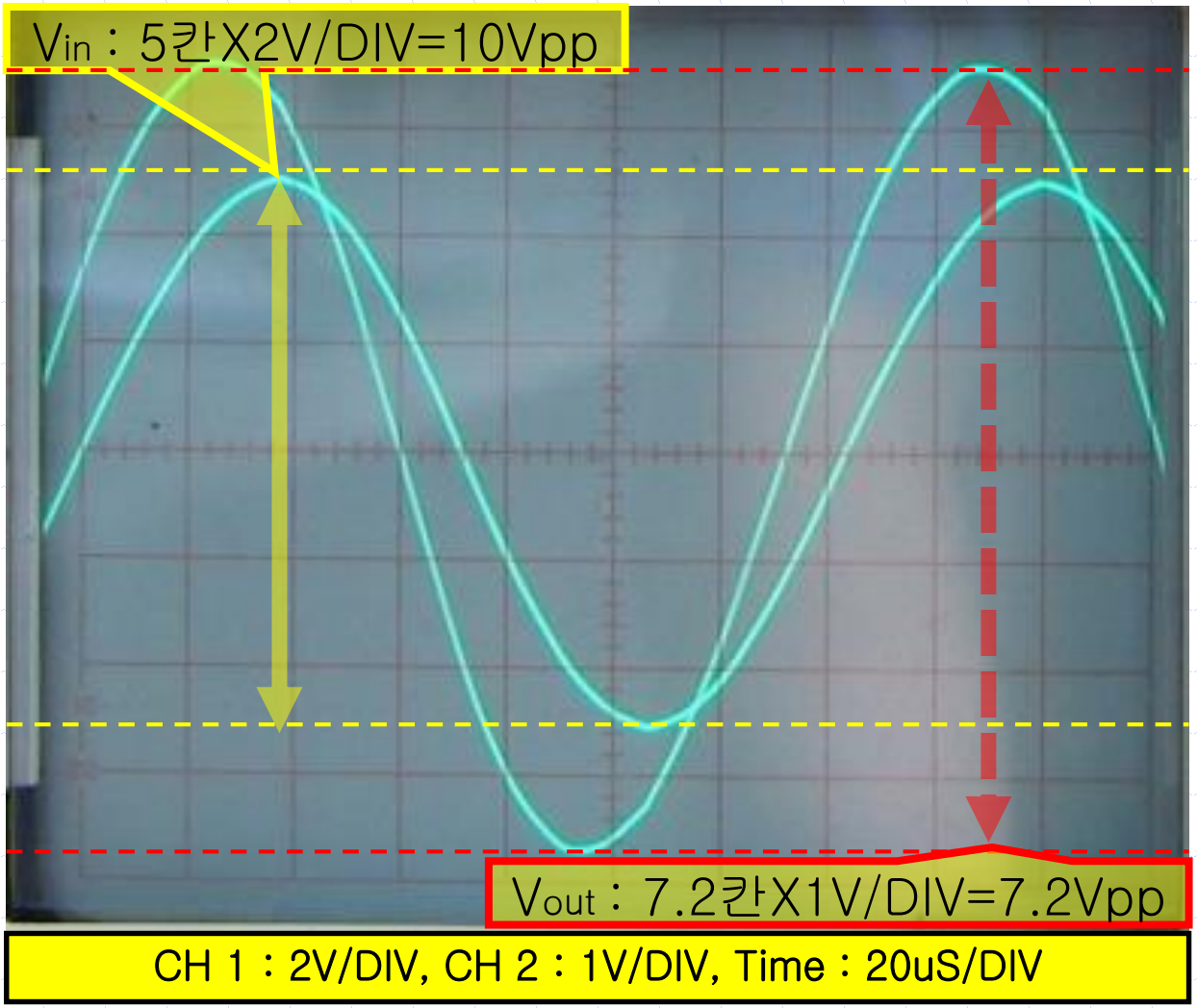
15-4. 주파수에 따른 전압

- ✓ 주파수 : 6kHz



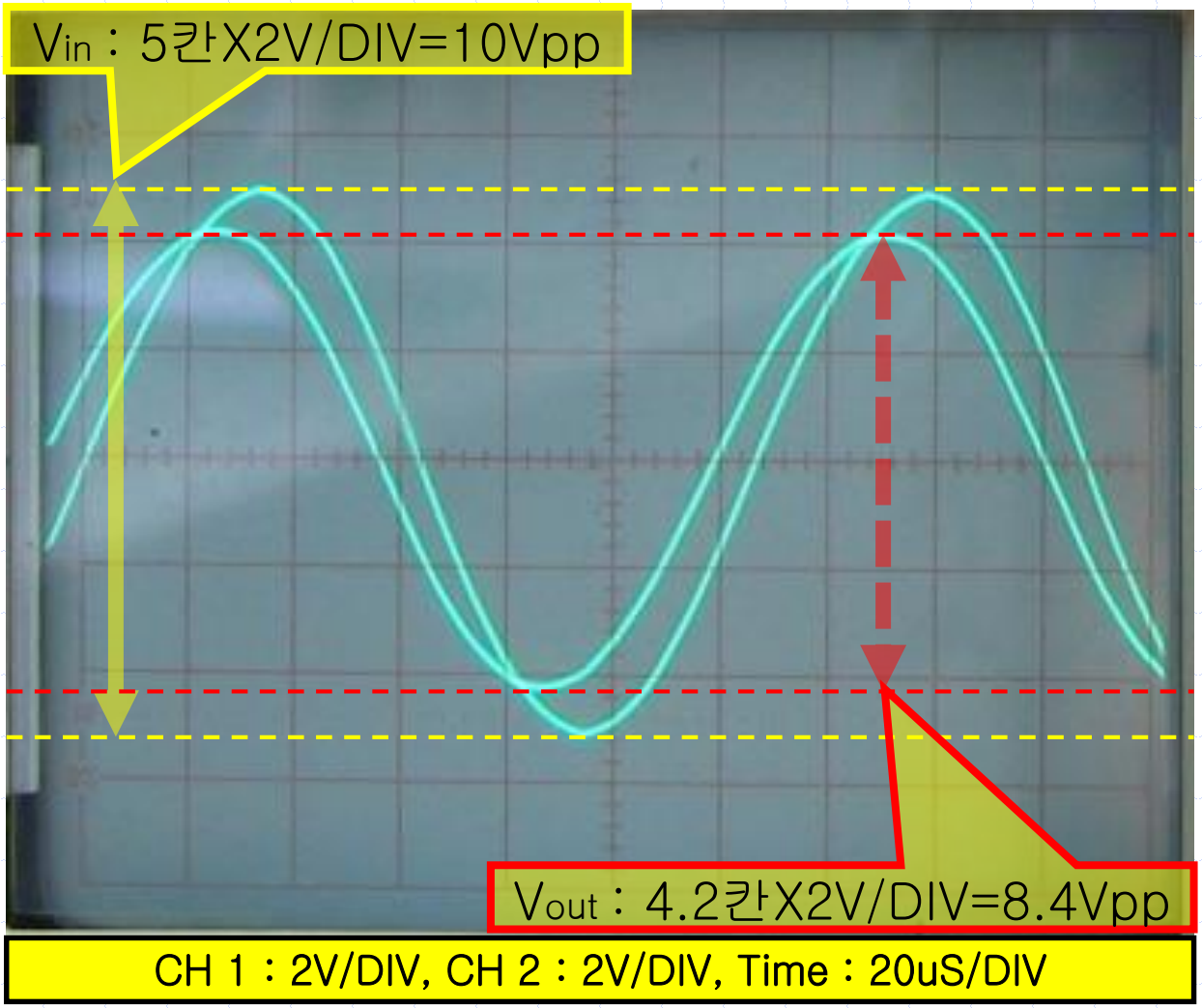
15-4. 주파수에 따른 전압

- ✓ 주파수 : 7kHz



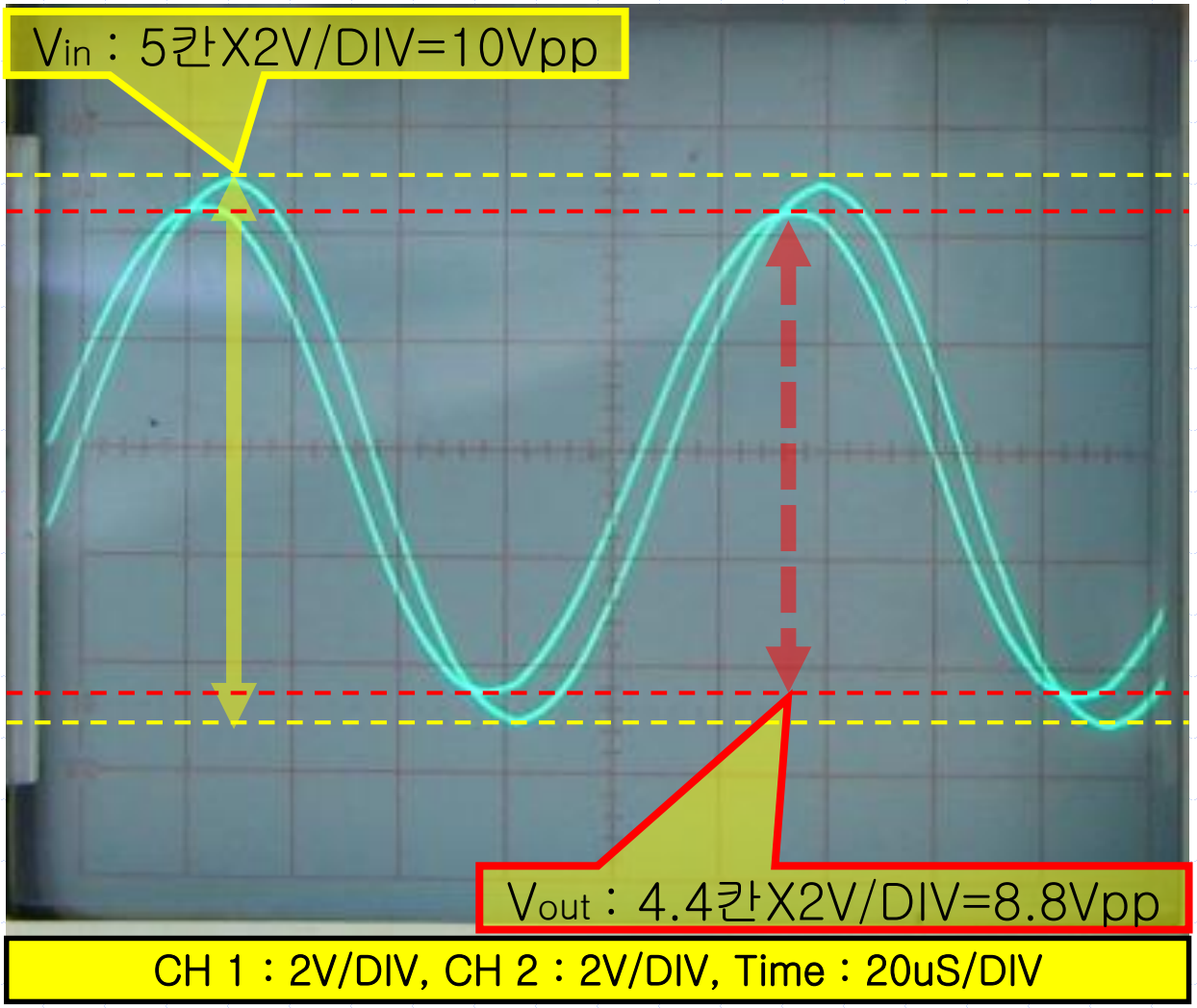
15-4. 주파수에 따른 전압

- ✓ 주파수 : 8kHz



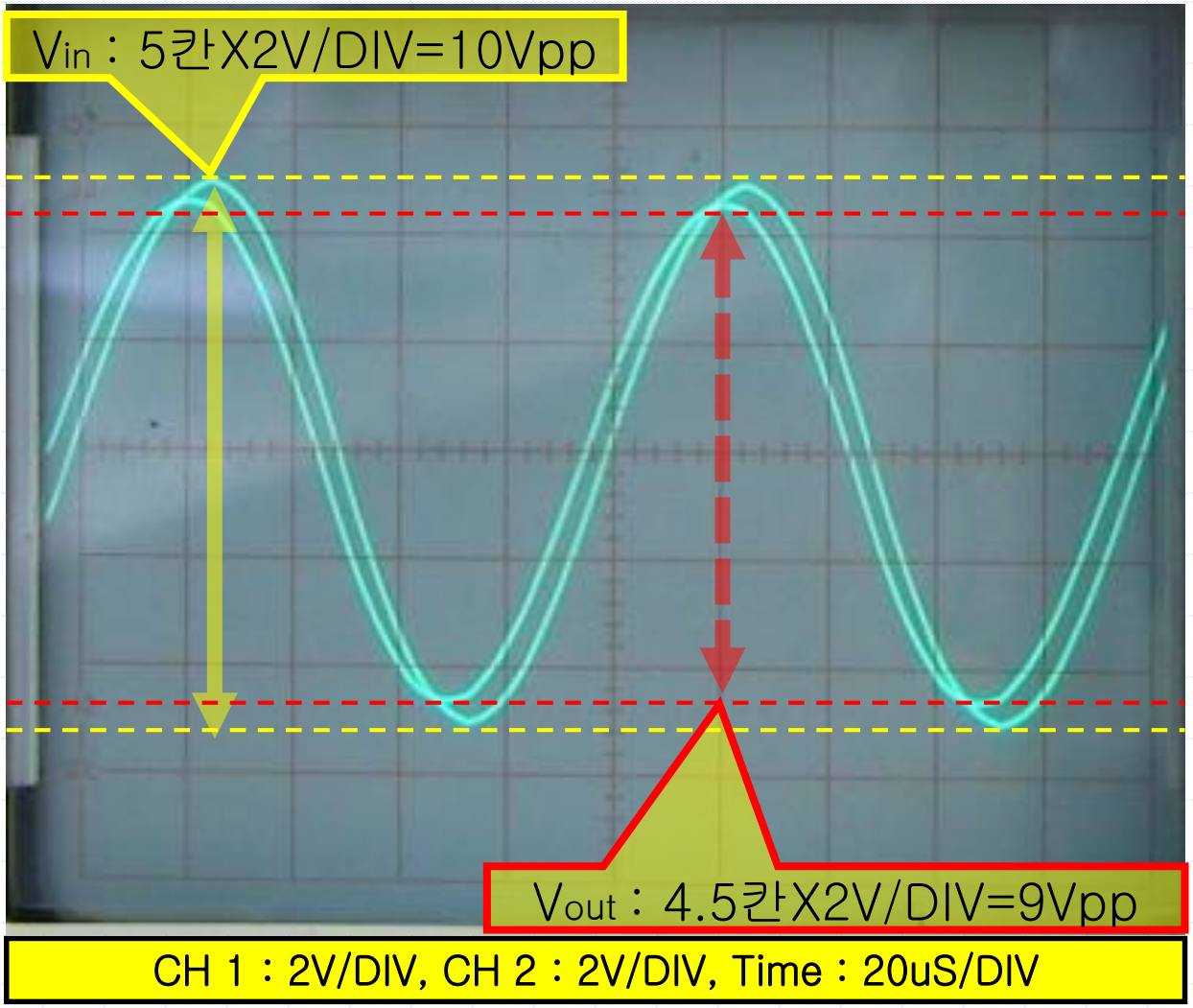
15-4. 주파수에 따른 전압

- ✓ 주파수 : 9kHz



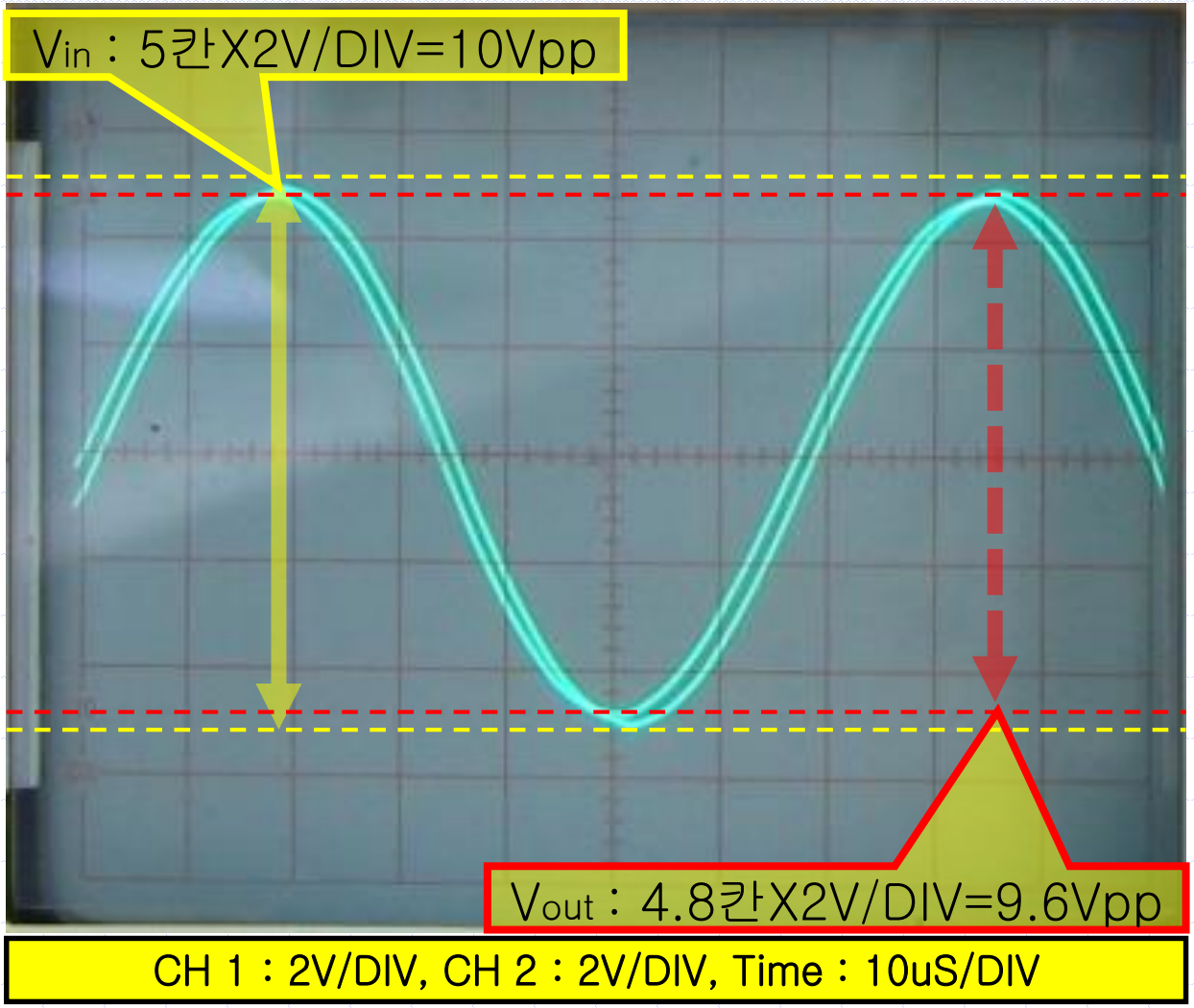
15-4. 주파수에 따른 전압

- ✓ 주파수 : 10kHz



15-4. 주파수에 따른 전압

- ✓ 주파수 : 15kHz

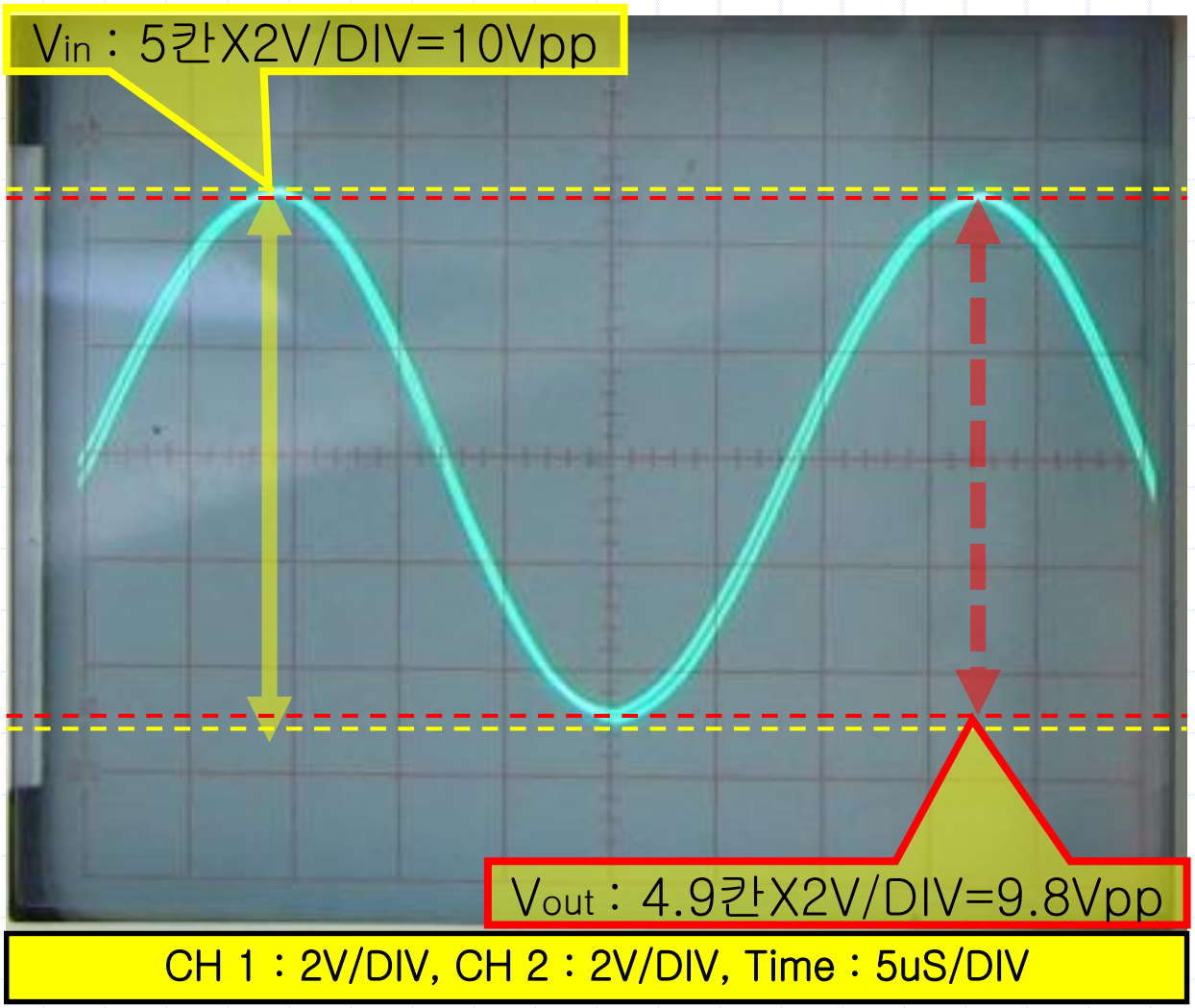


15-4. 주파수에 따른 전압

- ✓ 주파수 : 20kHz

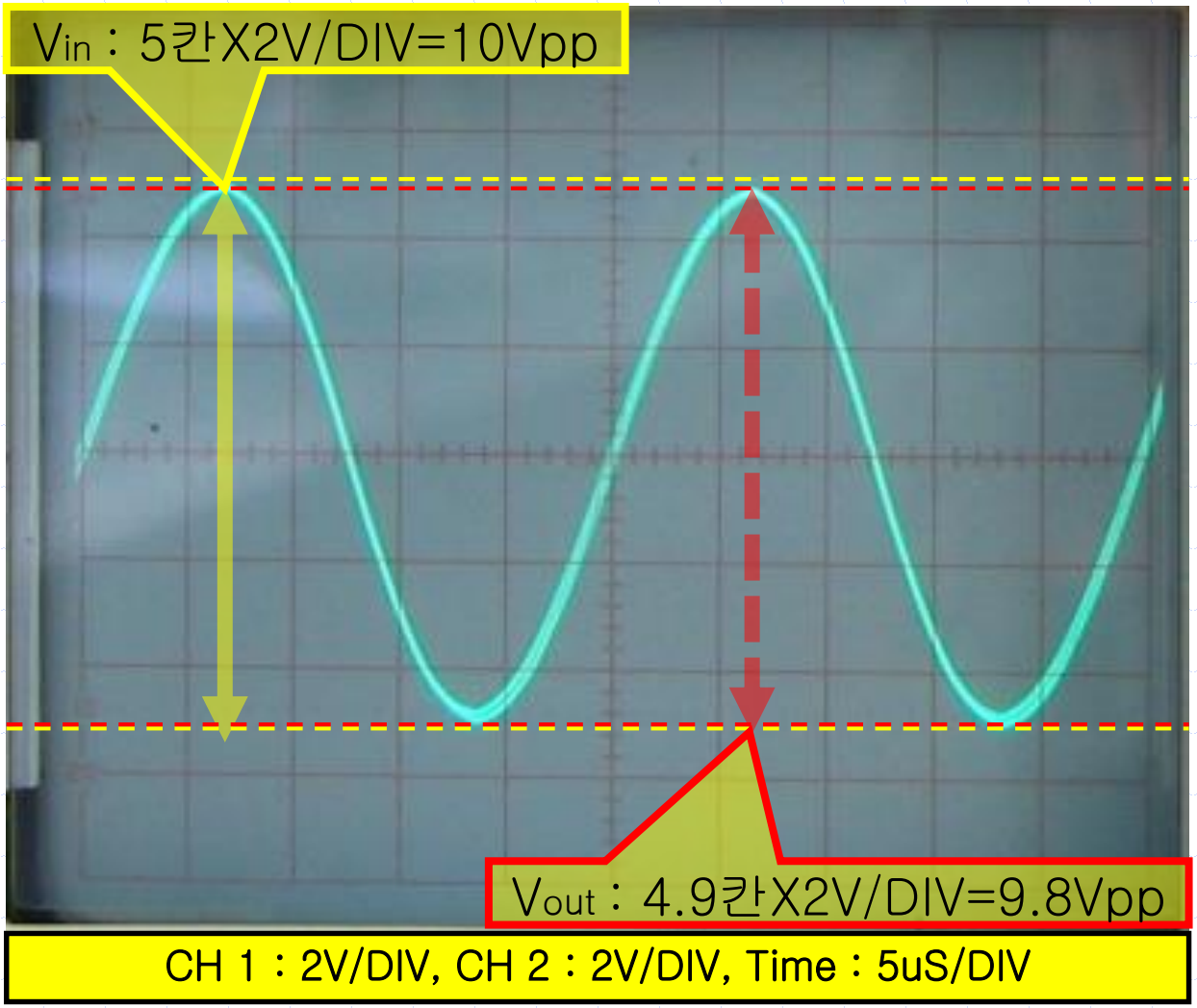
15-4. 주파수에 따른 전압

- ✓ 주파수 : 30kHz



15-4. 주파수에 따른 전압

- ✓ 주파수 : 40kHz



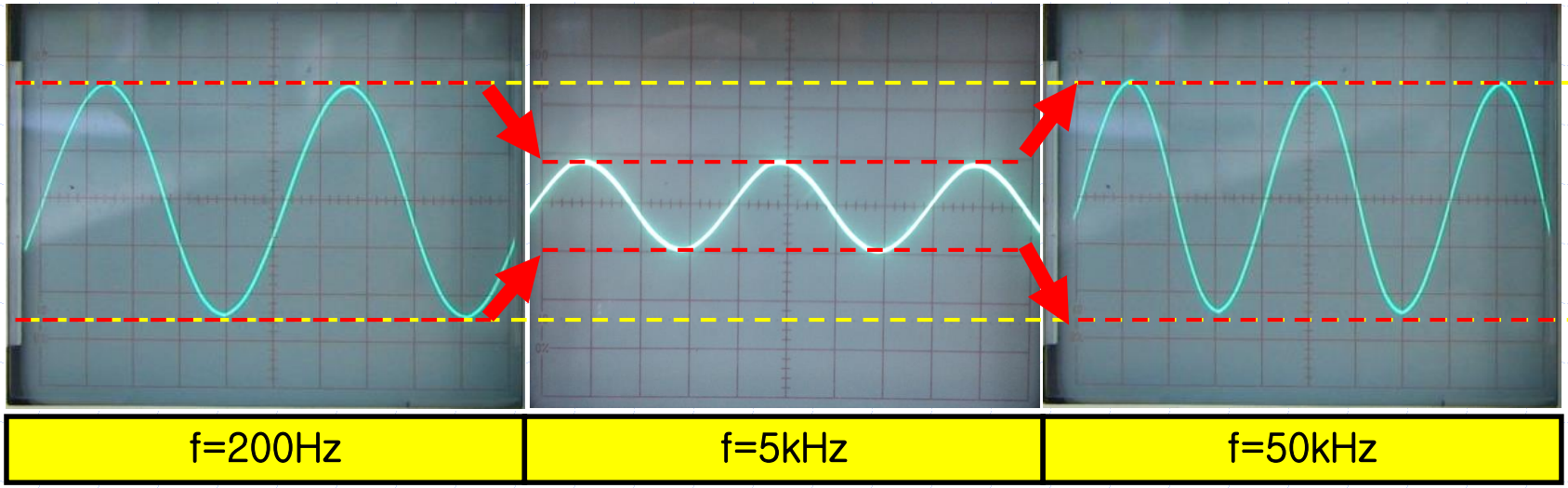
15-4. 주파수에 따른 전압

- ✓ 주파수 : 50kHz

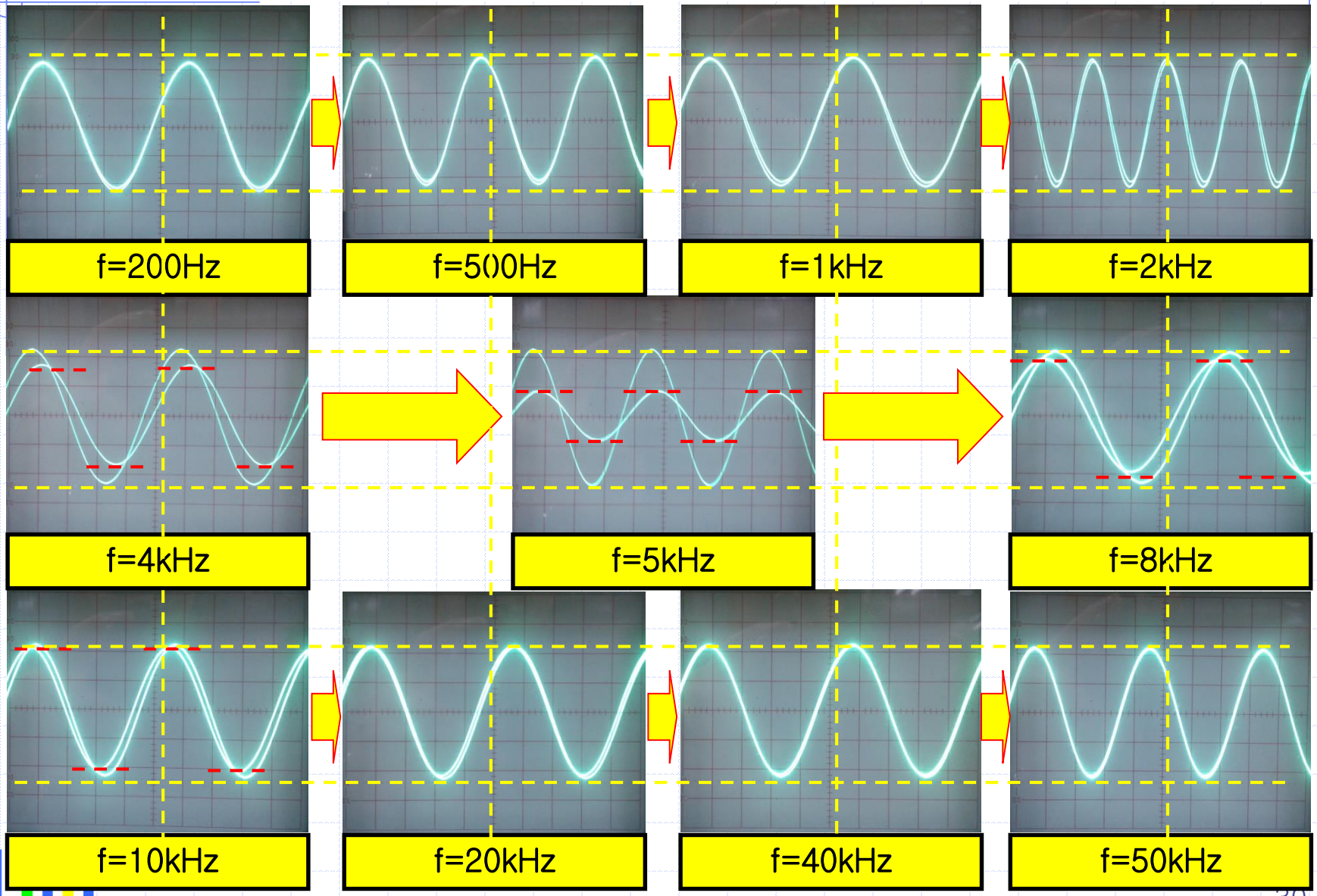
15-4. 주파수에 따른 전압

Frequency (Hz)	이 론					실 험				
	Vin (Vpp)	Vout (Vpp)	전압 이득		전체 전류	Vin (Vpp)	Vout (Vpp)	전압 이득		전체 전류
			이득	dB	IT (mApp)			이득	dB	IT (mApp)
200	10	10	1.00	0.00	10	10	9.8	0.98	-0.18	9.8
500	10	9.99	1.00	-0.01	9.99	10	9.8	0.98	-0.18	9.8
1,000	10	9.98	1.00	-0.02	9.98	10	9.8	0.98	-0.18	9.8
2,000	10	9.89	0.99	-0.10	9.89	10	9.6	0.96	-0.35	9.6
3,000	10	9.6	0.96	-0.35	9.6	10	9.2	0.92	-0.72	9.2
4,000	10	8.26	0.83	-1.66	8.26	10	8	0.80	-1.94	8
5,000	10	0.41	0.04	-27.74	0.41	10	4.3	0.43	-7.33	4.3
6,000	10	7.45	0.75	-2.56	7.45	10	4.4	0.44	-7.13	4.4
7,000	10	9.05	0.91	-0.87	9.05	10	7.2	0.72	-2.85	7.2
8,000	10	9.5	0.95	-0.45	9.5	10	8.4	0.84	-1.51	8.4
9,000	10	9.68	0.97	-0.28	9.68	10	8.8	0.88	-1.11	8.8
10,000	10	9.78	0.98	-0.19	9.78	10	9	0.90	-0.92	9
15,000	10	9.93	0.99	-0.06	9.93	10	9.6	0.96	-0.35	9.6
20,000	10	9.96	1.00	-0.03	9.96	10	9.8	0.98	-0.18	9.8
30,000	10	9.99	1.00	-0.01	9.99	10	9.8	0.98	-0.18	9.8
40,000	10	9.99	1.00	-0.01	9.99	10	9.8	0.98	-0.18	9.8
50,000	10	9.99	1.00	-0.01	9.99	10	10	1.00	0.00	10

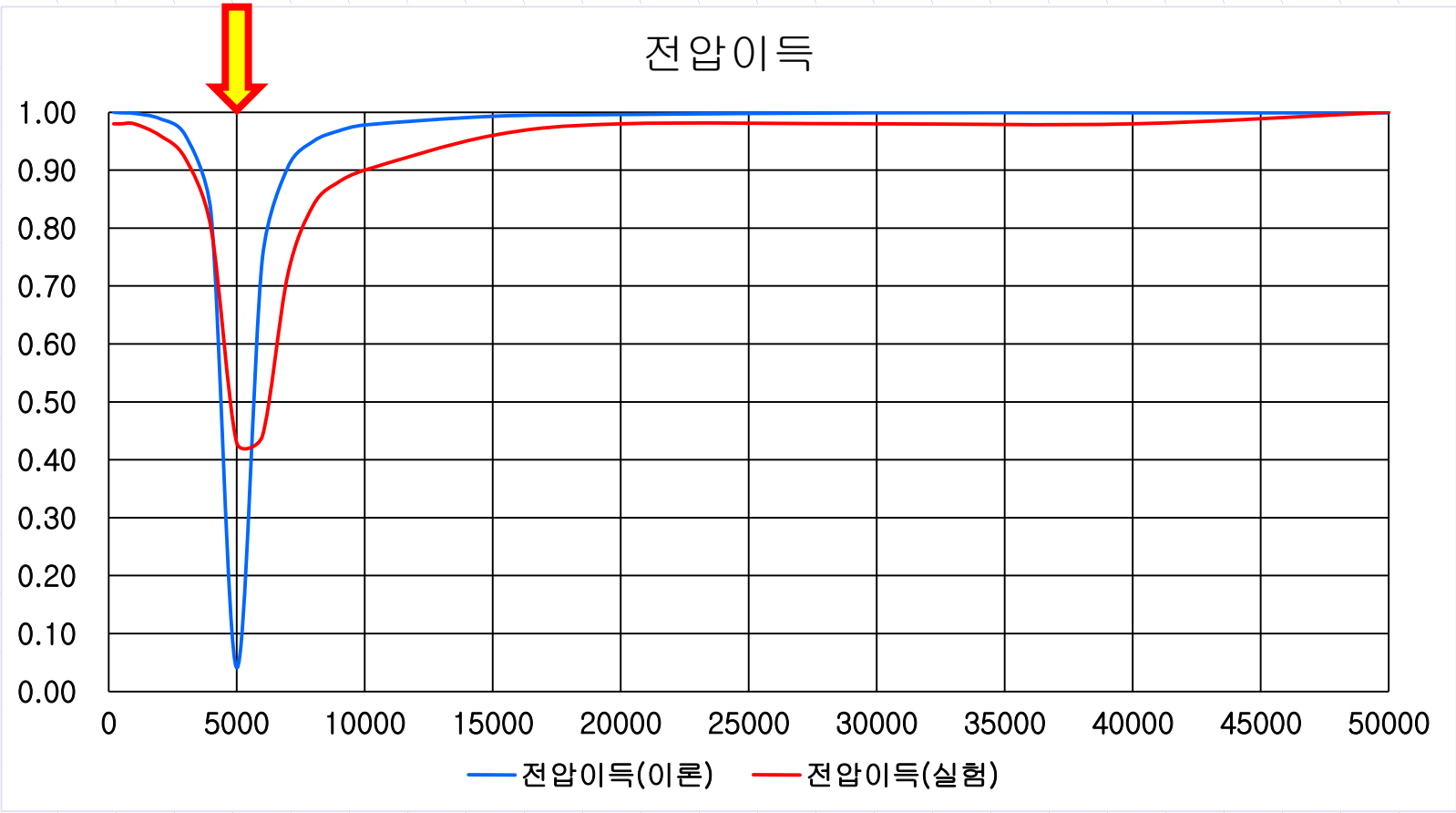
15-4. 주파수에 따른 전압



15-4. 주파수에 따른 전압

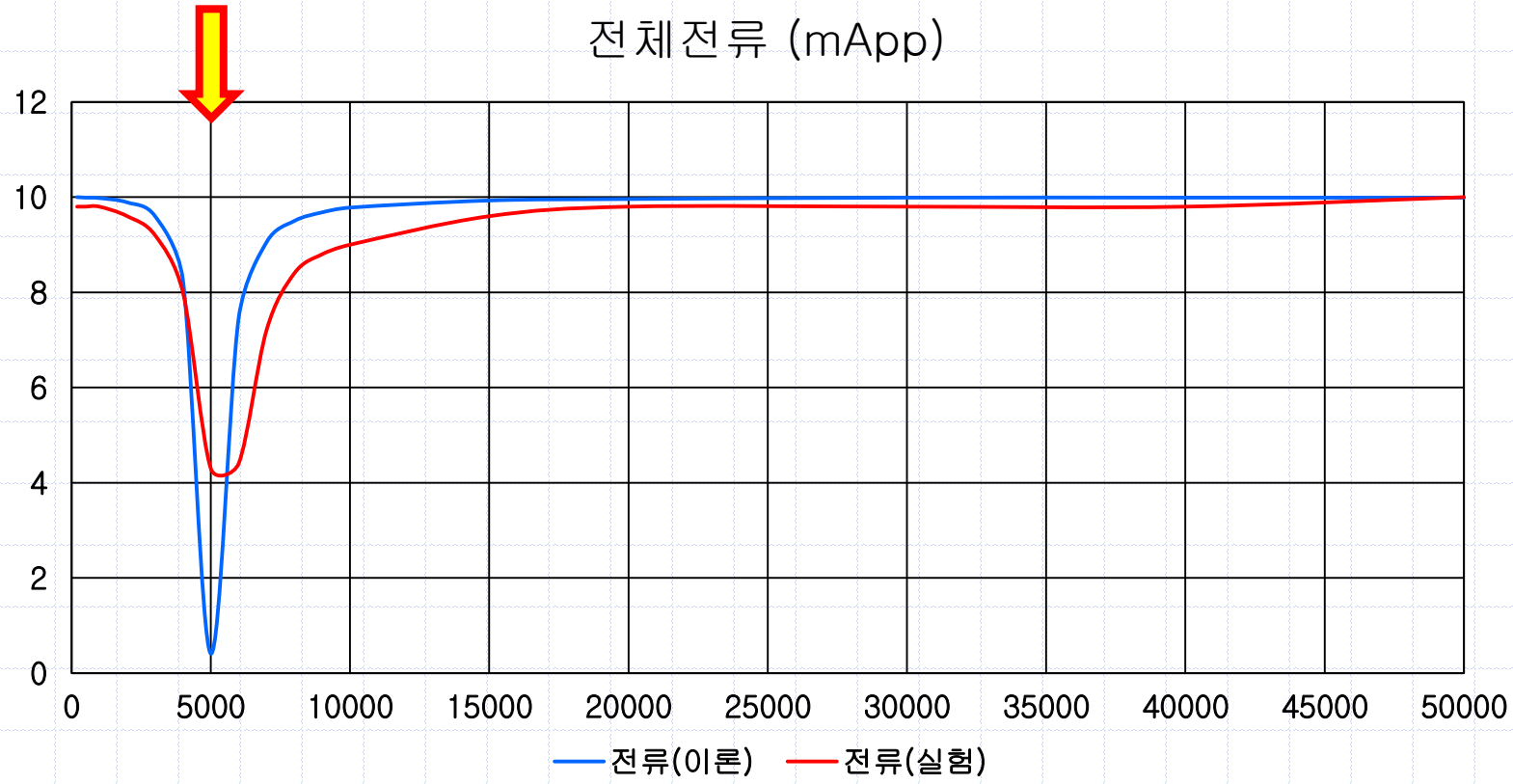


15-5. 공진 주파수



$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10mH \times 0.1uF}} = 5032.9Hz$$

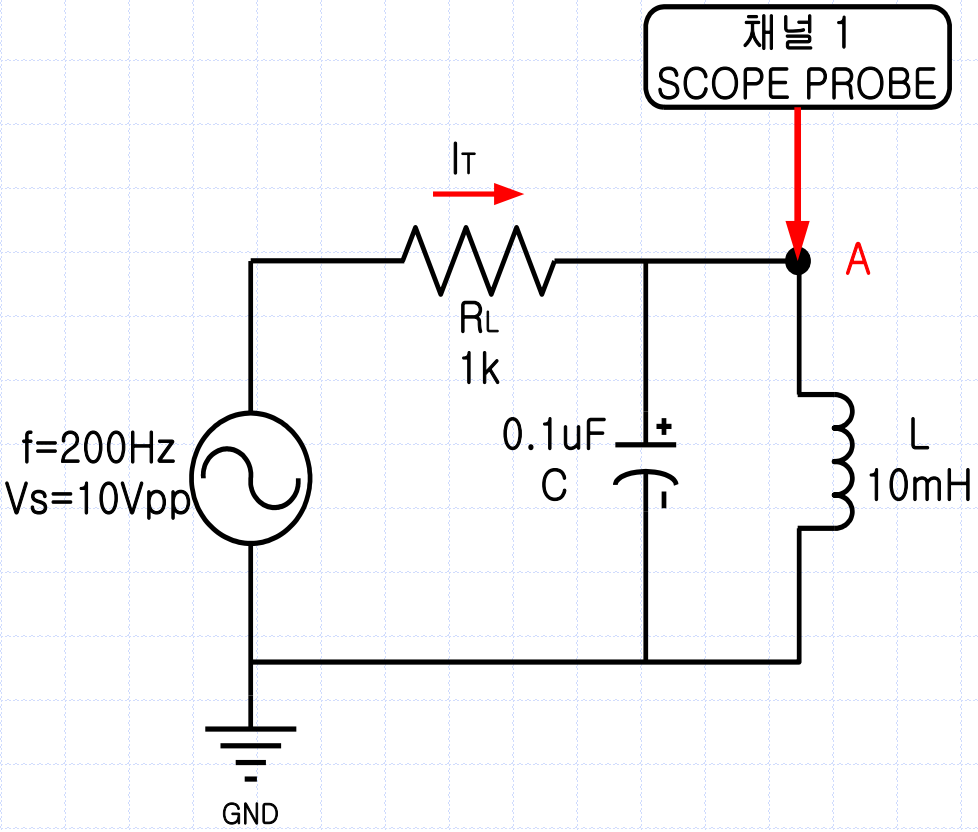
15-5. 공진 주파수



$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10mH \times 0.1uF}} = 5032.9Hz$$

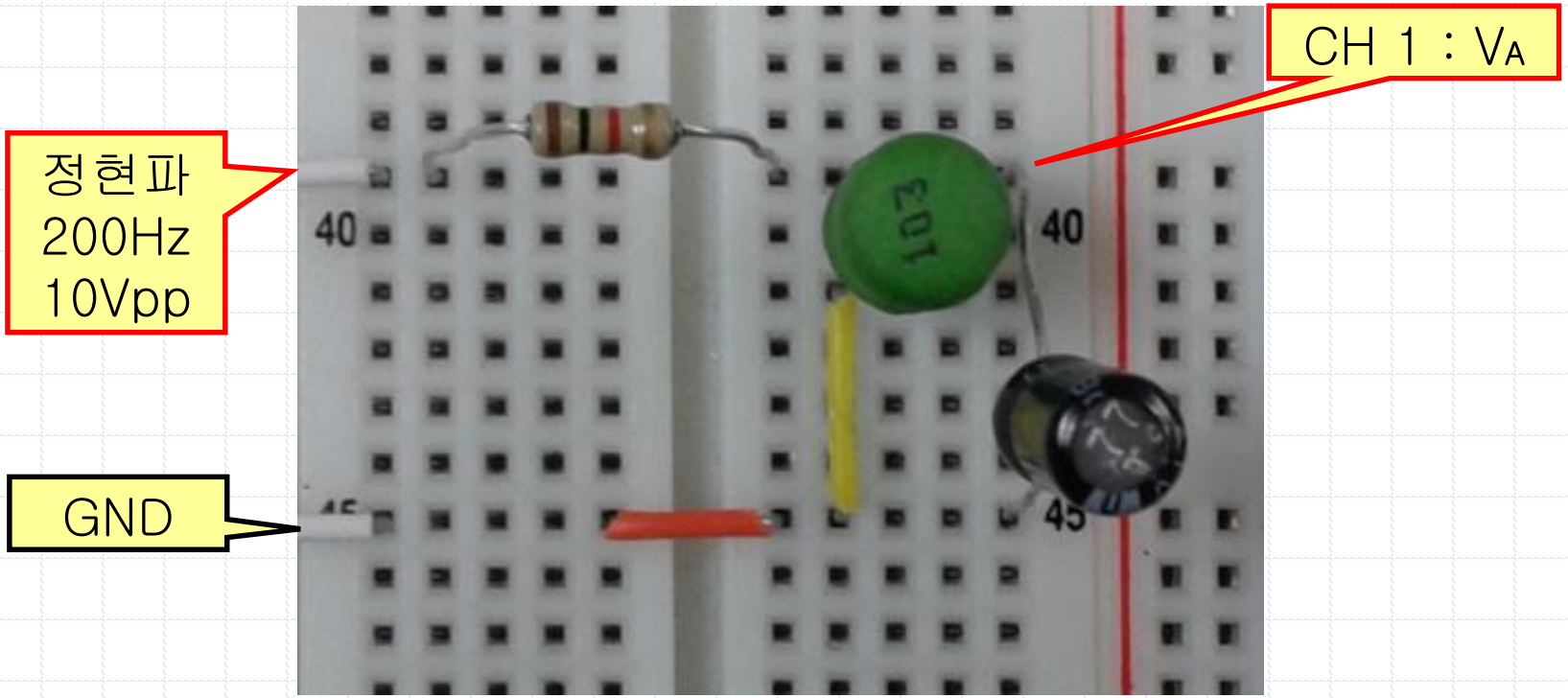
15-6. 주파수에 따른 전류, 임피던스

- 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.

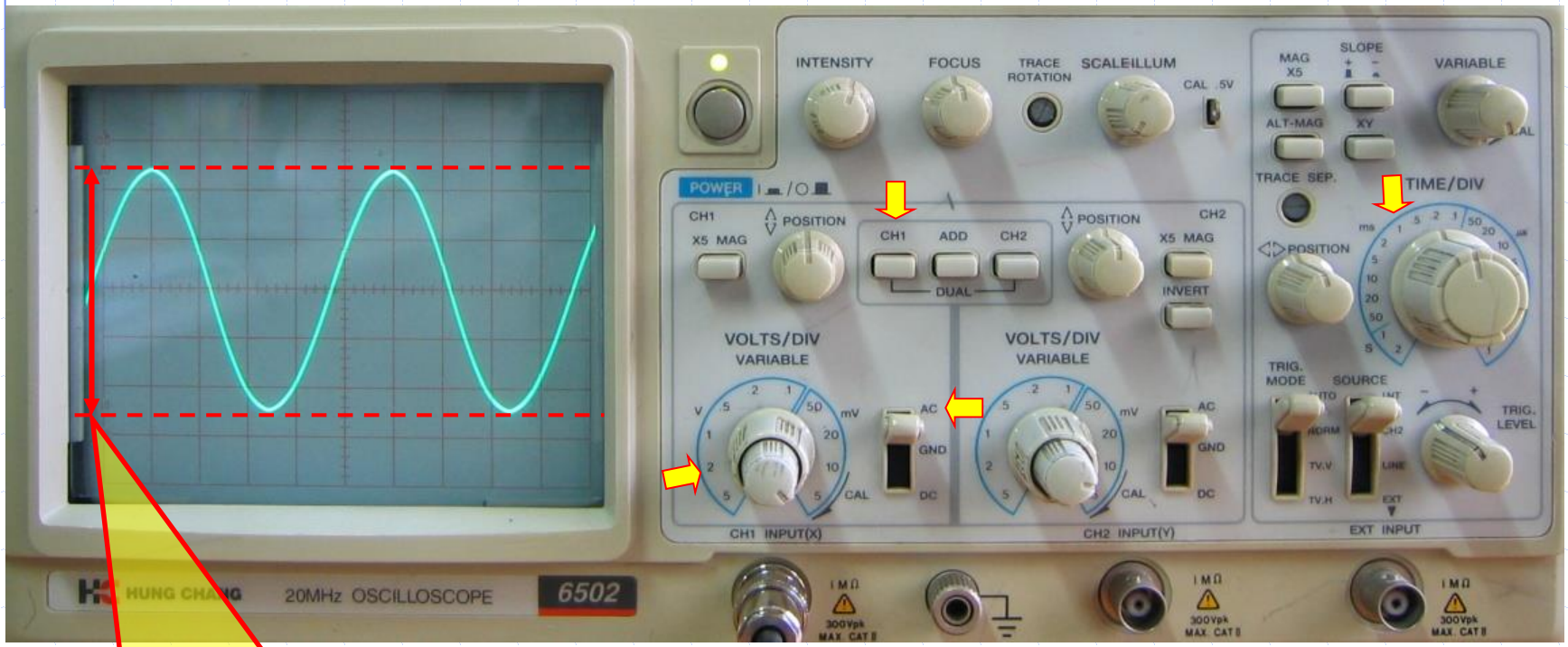


15-6. 주파수에 따른 전류, 임피던스

- 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.



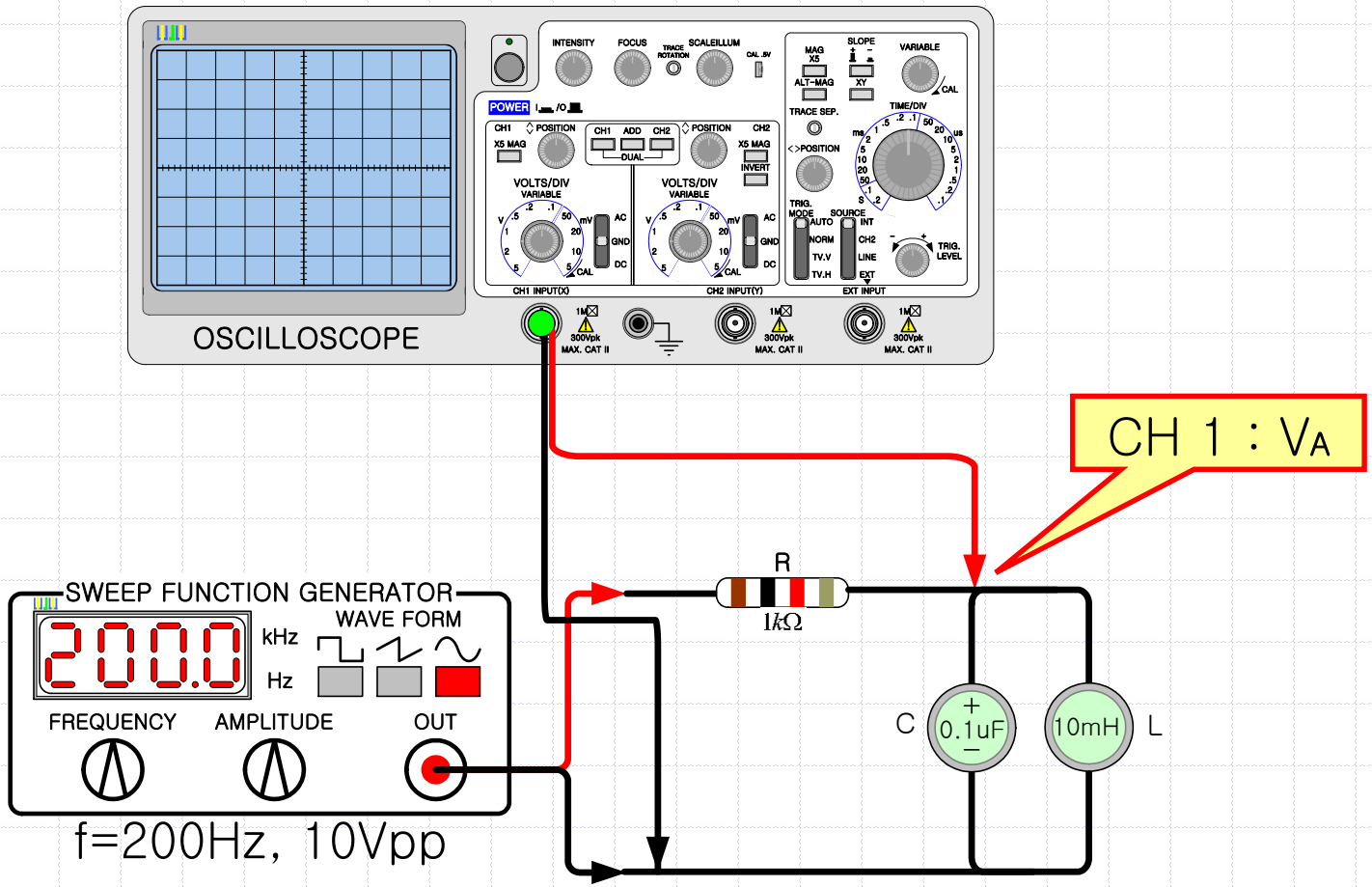
15-6. 주파수에 따른 전류, 임피던스



5칸X2V/DIV=10Vpp

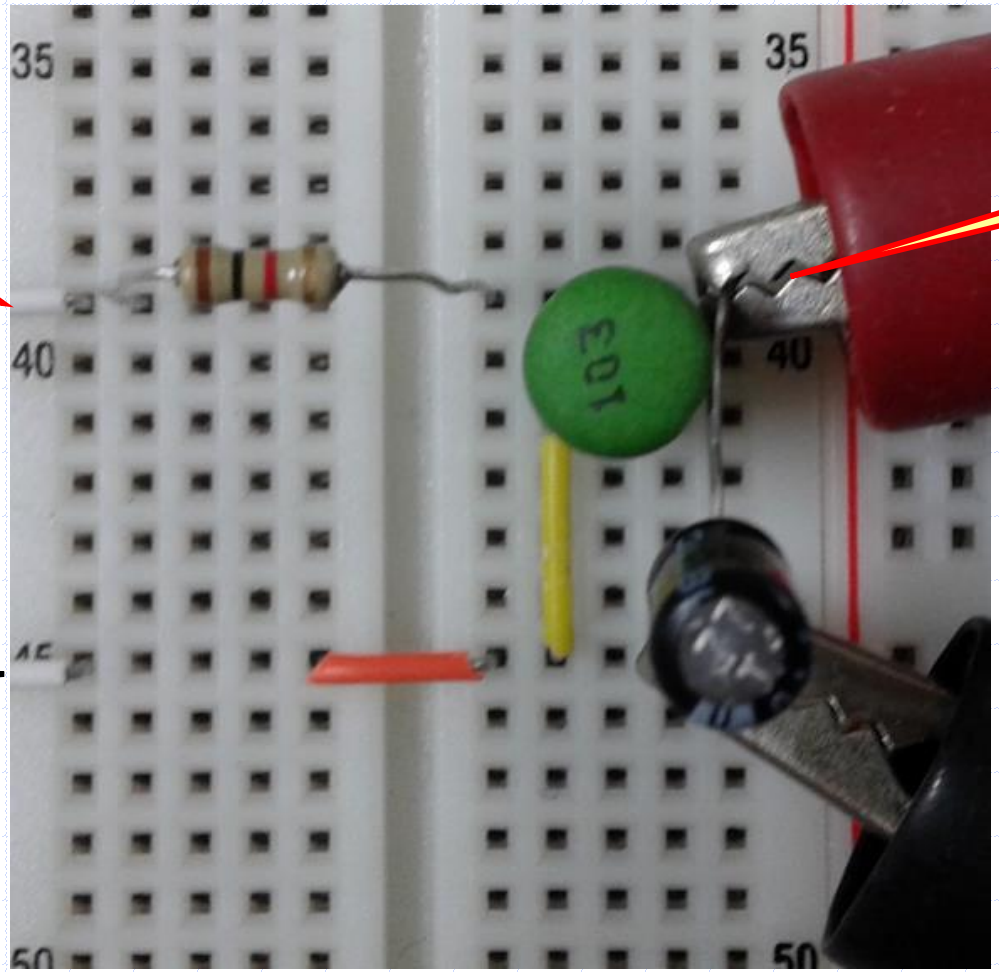
15-6. 주파수에 따른 전류, 임피던스

- 오실로스코프의 CH 1 을 이용하여 병렬 공진 회로 양단의 전압을 측정한다.



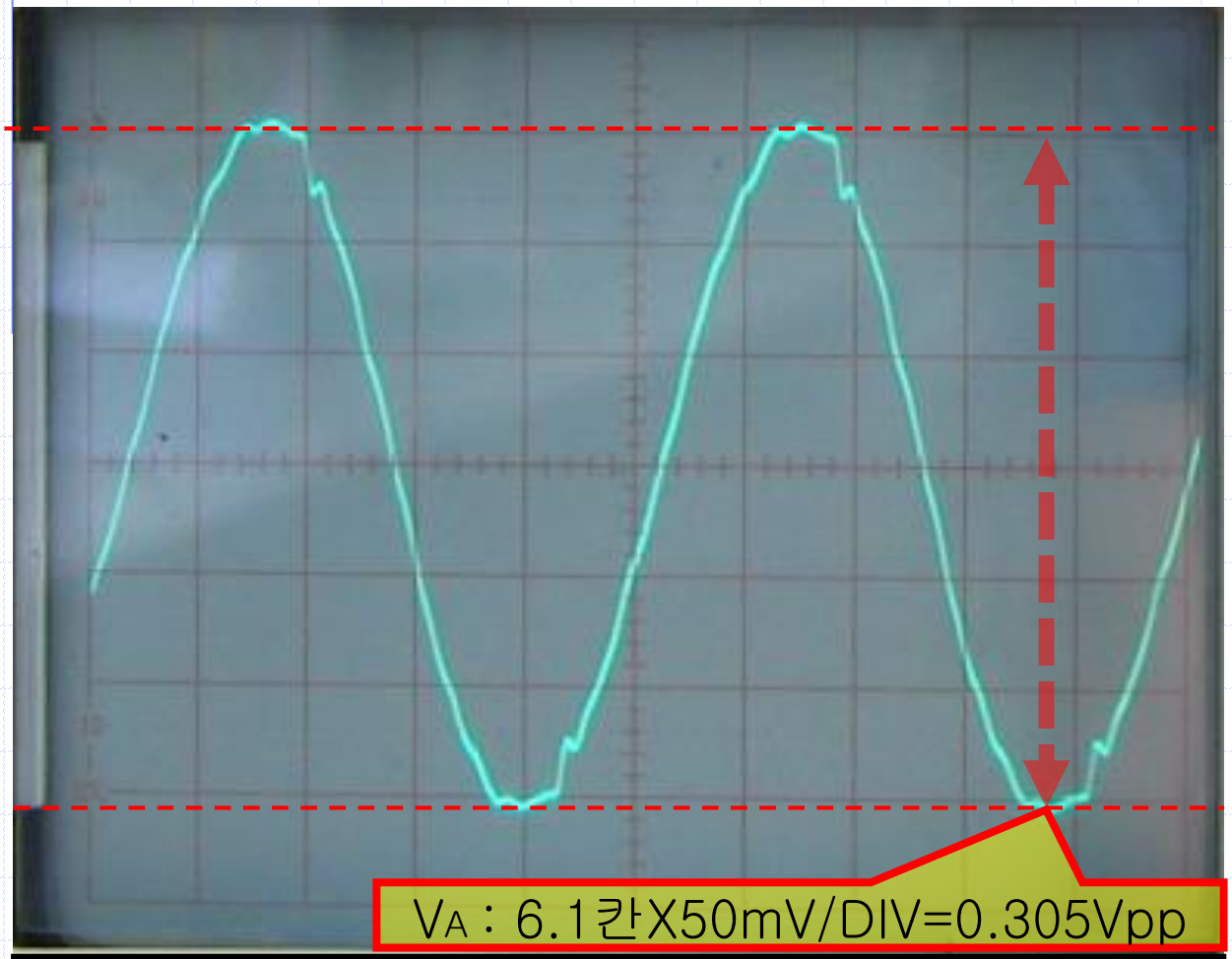
15-6. 주파수에 따른 전류, 임피던스

- ✓ 주파수 : 200Hz



15-6. 주파수에 따른 전류, 임피던스

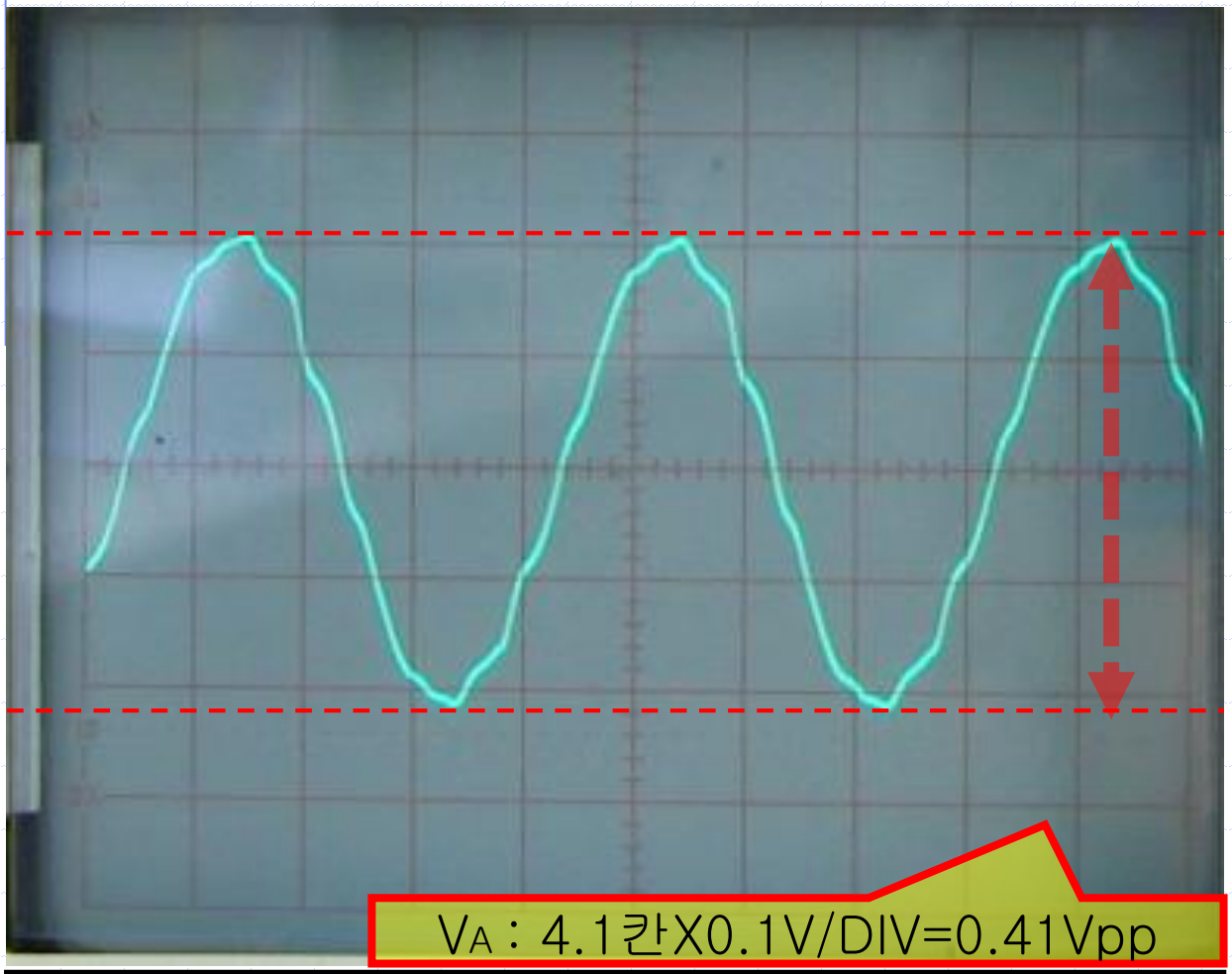
✓ 주파수 : 200Hz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.305V_{PP}}{9.8mA_{PP}} = 31.12\Omega$$

15-6. 주파수에 따른 전류, 임피던스

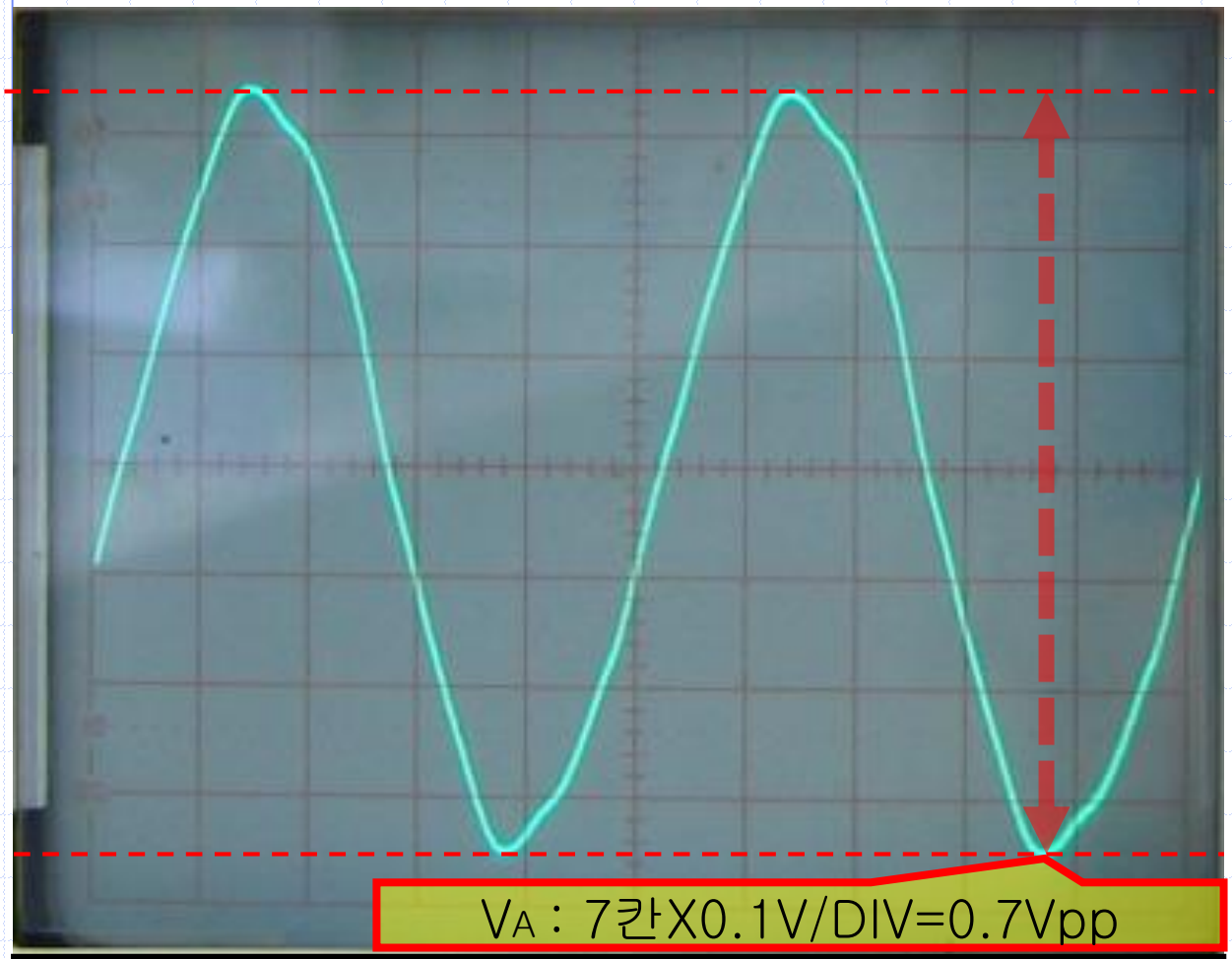
✓ 주파수 : 500Hz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.41V_{PP}}{9.8mA_{PP}} = 41.84\Omega$$

15-6. 주파수에 따른 전류, 임피던스

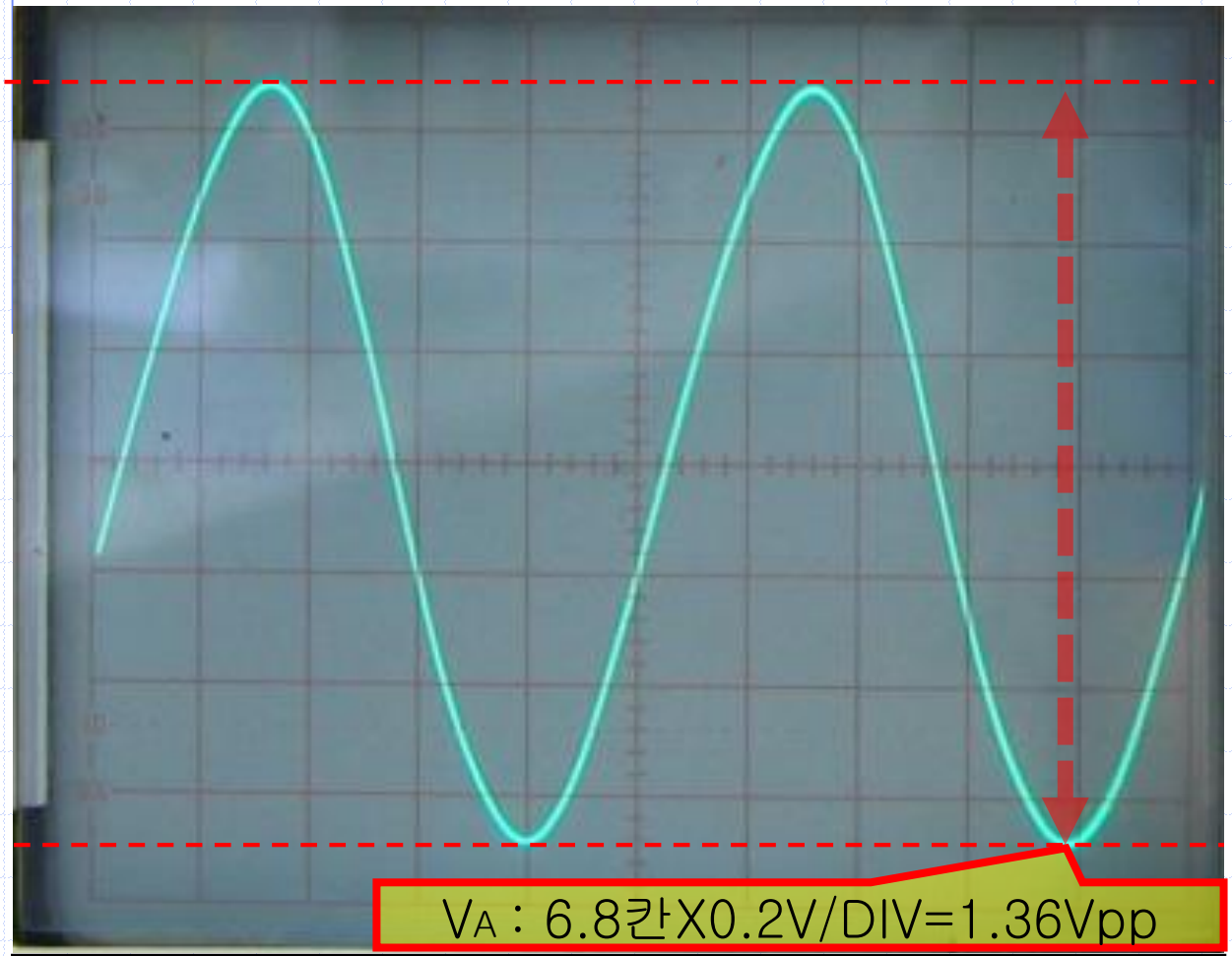
✓ 주파수 : 1kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.7V_{PP}}{9.8mA_{PP}} = 71.43\Omega$$

15-6. 주파수에 따른 전류, 임피던스

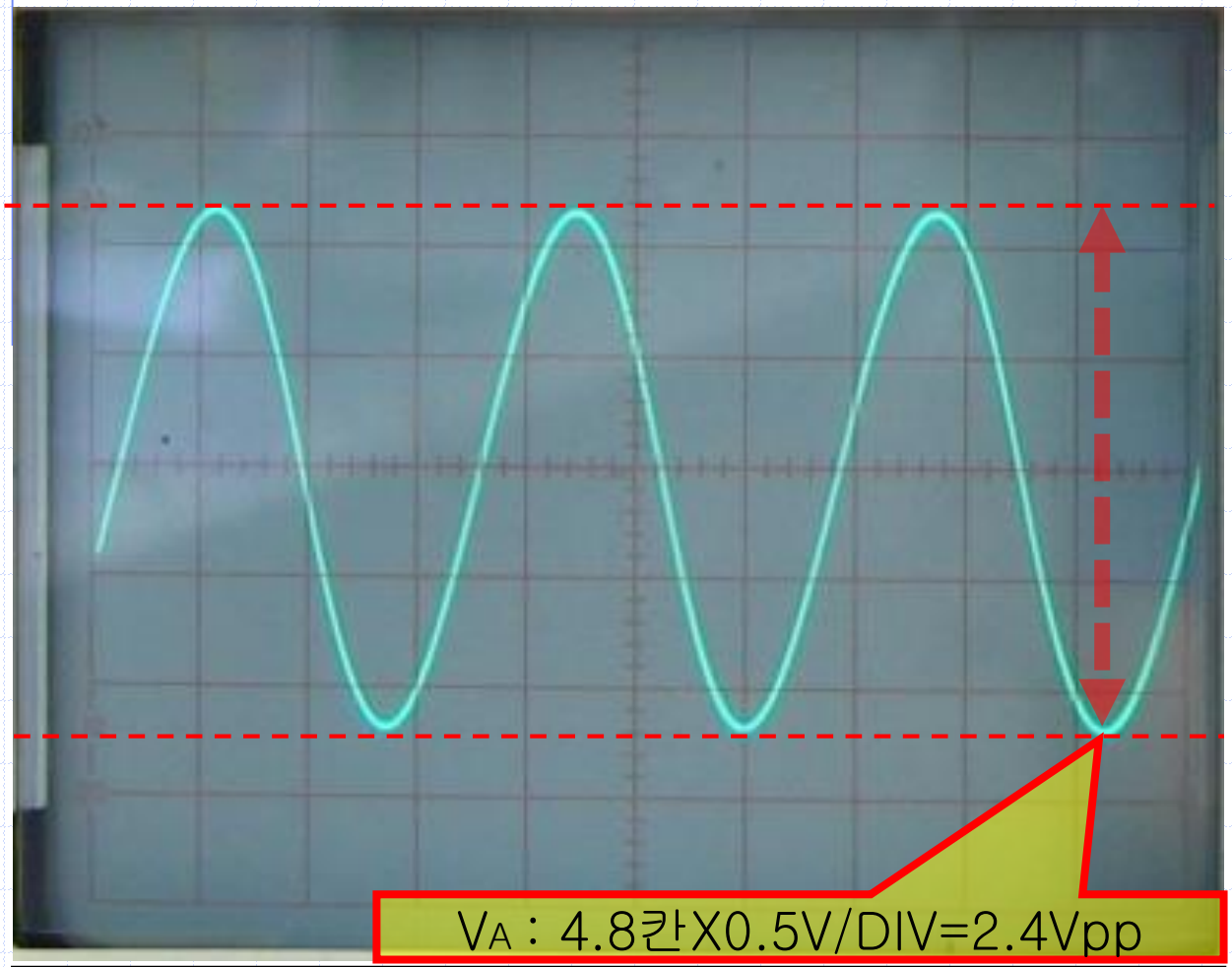
✓ 주파수 : 2kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{1.36V_{PP}}{9.6mA_{PP}} = 141.67\Omega$$

15-6. 주파수에 따른 전류, 임피던스

✓ 주파수 : 3kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{2.4V_{PP}}{9.2mA_{PP}} = 260.87\Omega$$

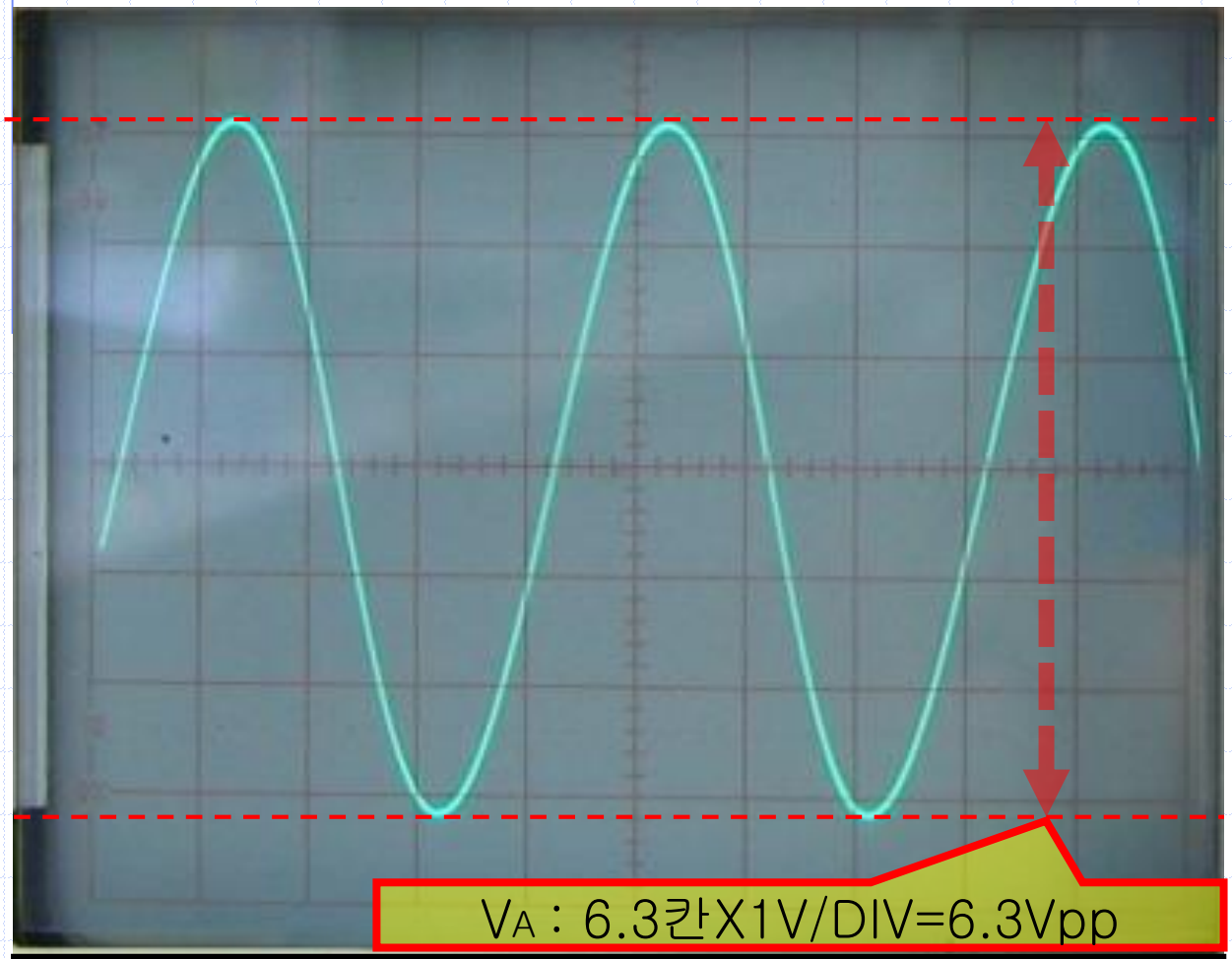
15-6. 주파수에 따른 전류, 임피던스

✓ 주파수 : 4kHz

$$|Z| = \frac{V_{AB}}{I_T} = \frac{4V_{PP}}{8mA_{PP}} = 500\Omega$$

15-6. 주파수에 따른 전류, 임피던스

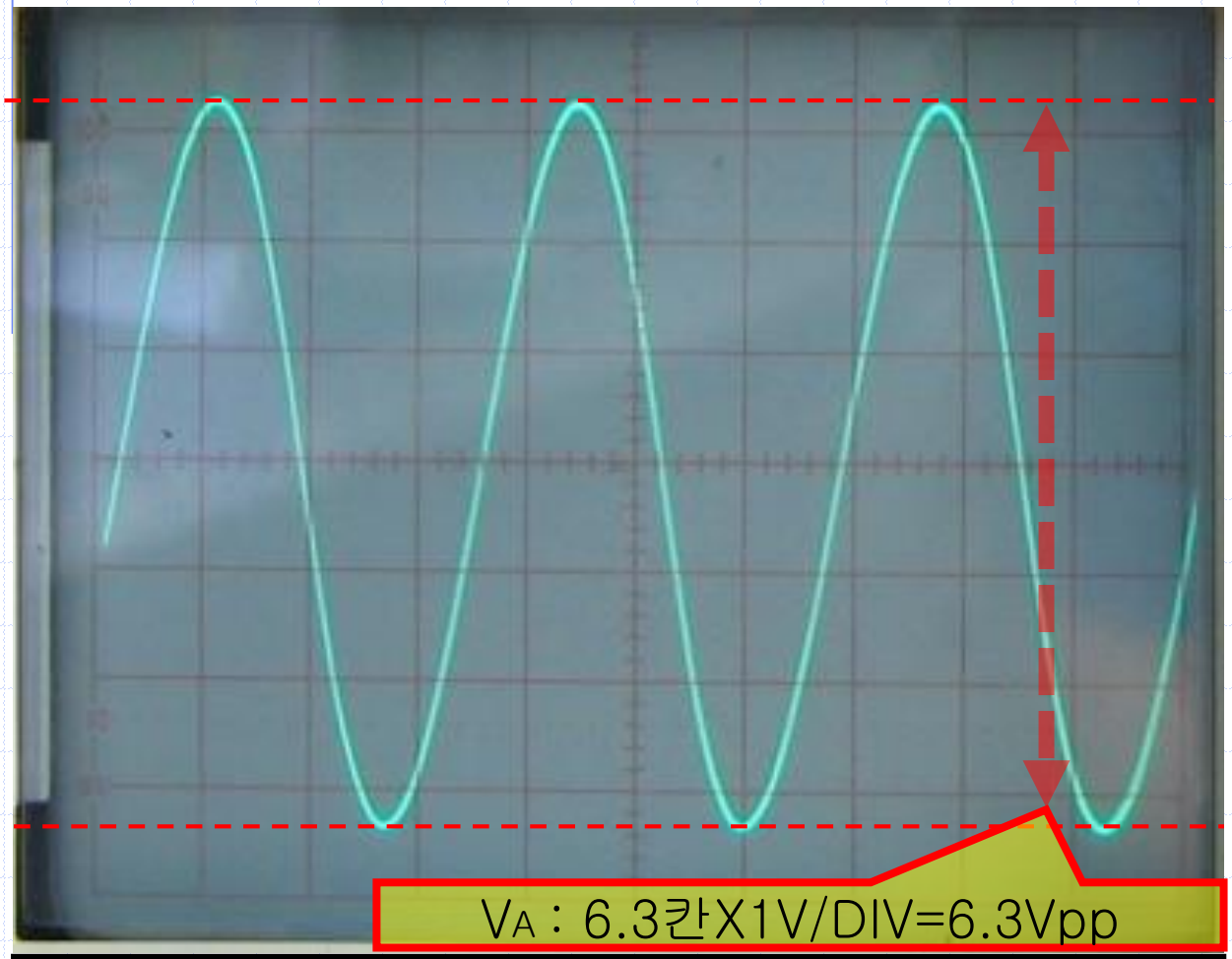
✓ 주파수 : 5kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{6.3V_{PP}}{4.6mA_{PP}} = 1{,}369.57\Omega$$

15-6. 주파수에 따른 전류, 임피던스

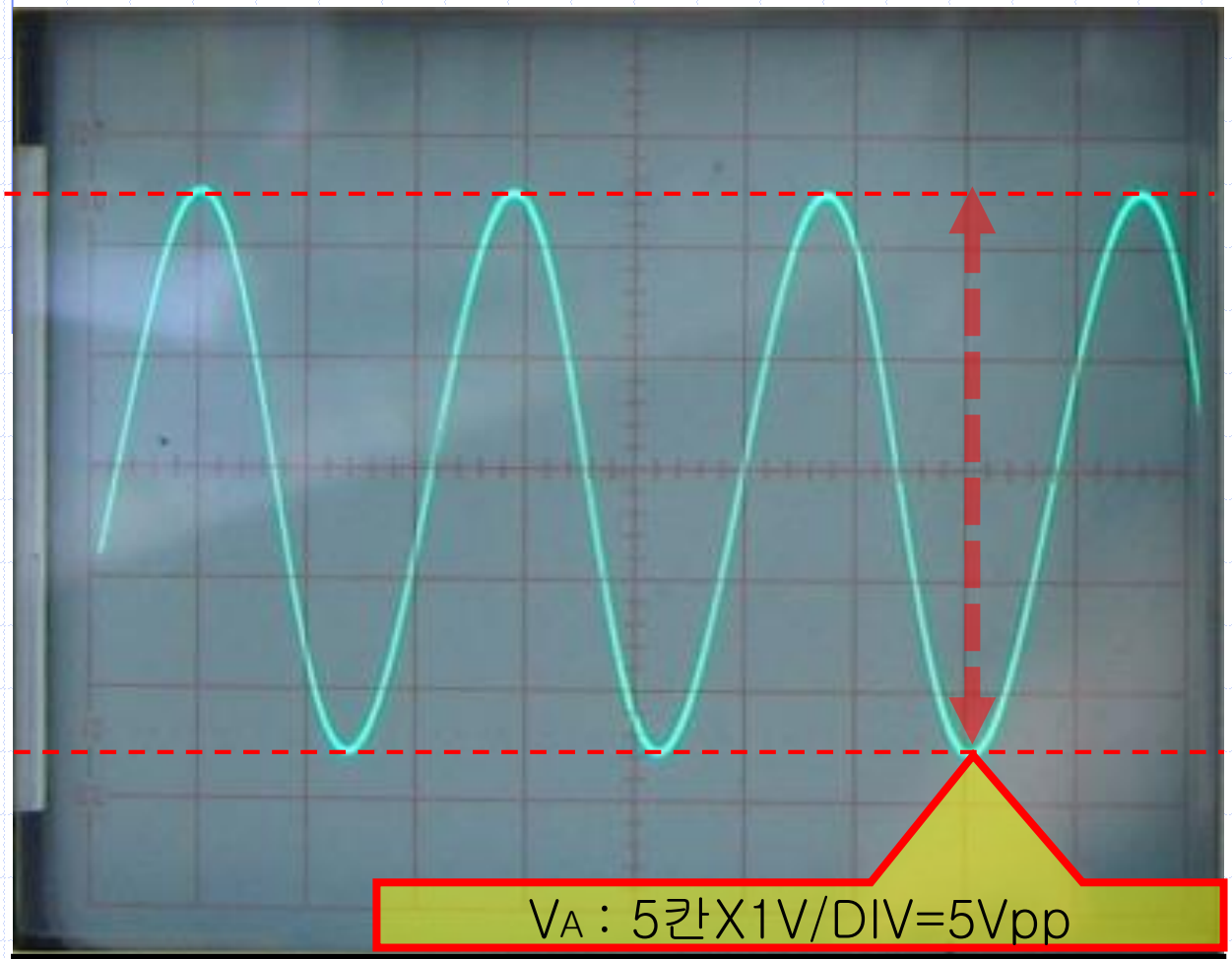
✓ 주파수 : 6kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{6.3V_{PP}}{4.4mA_{PP}} = 1{,}431.82\Omega$$

15-6. 주파수에 따른 전류, 임피던스

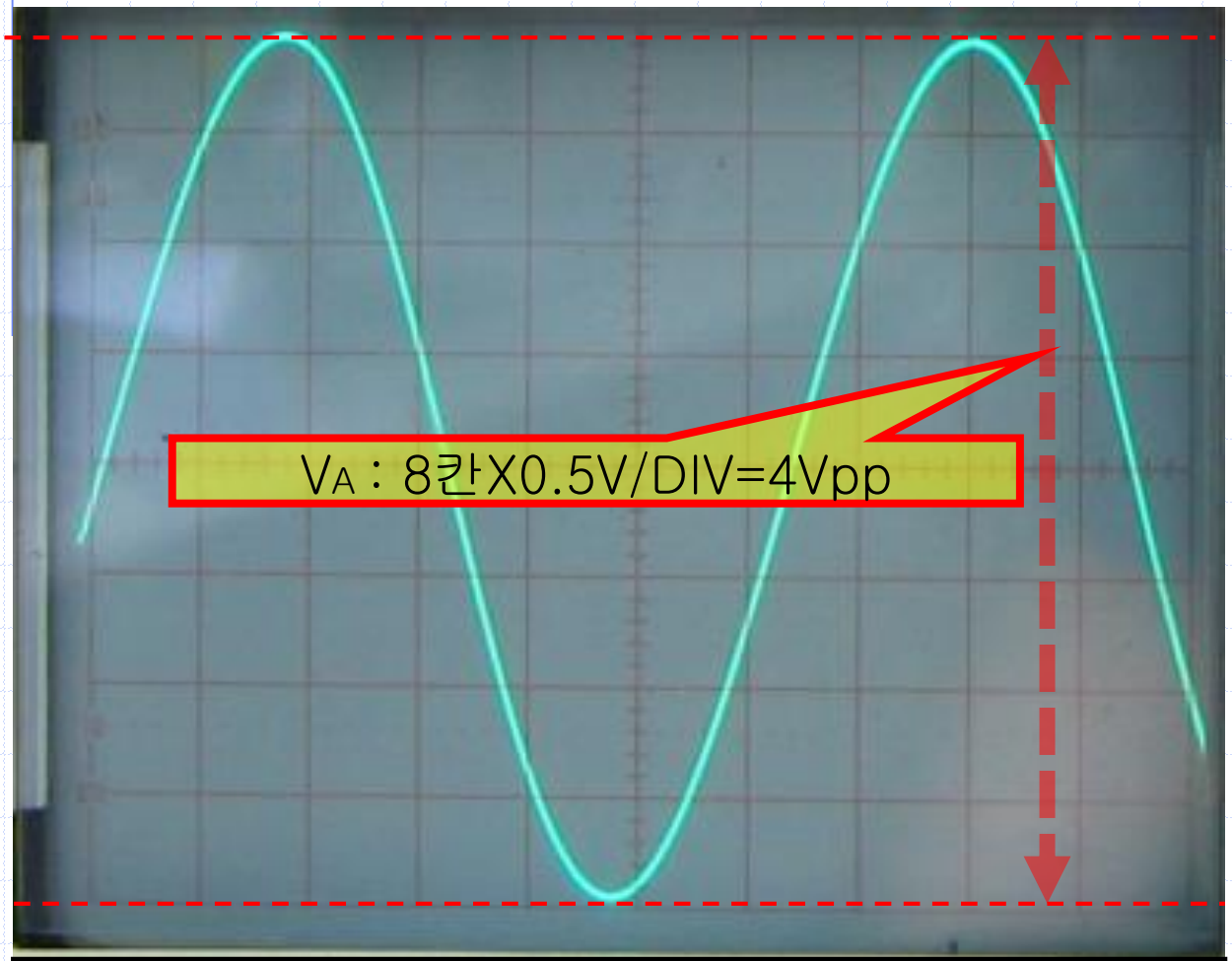
✓ 주파수 : 7kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{5V_{PP}}{7.2mA_{PP}} = 694.44\Omega$$

15-6. 주파수에 따른 전류, 임피던스

✓ 주파수 : 8kHz

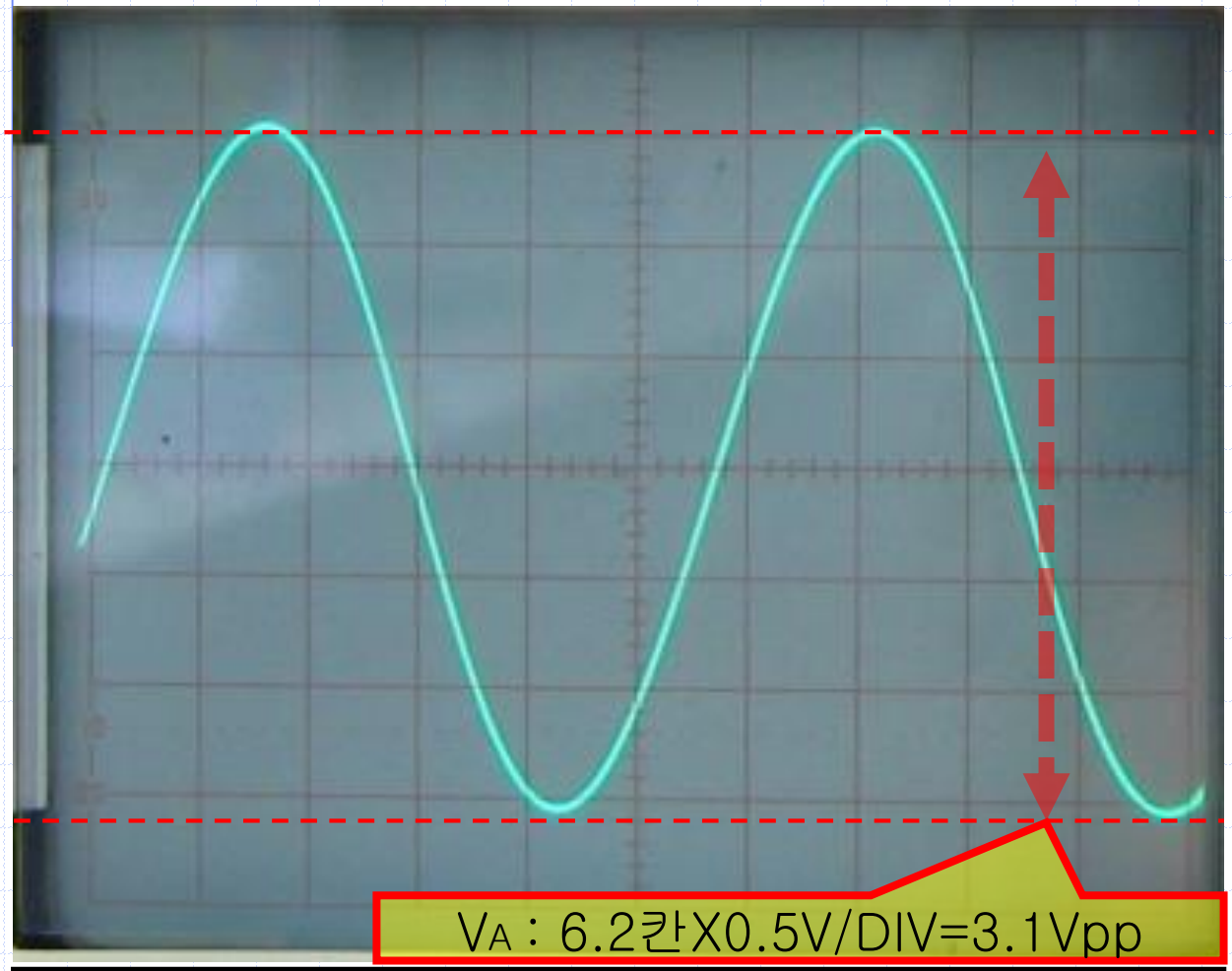


CH 1 : 0.5V/DIV, Time : 1mS/DIV

$$|Z| = \frac{V_{AB}}{I_T} = \frac{4V_{PP}}{8.4mA_{PP}} = 476.19\Omega$$

15-6. 주파수에 따른 전류, 임피던스

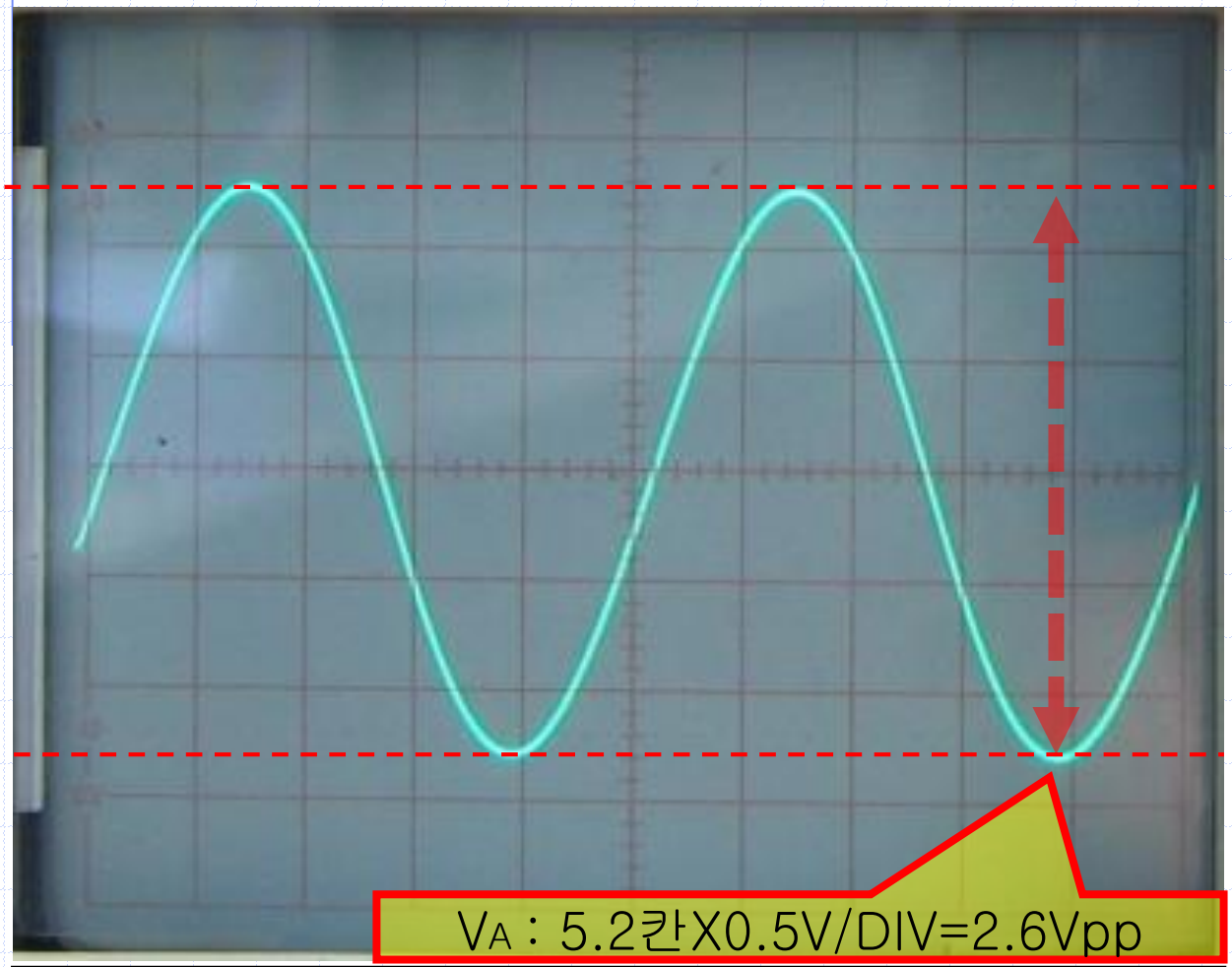
✓ 주파수 : 9kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{3.1V_{PP}}{8.8mA_{PP}} = 352.27\Omega$$

15-6. 주파수에 따른 전류, 임피던스

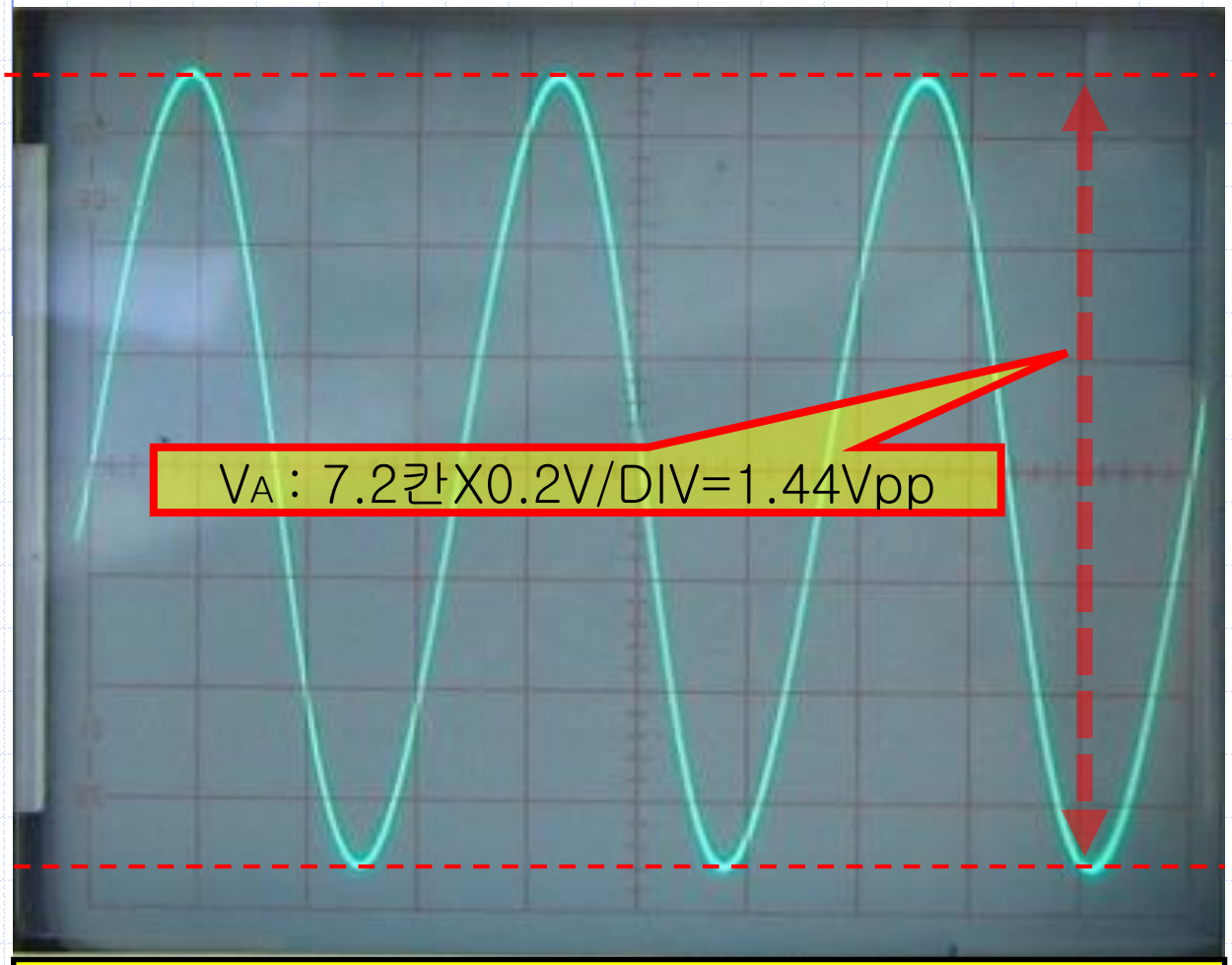
✓ 주파수 : 10kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{2.6V_{PP}}{9mA_{PP}} = 288.89\Omega$$

15-6. 주파수에 따른 전류, 임피던스

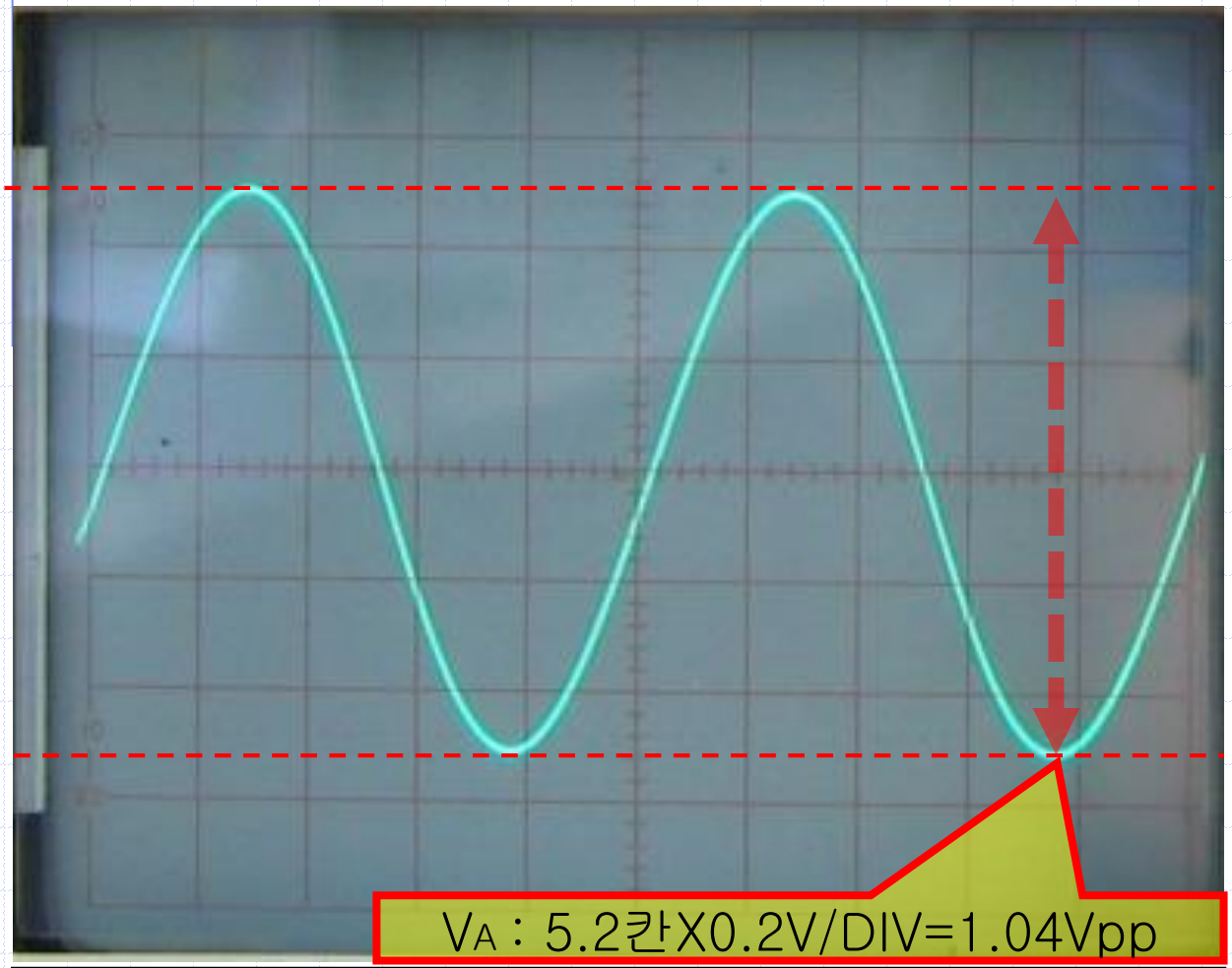
✓ 주파수 : 15kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{1.44V_{PP}}{9.6mA_{PP}} = 150\Omega$$

15-6. 주파수에 따른 전류, 임피던스

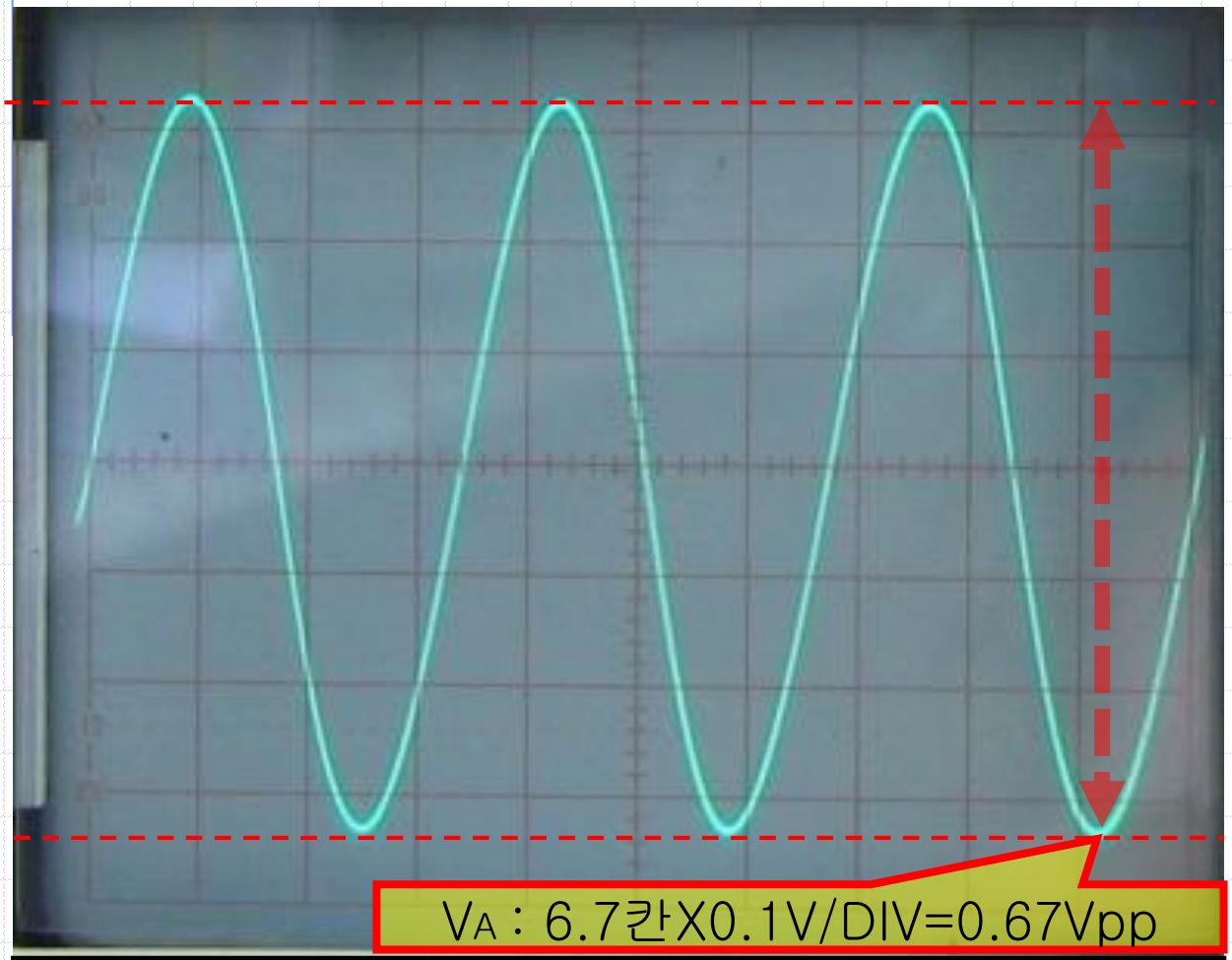
✓ 주파수 : 20kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{1.04V_{PP}}{9.8mA_{PP}} = 106.12\Omega$$

15-6. 주파수에 따른 전류, 임피던스

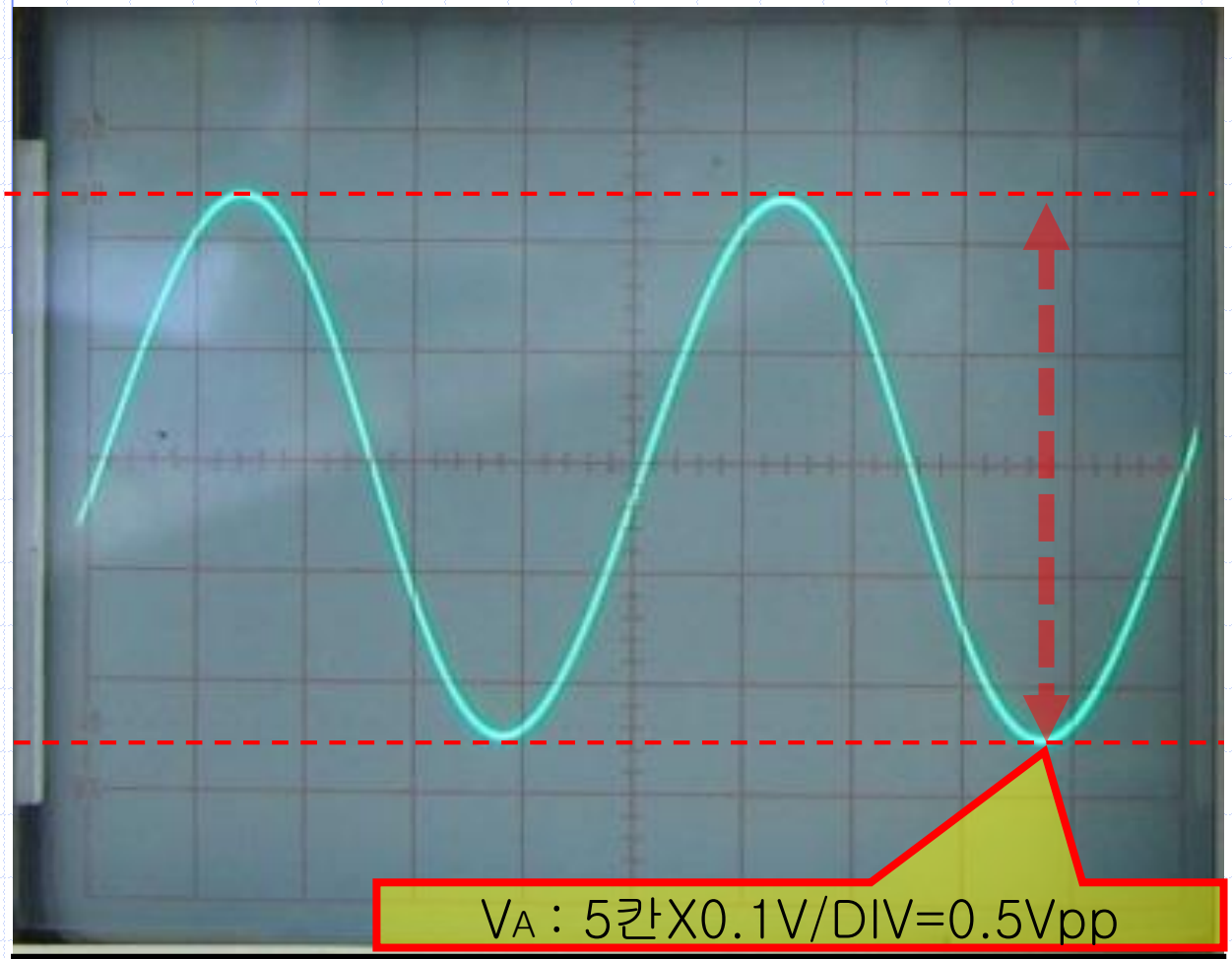
✓ 주파수 : 30kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.67V_{PP}}{9.8mA_{PP}} = 68.37\Omega$$

15-6. 주파수에 따른 전류, 임피던스

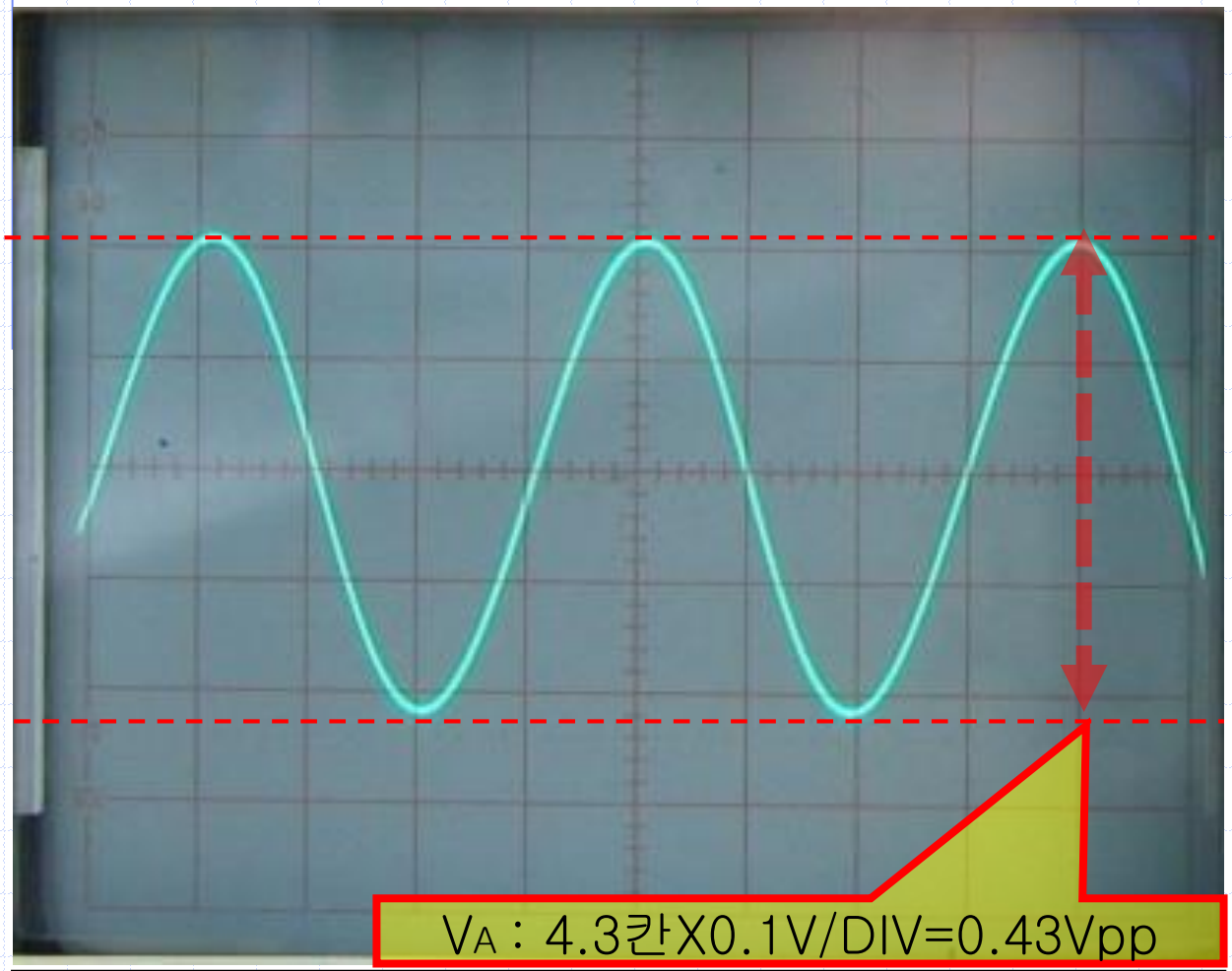
✓ 주파수 : 40kHz



$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.5V_{PP}}{9.8mA_{PP}} = 51.02\Omega$$

15-6. 주파수에 따른 전류, 임피던스

✓ 주파수 : 50kHz

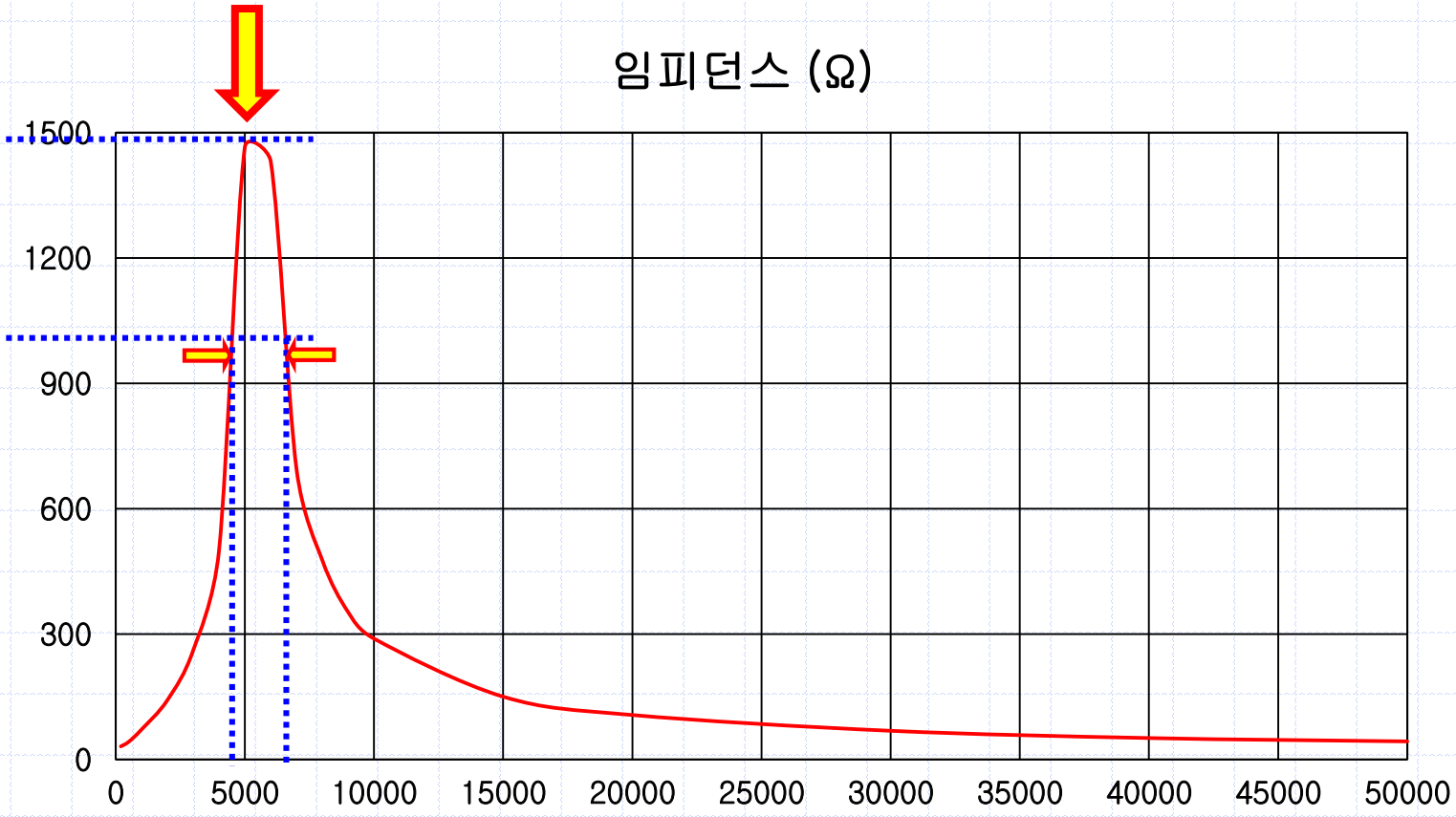


$$|Z| = \frac{V_{AB}}{I_T} = \frac{0.43V_{PP}}{10mA_{PP}} = 43\Omega$$

15-6. 주파수에 따른 전류, 임피던스

Frequency (Hz)	이 론			실 험		
	VA (Vpp)	전체 전류 IT (mApp)	임피던스 |Z| (Ω)	VA (Vpp)	전체 전류 IT (mApp)	임피던스 |Z| (Ω)
200	0.13	10	13.00	0.305	9.8	31.12
500	0.32	9.99	32.03	0.41	9.8	41.84
1,000	0.65	9.98	65.13	0.7	9.8	71.43
2,000	1.48	9.89	149.65	1.36	9.6	141.67
3,000	2.81	9.6	292.71	2.4	9.2	260.87
4,000	5.64	8.26	682.81	4	8	500.00
5,000	9.99	0.41	24365.85	6.3	4.3	1465.12
6,000	6.67	7.45	895.3	6.3	4.4	1431.82
7,000	4.26	9.05	470.72	5	7.2	694.44
8,000	3.13	9.5	329.47	4	8.4	476.19
9,000	2.49	9.68	257.23	3.1	8.8	352.27
10,000	2.08	9.78	212.68	2.6	9	288.89
15,000	1.19	9.93	119.84	1.44	9.6	150.00
20,000	0.85	9.96	85.34	1.04	9.8	106.12
30,000	0.55	9.99	55.06	0.67	9.8	68.37
40,000	0.4	9.99	40.04	0.5	9.8	51.02
50,000	0.32	9.99	32.03	0.43	10	43.00

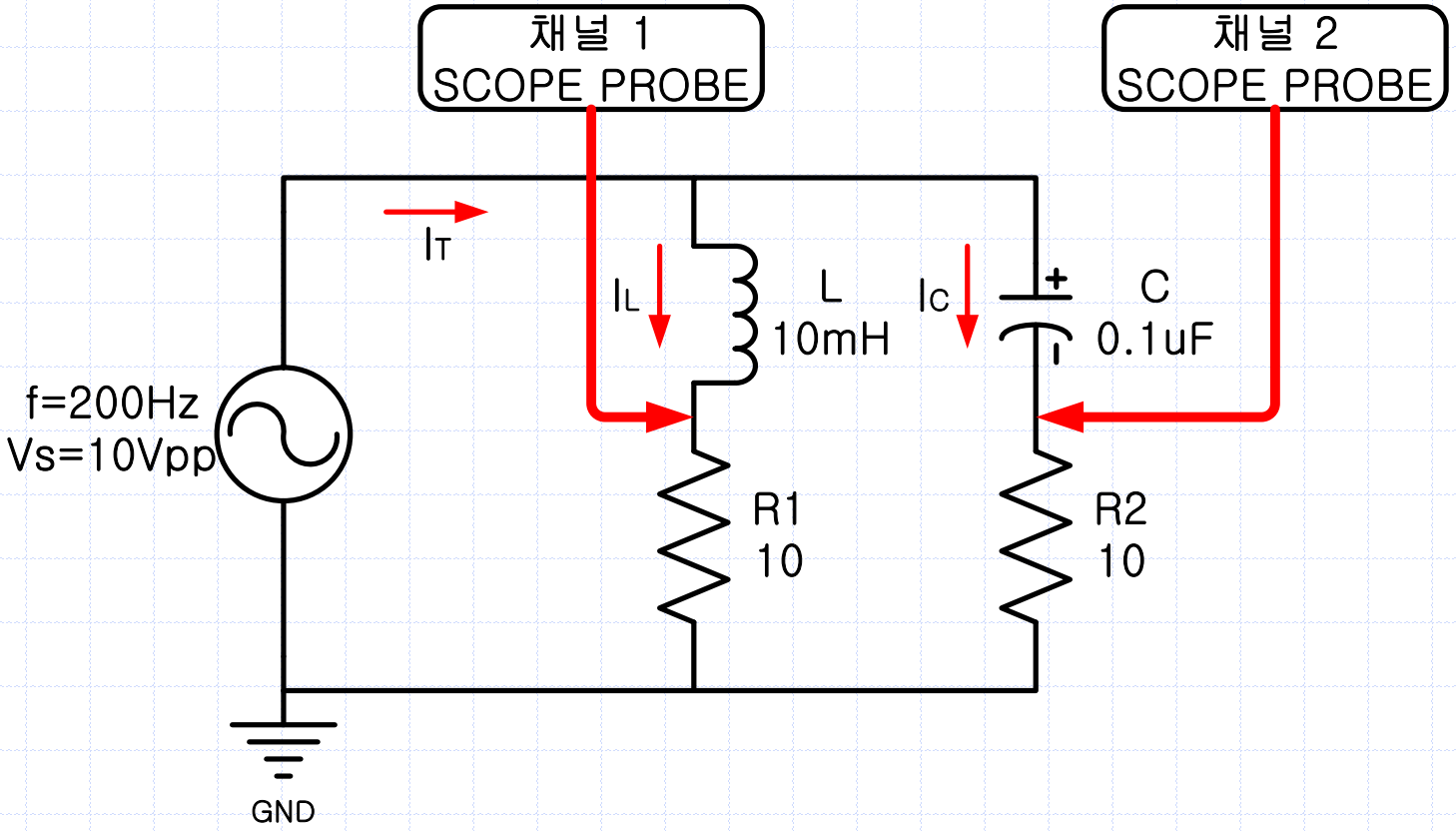
15-7. 대역폭 측정



$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10mH \times 0.1uF}} = 5032.9Hz$$

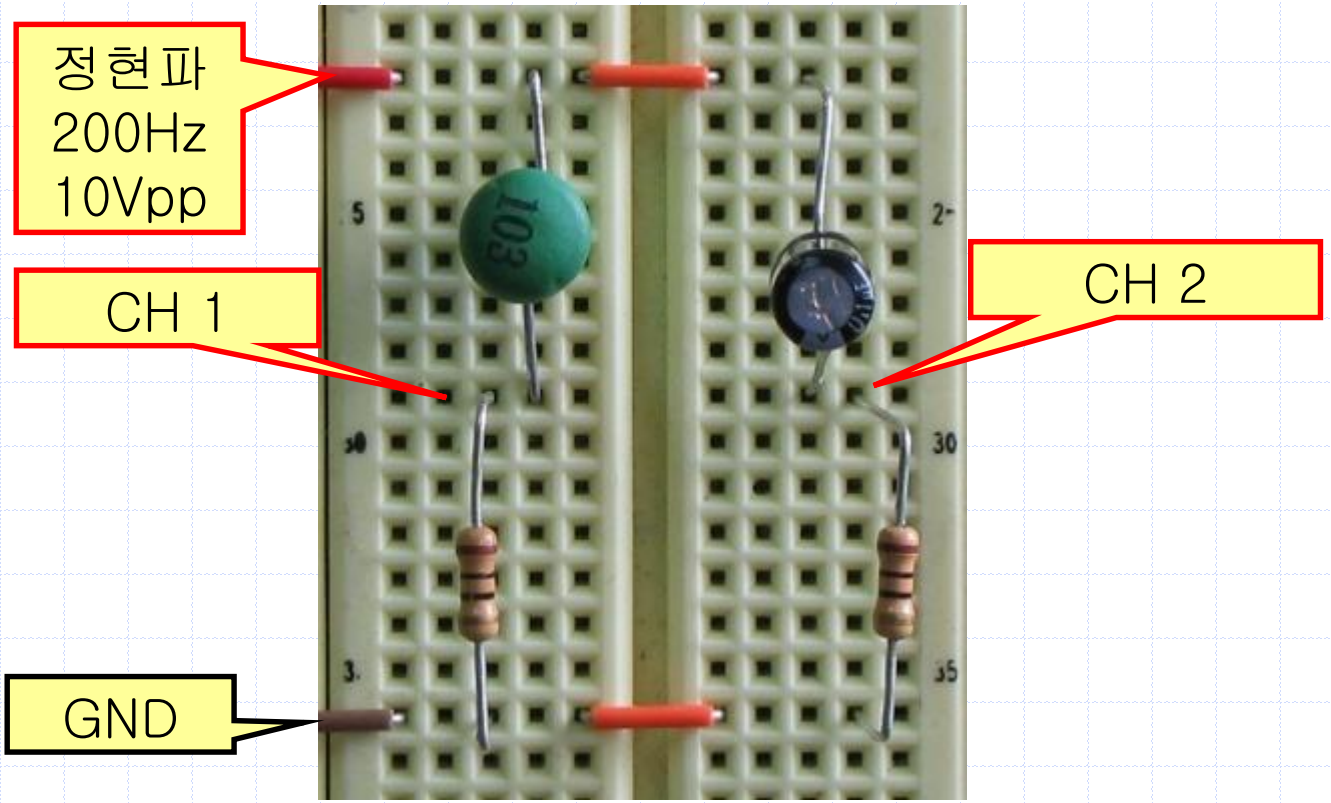
15-8. 주파수에 따른 위상 변화

- 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.

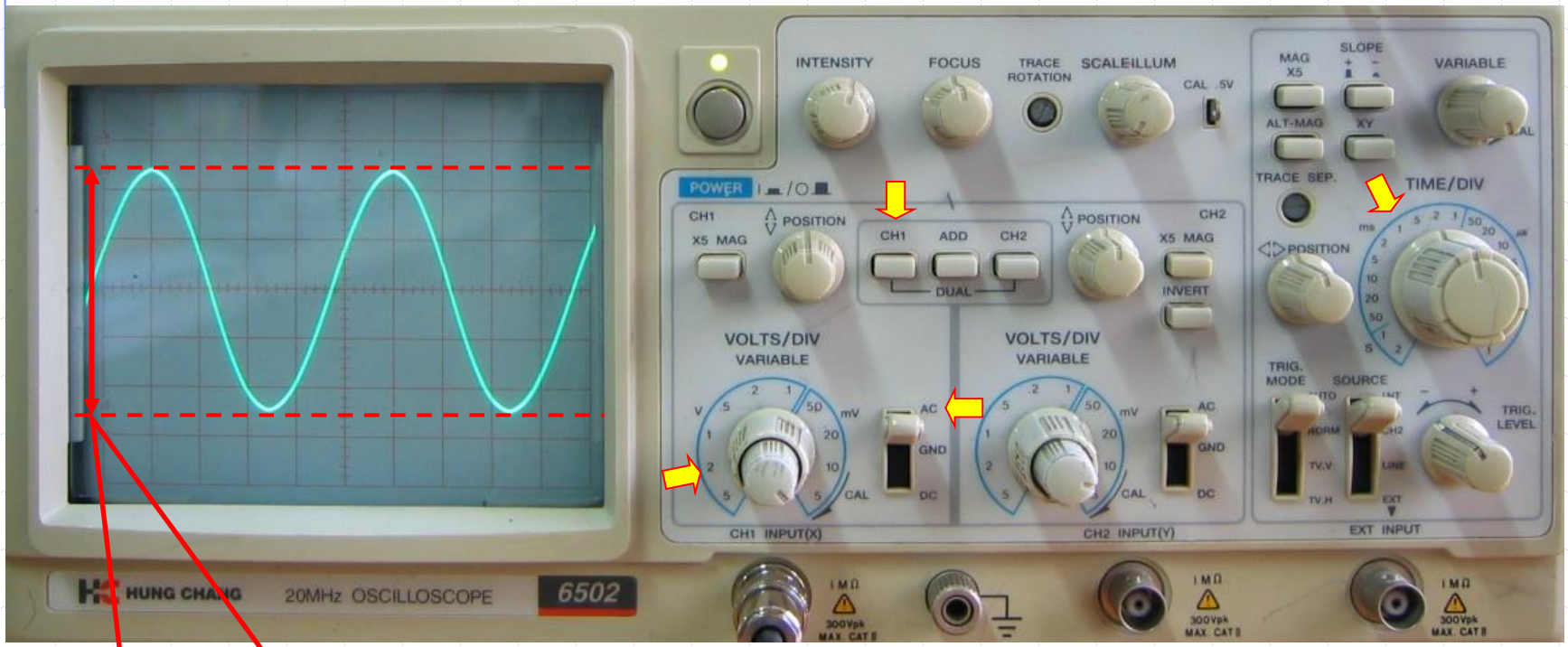


15-8. 주파수에 따른 위상 변화

- 다음과 같이 회로를 연결하고, 신호 발생기를 조절하여 주파수 200Hz, 10Vpp 의 정현파가 나오도록 한다.



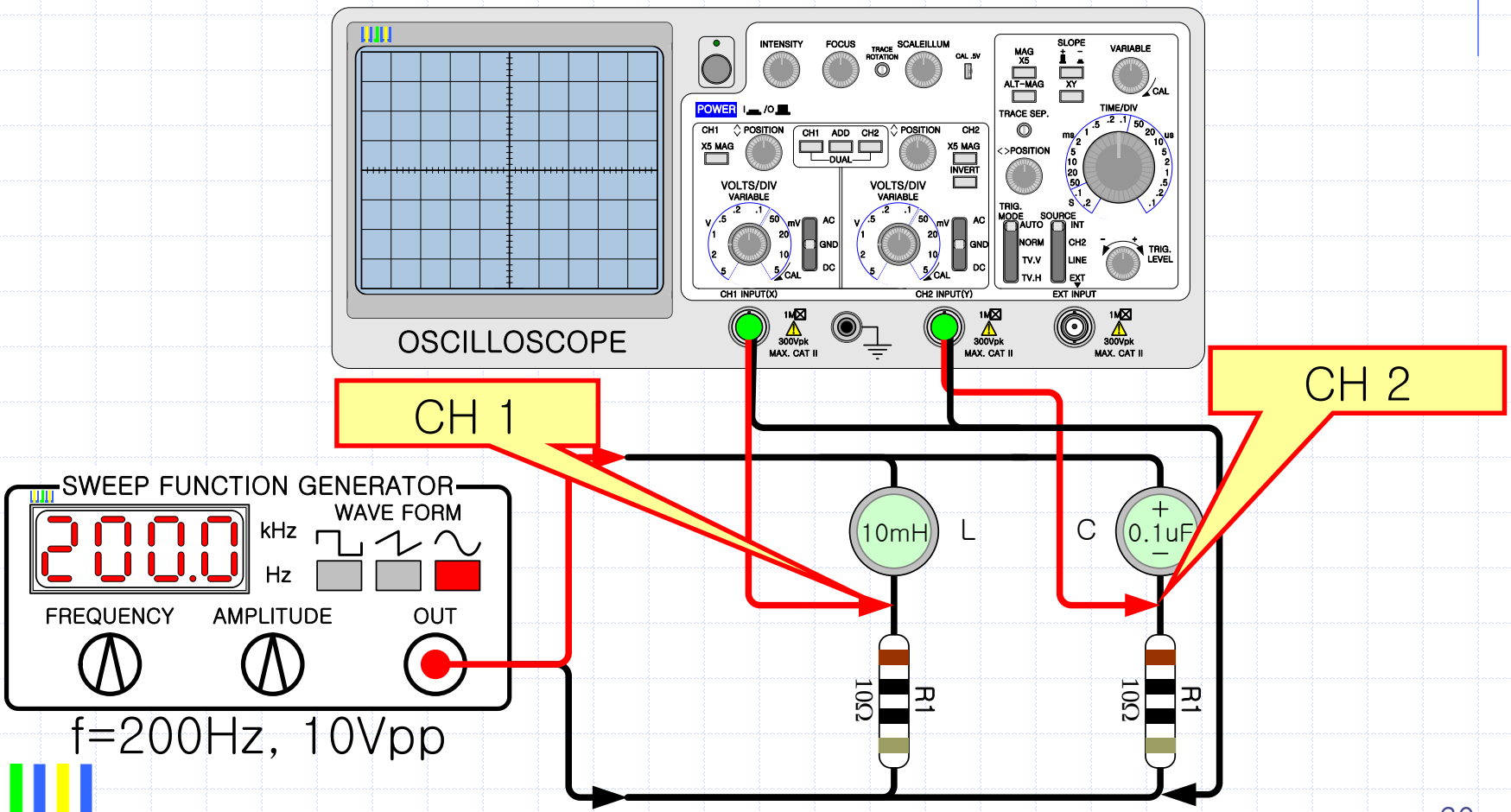
15-8. 주파수에 따른 위상 변화



5칸X2V/DIV=10Vpp

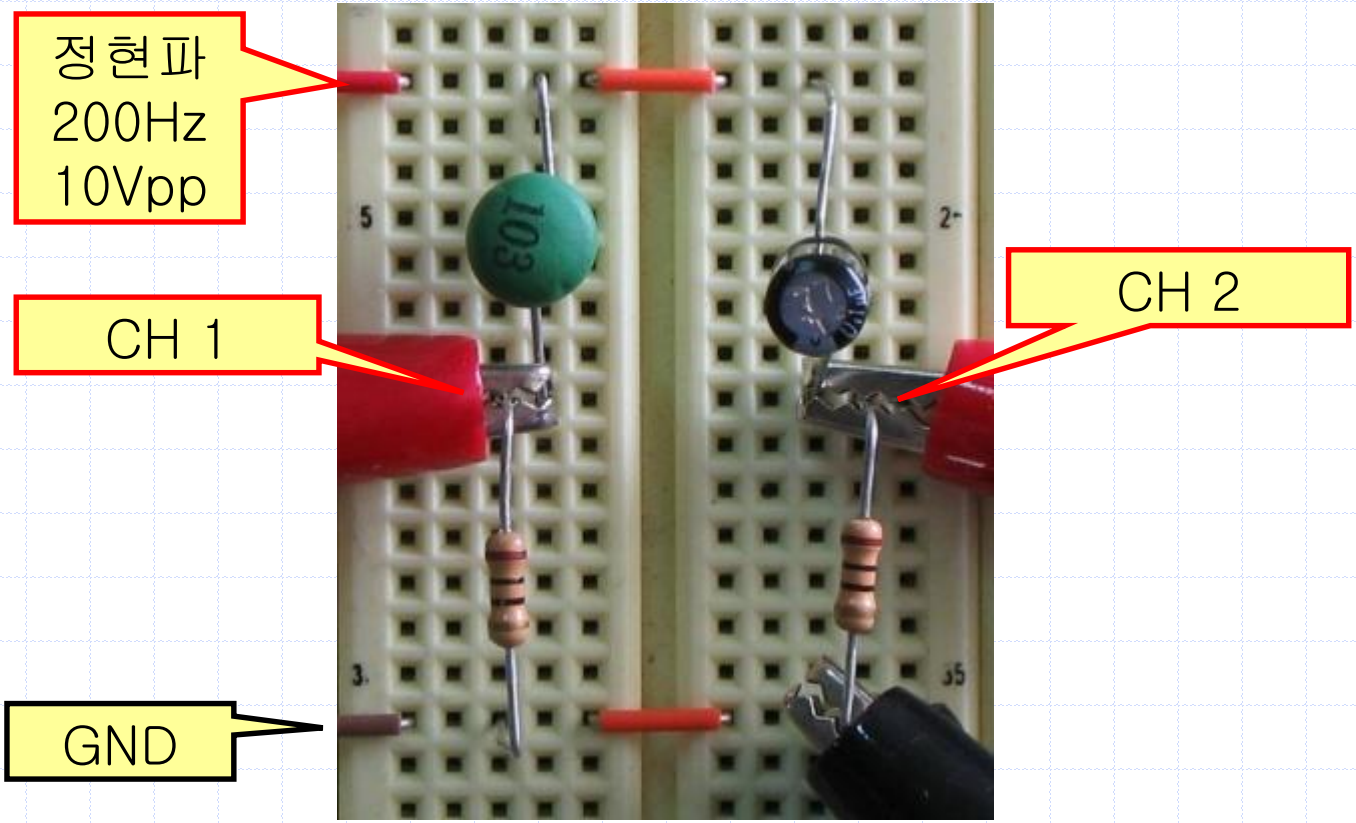
15-8. 주파수에 따른 위상 변화

- 오실로스코프의 CH 1 을 이용하여 입력 전압(Vin)을 측정하고, CH 2는 출력 전압(Vout)을 측정한다.

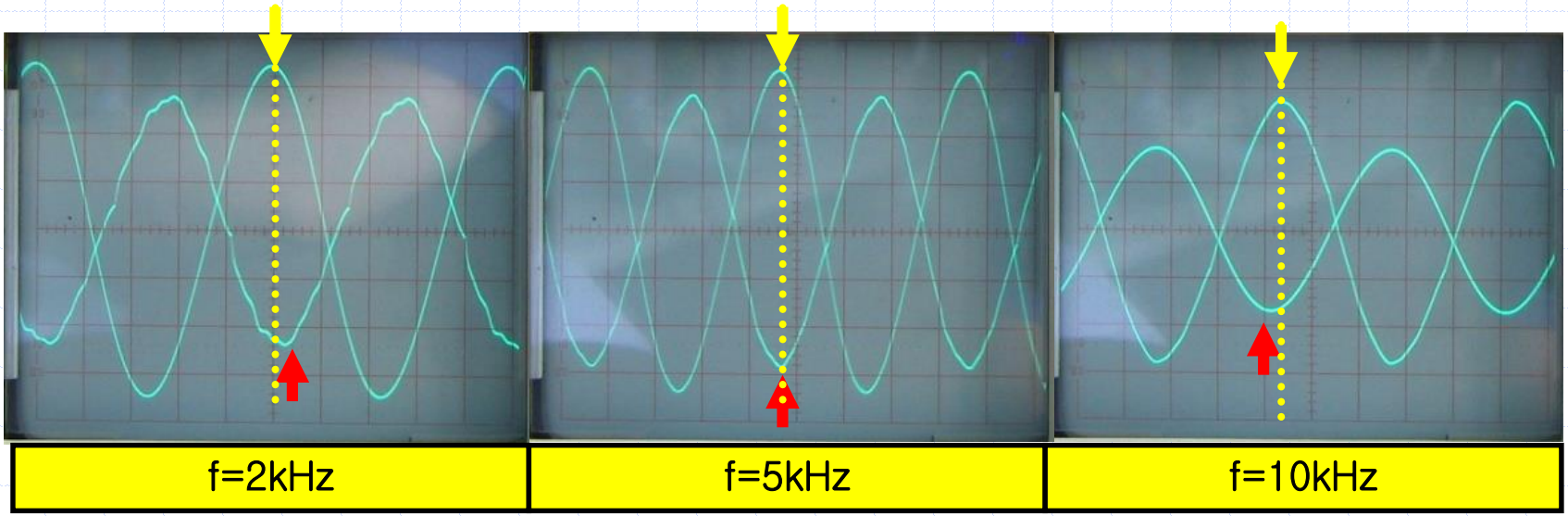


15-8. 주파수에 따른 위상 변화

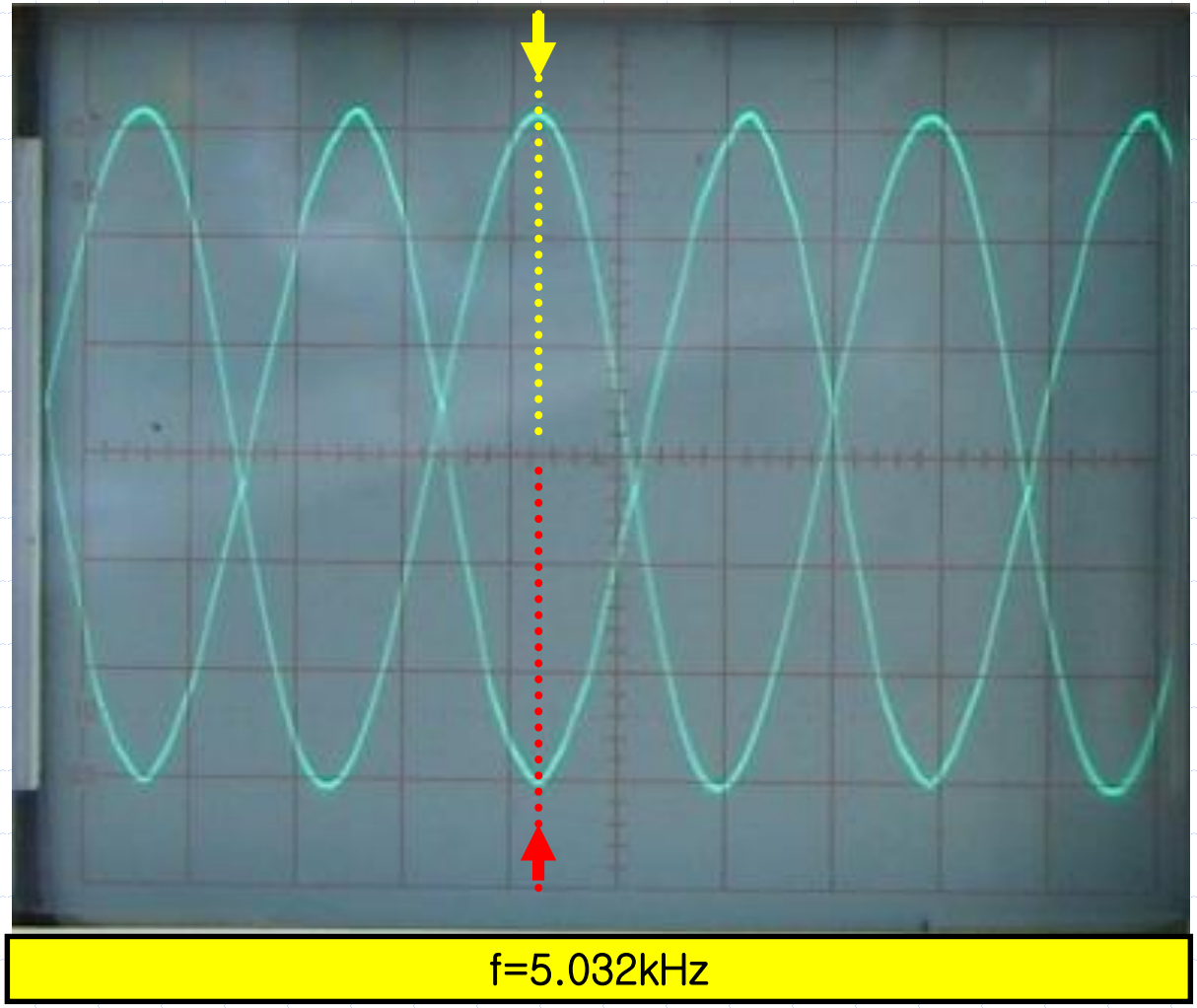
- ✓ 주파수 : 200Hz



15-8. 주파수에 따른 위상 변화

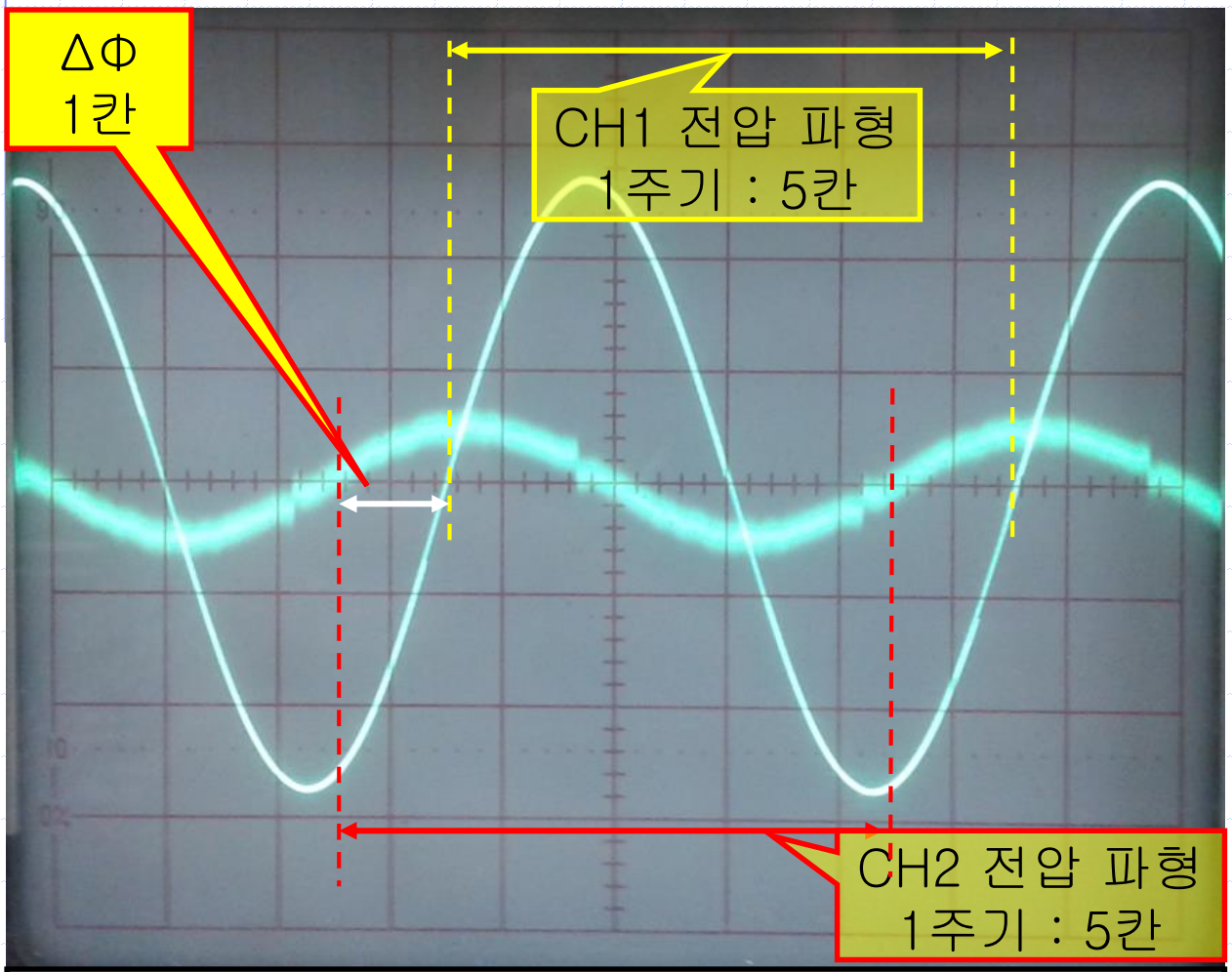


15-8. 주파수에 따른 위상 변화



15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 200Hz)



$1T = 5칸 \times 1mSec$
$= 5mSec$

$\Delta t = 1칸 \times 1mSec$
$= 1mSec$

$5mSec : 1mSec$
$= 360° : \Delta\theta$

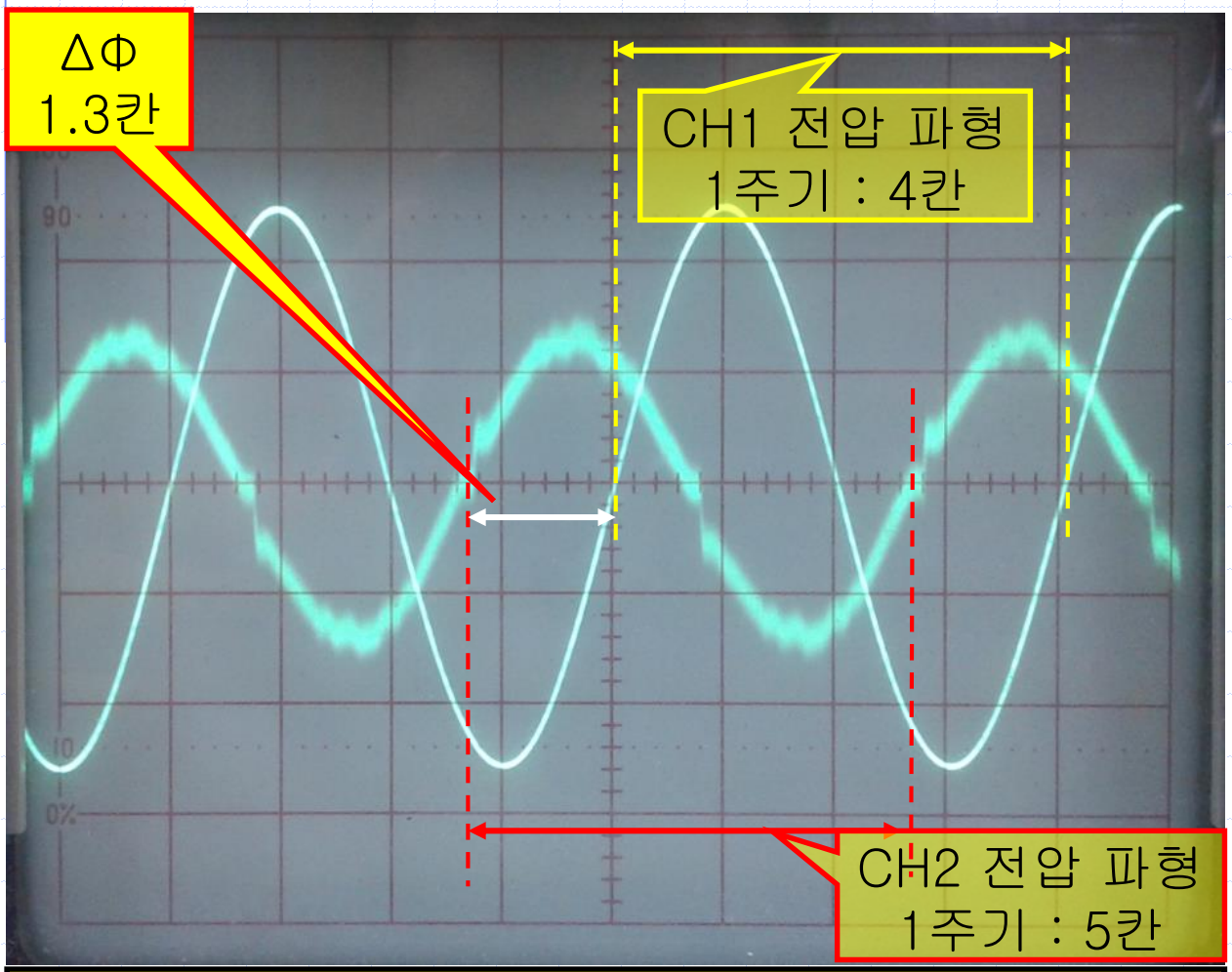
$\Delta\theta = 72°$

$V_{R1} = 1.12V_{pp}$

$V_{R2} = 6mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 500Hz)



CH 1 : 0.2V/DIV, CH 2 : 5mV/DIV, Time : 0.5mS/DIV

$1T = 4칸 \times 0.5mSec$
$= 2mSec$

$\Delta t = 1.3칸 \times 0.5mSec$
$= 0.65mSec$

$2mSec : 0.65mSec$
$= 360° : \Delta\theta$

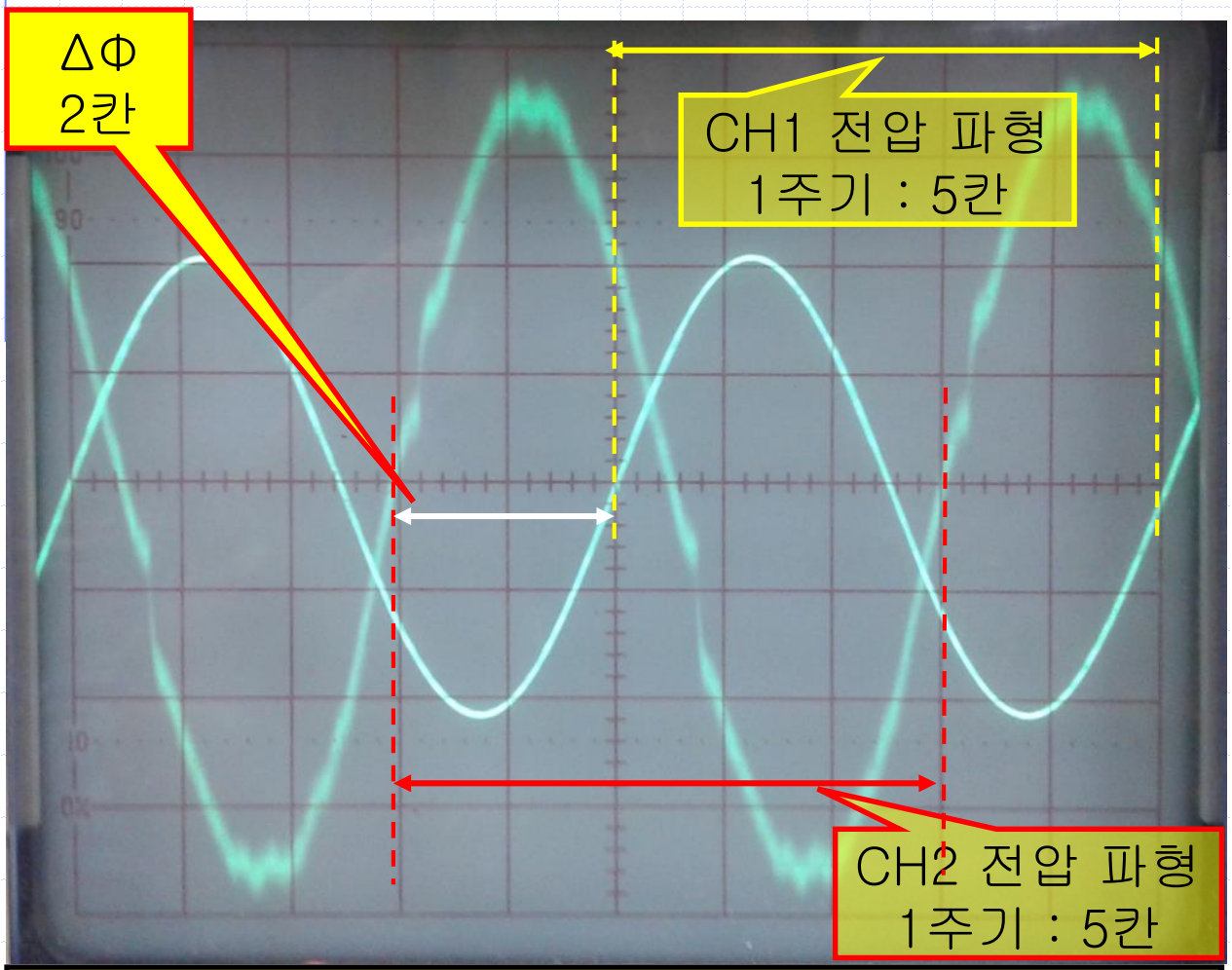
$\Delta\theta = 117°$

$V_{R1} = 1.1V_{pp}$

$V_{R2} = 15mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 1kHz)



$1T = 5칸 \times 0.2mSec$
$= 1mSec$

$\Delta t = 2칸 \times 0.2mSec$
$= 0.4mSec$

$1mSec : 0.4mSec$
$= 360° : \Delta\theta$

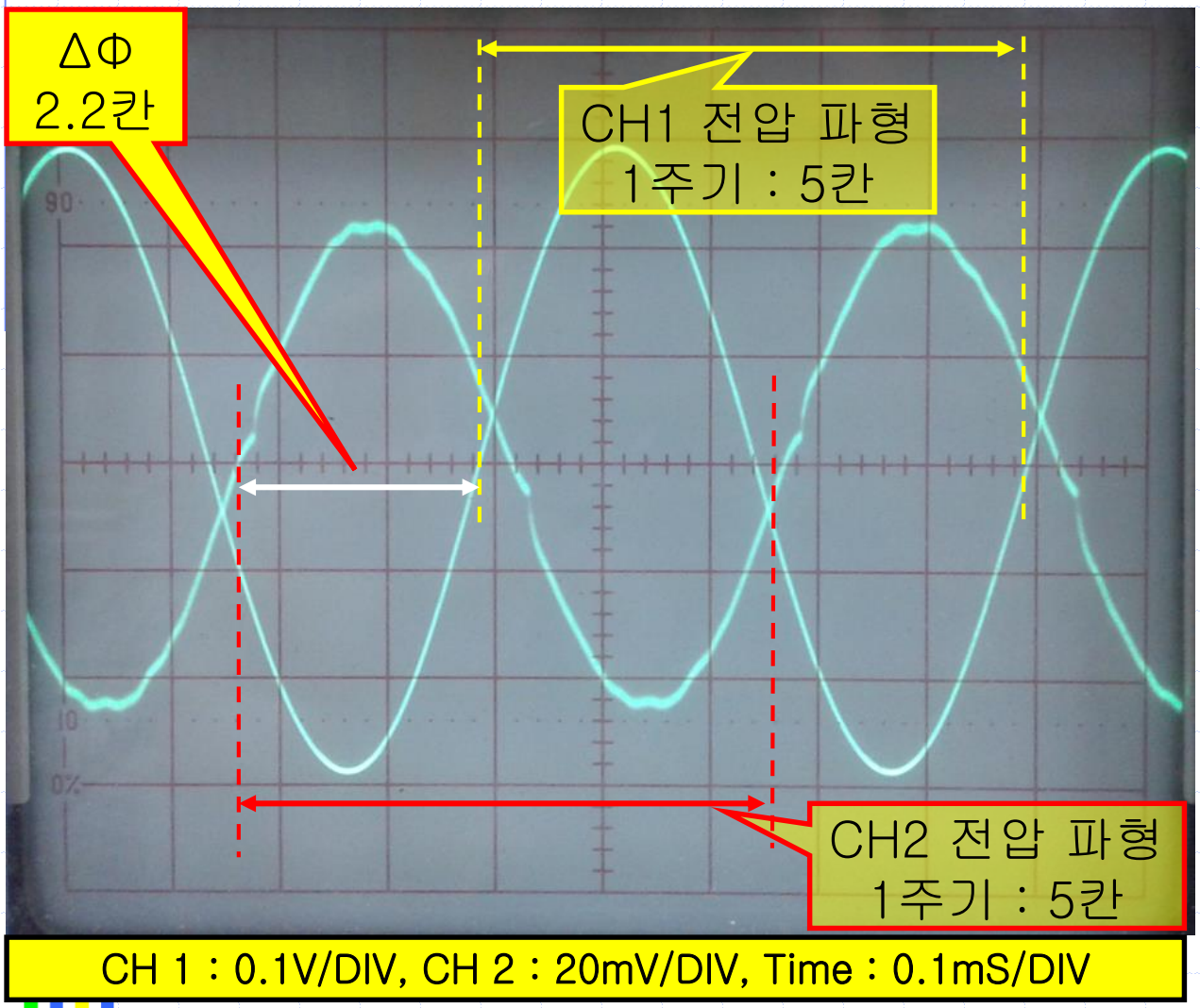
$\Delta\theta = 144°$

$V_{R1} = 0.86V_{pp}$

$V_{R2} = 38mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 2kHz)



$1T = 5칸 \times 0.1mSec$
$= 0.5mSec$

$\Delta t = 2.2칸 \times 0.1mSec$
$= 0.22mSec$

$0.5mSec : 0.22mSec$
$= 360° : \Delta\theta$

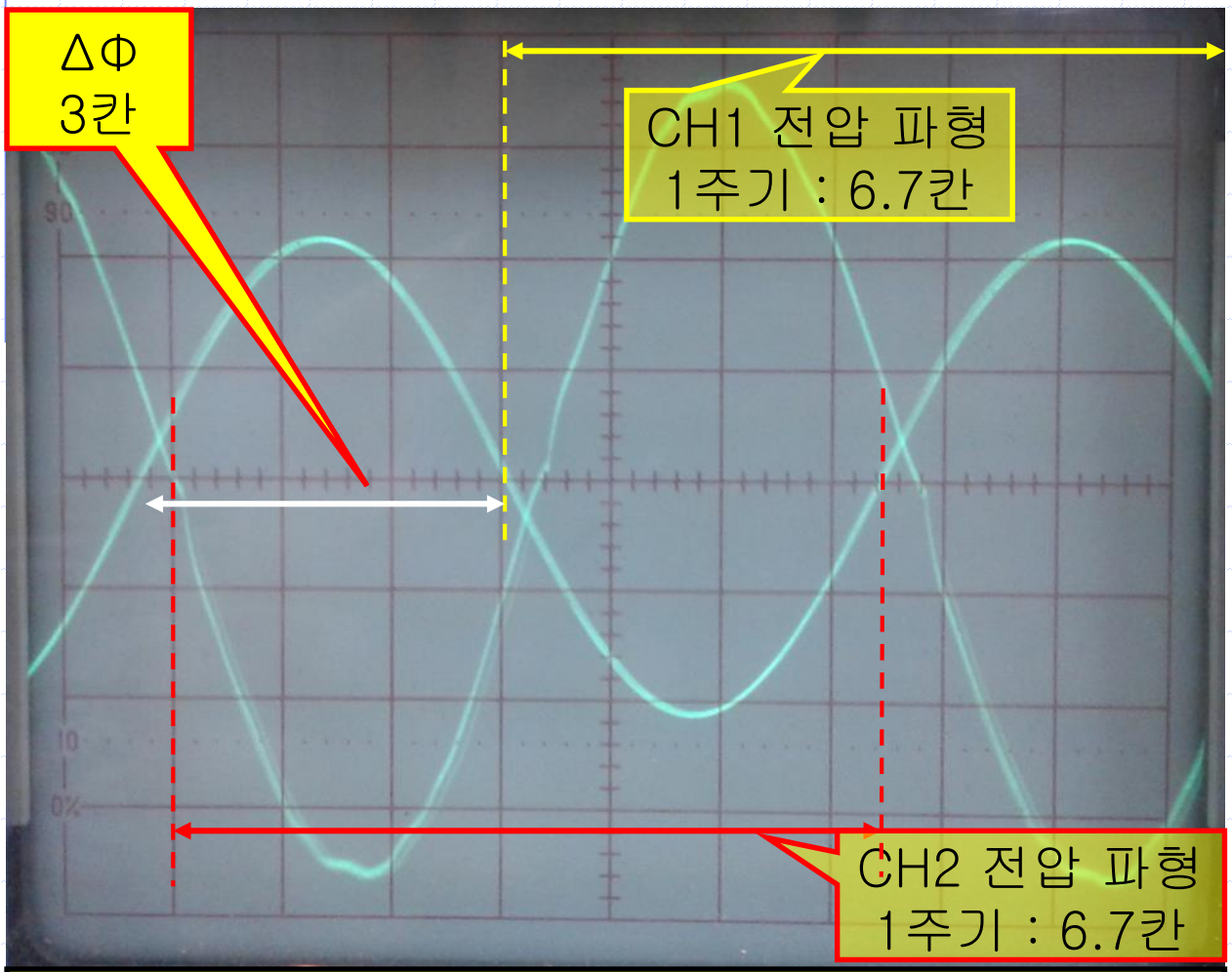
$\Delta\theta = 144°$

$V_{R1} = 0.6V_{pp}$

$V_{R2} = 88mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 3kHz)



$1T = 6.67칸 \times 50uSec$
$= 333.3uSec$

$\Delta t = 3칸 \times 50uSec$
$= 150uSec$

$333.3uSec : 150umSec$
$= 360° : \Delta\theta$

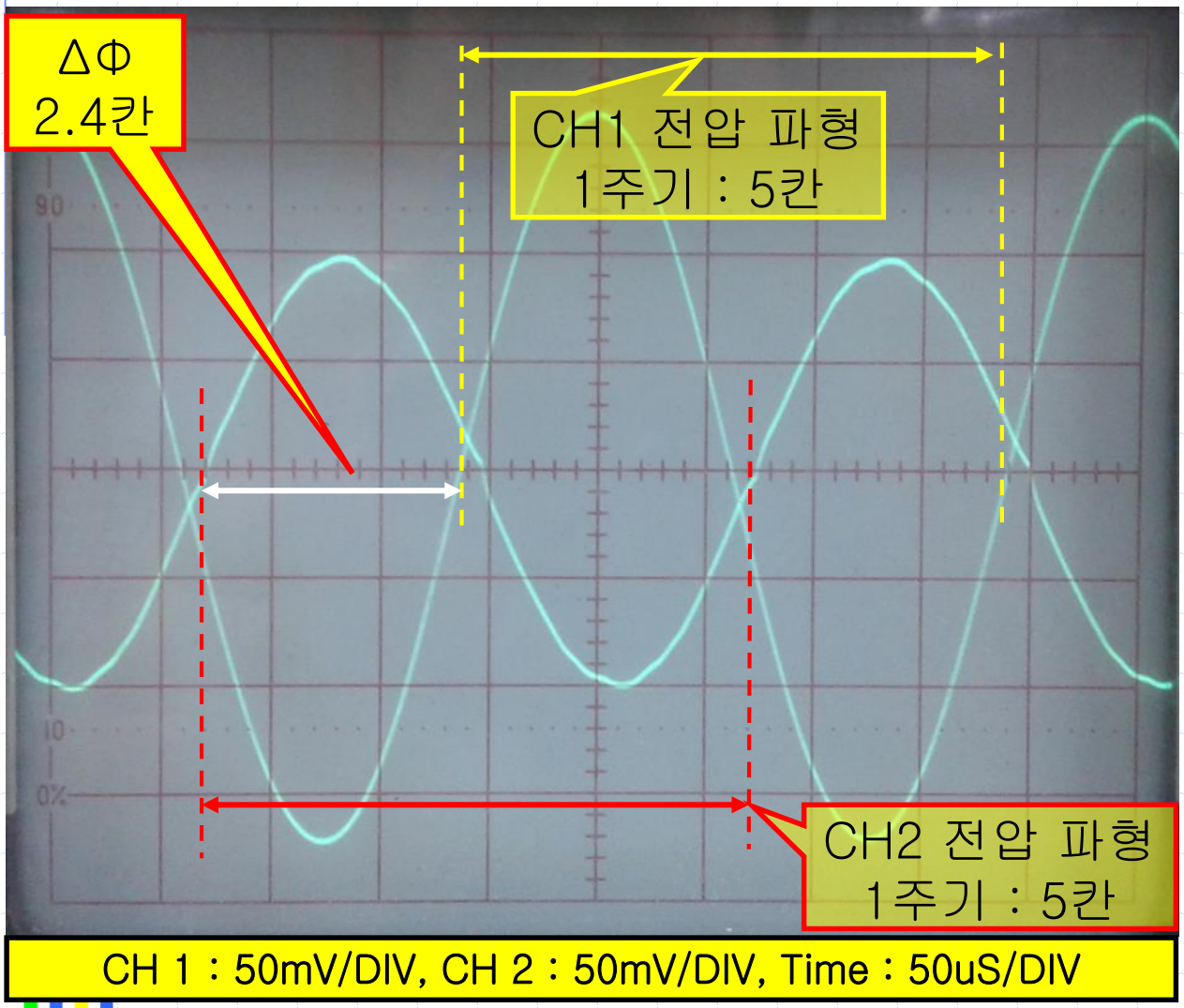
$\Delta\theta = 162°$

$V_{R1} = 0.44V_{pp}$

$V_{R2} = 150mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 4kHz)



$1T = 5칸 \times 50uSec$
$= 250uSec$

$\Delta t = 2.4칸 \times 50uSec$
$= 120uSec$

$250uSec : 120uSec$
$= 360° : \Delta\theta$

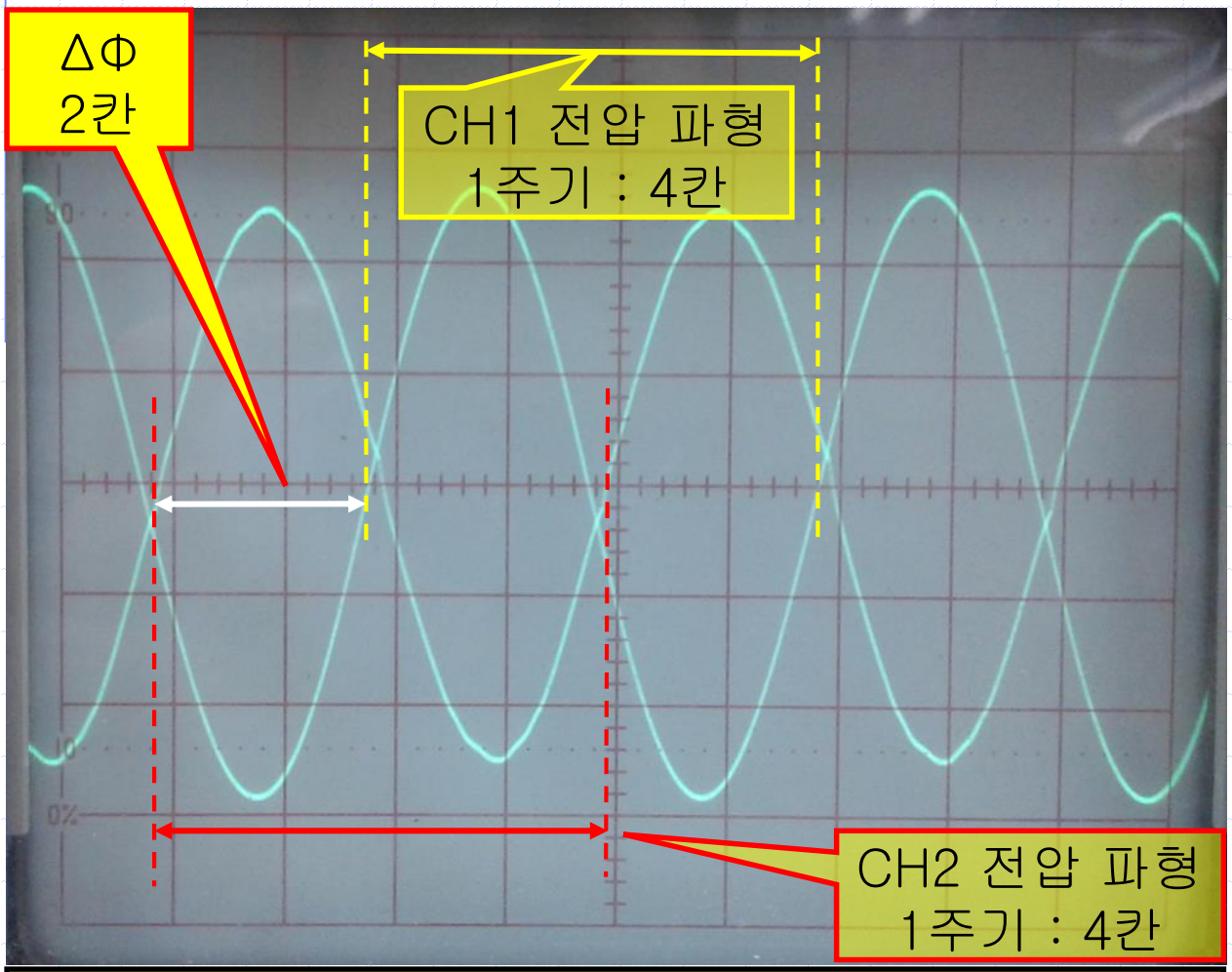
$\Delta\theta = 172.8°$

$V_{R1} = 350mV_{pp}$

$V_{R2} = 200mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 5kHz)



$1T = 4칸 \times 50uSec$
$= 200uSec$

$\Delta t = 2칸 \times 50uSec$
$= 100uSec$

$200uSec : 100uSec$
$= 360° : \Delta\theta$

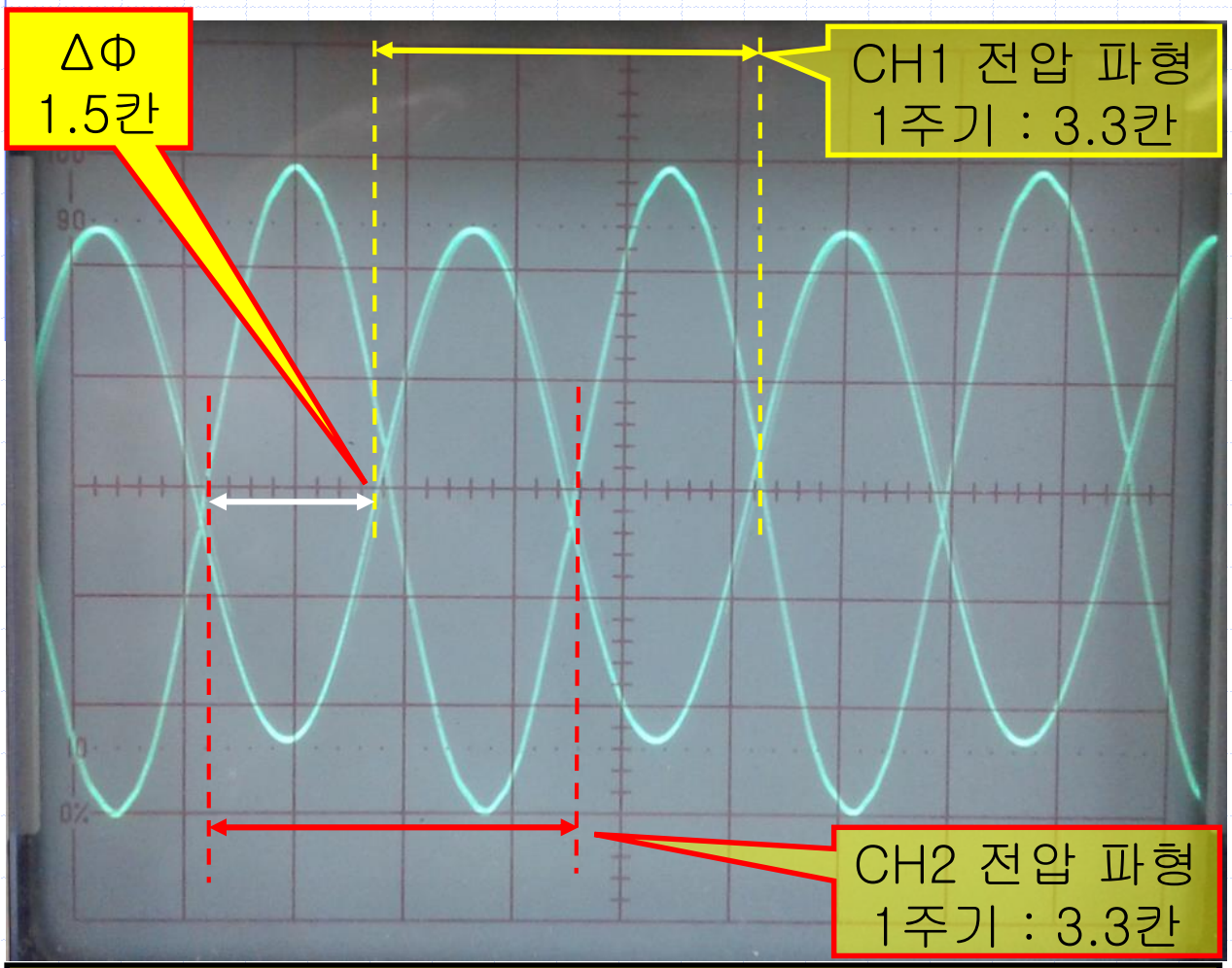
$\Delta\theta = 180°$

$V_{R1} = 290mV_{pp}$

$V_{R2} = 280mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 6kHz)



$1T = 3.3칸 \times 50uSec$
$= 165uSec$

$\Delta t = 1.5칸 \times 50uSec$
$= 75uSec$

$165uSec : 75uSec$
$= 360° : \Delta\theta$

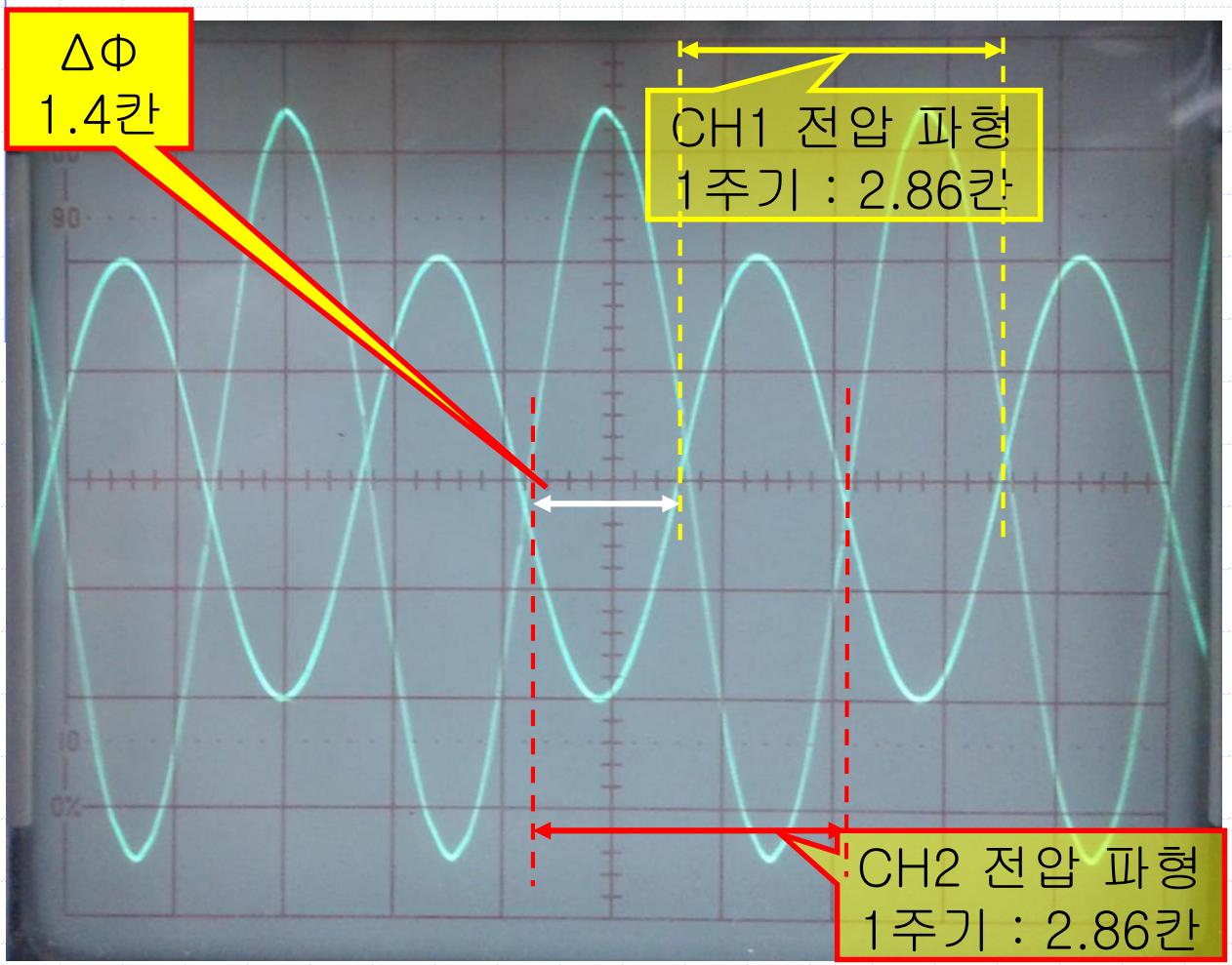
$\Delta\theta = 163.6°$

$V_{R1} = 240mV_{pp}$

$V_{R2} = 300mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 7kHz)



$1T = 2.86칸 \times 50uSec$
$= 143uSec$

$\Delta t = 1.4칸 \times 50uSec$
$= 70uSec$

$143uSec : 70uSec$
$= 360° : \Delta\theta$

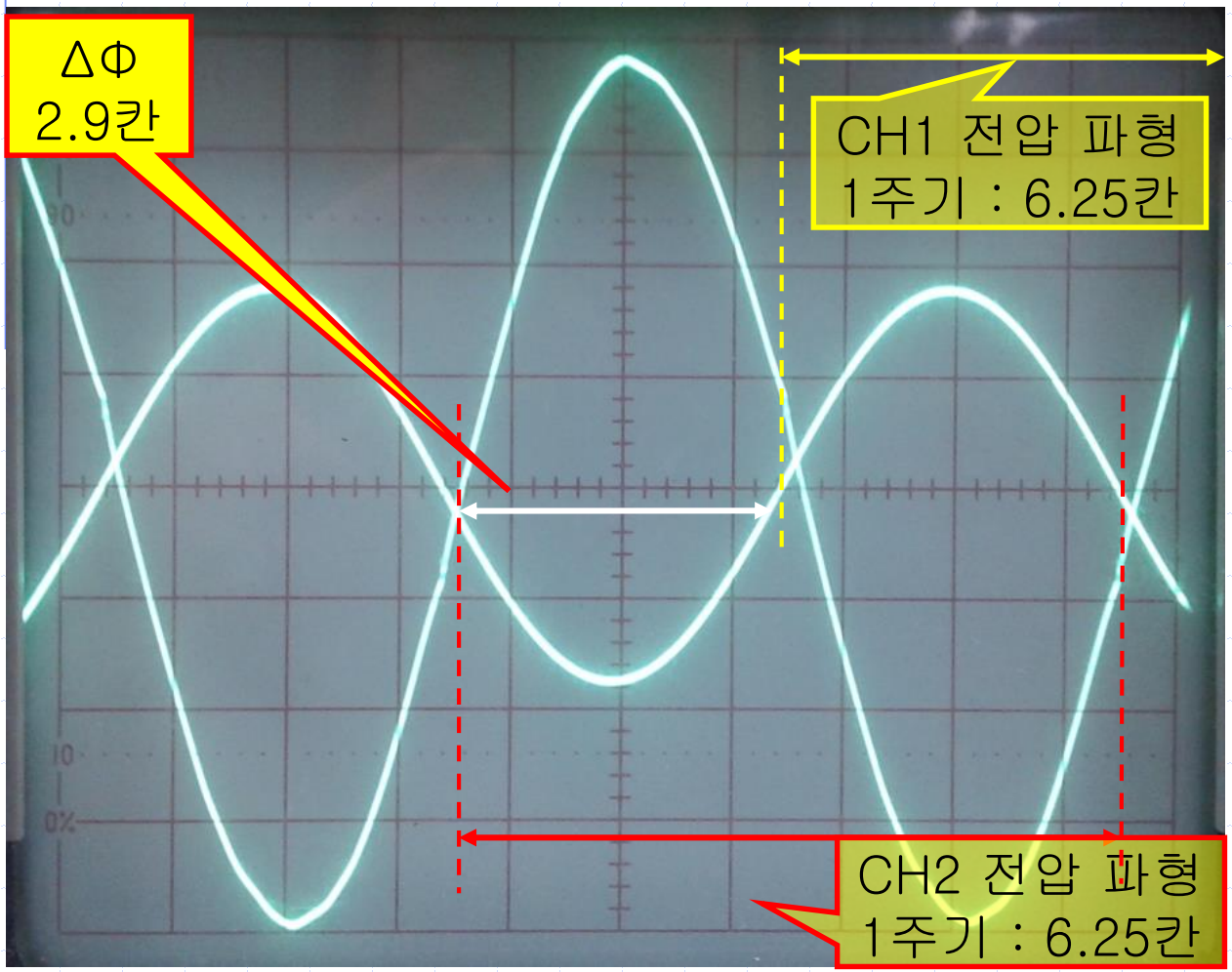
$\Delta\theta = 176.2°$

$V_{R1} = 205mV_{pp}$

$V_{R2} = 350mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 8kHz)



CH 1 : 50mV/DIV, CH 2 : 50mV/DIV, Time : 20uS/DIV

$1T = 6.25칸 \times 20uSec$
$= 125uSec$

$\Delta t = 2.9칸 \times 20uSec$
$= 58uSec$

$125uSec : 58uSec$
$= 360° : \Delta\theta$

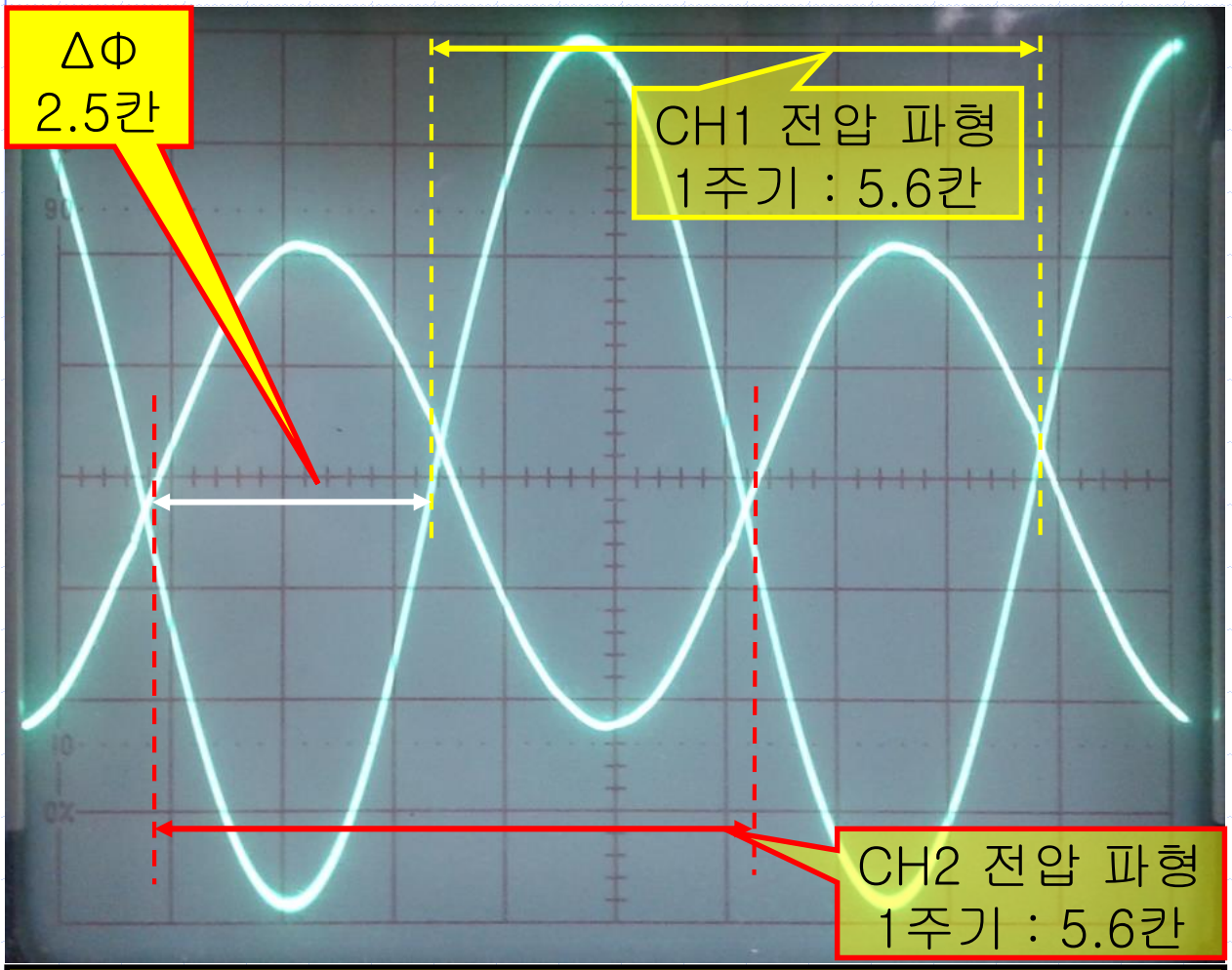
$\Delta\theta = 167°$

$V_{R1} = 180mV_{pp}$

$V_{R2} = 400mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 9kHz)



$1T = 5.6칸 \times 20uSec$
$= 112uSec$

$\Delta t = 2.5칸 \times 20uSec$
$= 50uSec$

$112uSec : 50uSec$
$= 360° : \Delta\theta$

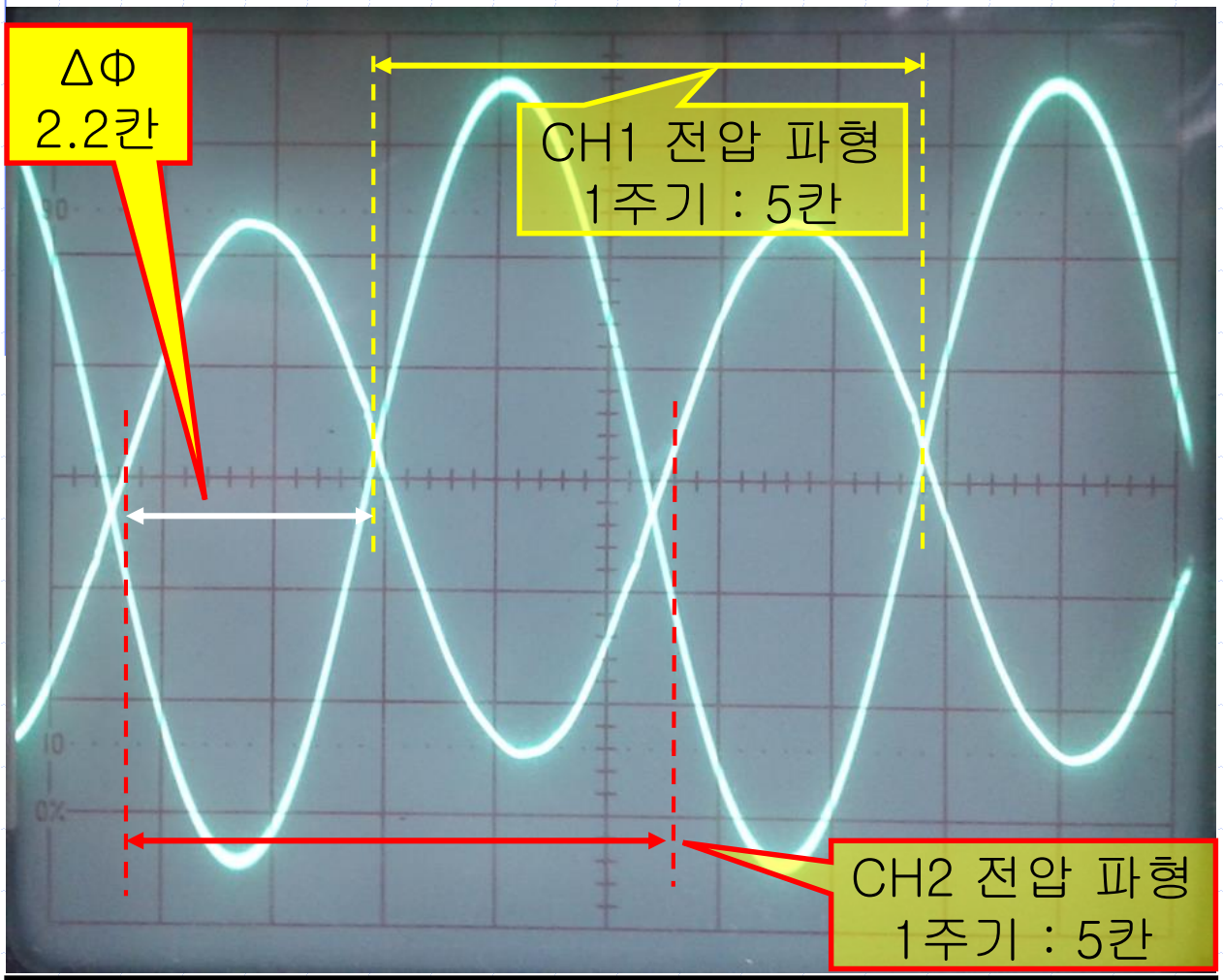
$\Delta\theta = 160.7°$

$V_{R1} = 160mV_{pp}$

$V_{R2} = 430mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 10kHz)



$1T = 5칸 \times 20uSec$
$= 100uSec$

$\Delta t = 2.2칸 \times 20uSec$
$= 44uSec$

$100uSec : 44uSec$
$= 360° : \Delta\theta$

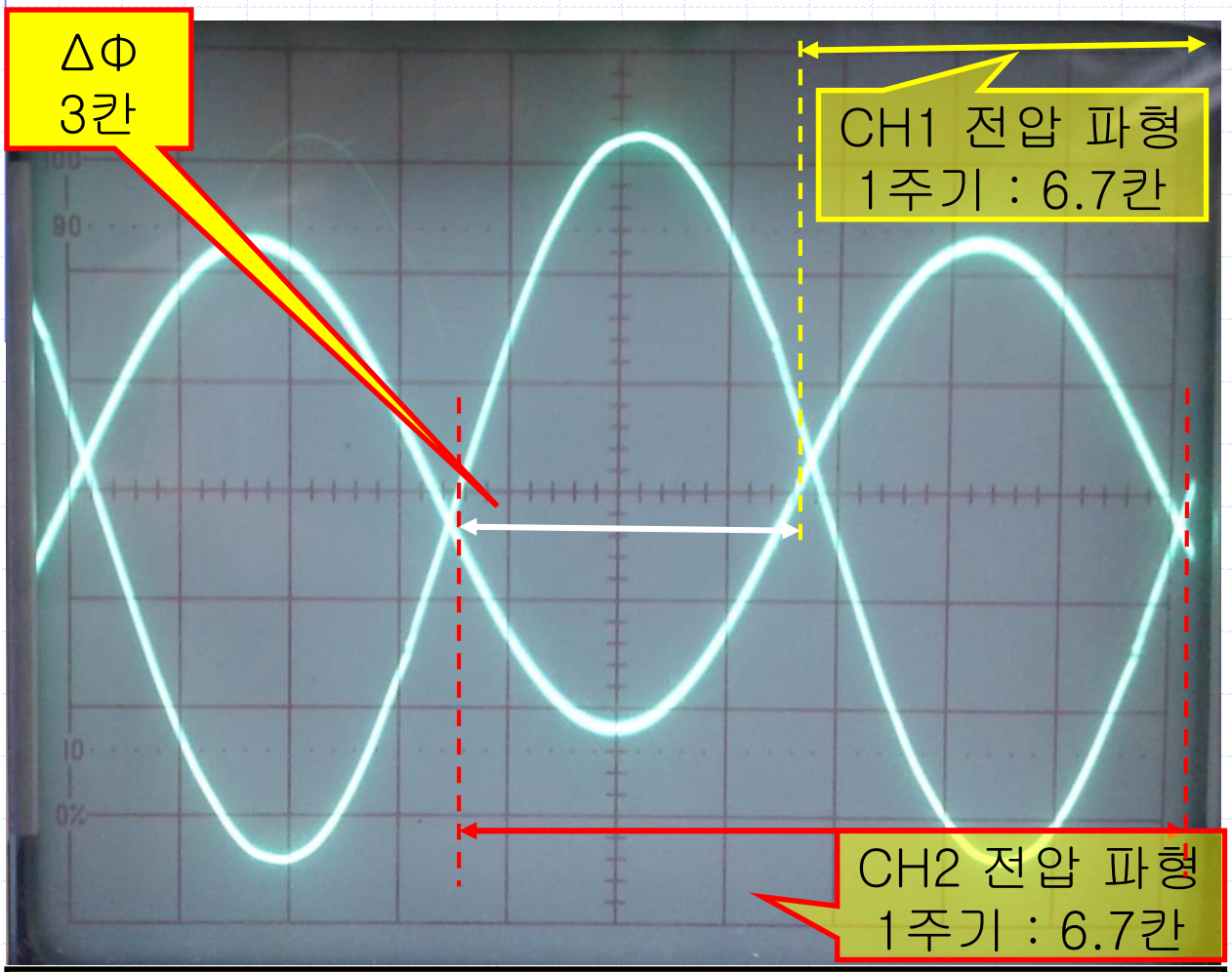
$\Delta\theta = 158.4°$

$V_{R1} = 140mV_{pp}$

$V_{R2} = 500mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 15kHz)



$1T = 6.7칸 \times 10uSec$
$= 67uSec$

$\Delta t = 3칸 \times 10uSec$
$= 30uSec$

$67uSec : 30uSec$
$= 360° : \Delta\theta$

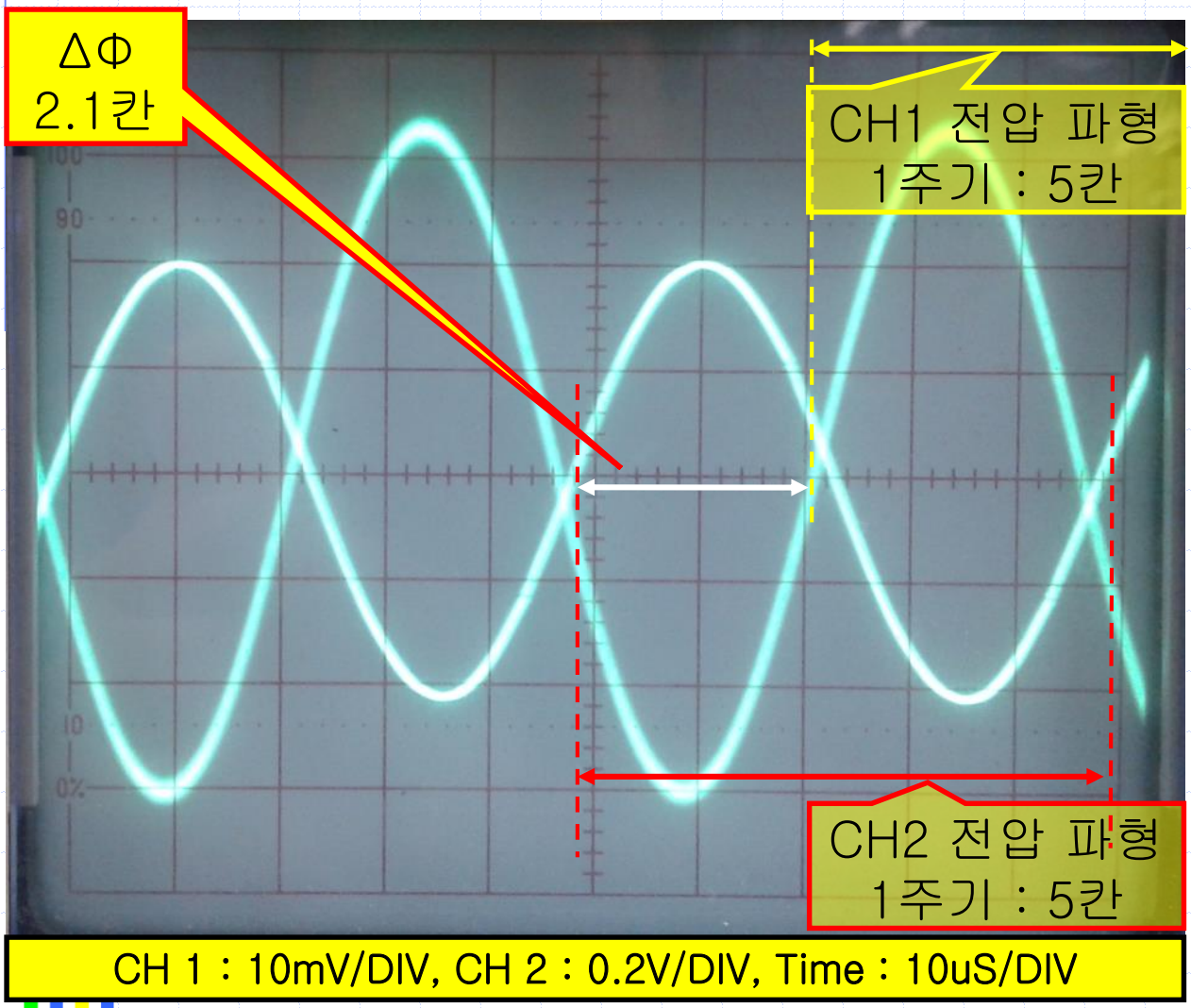
$\Delta\theta = 161.2°$

$V_{R1} = 90mV_{pp}$

$V_{R2} = 700mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 20kHz)



$1T = 5칸 \times 10uSec$
$= 50uSec$

$\Delta t = 2.1칸 \times 10uSec$
$= 21uSec$

$50uSec : 22uSec$
$= 360° : \Delta\theta$

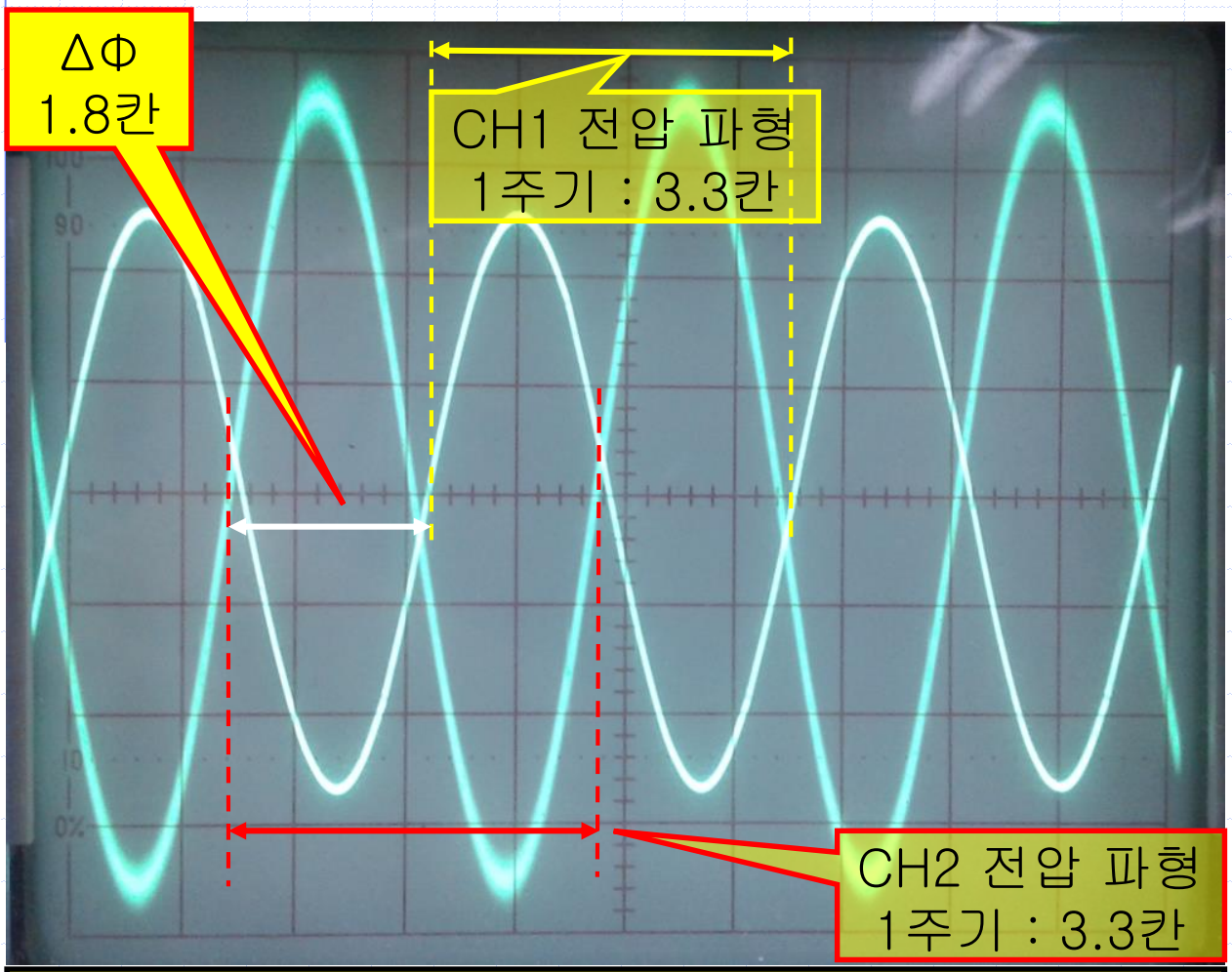
$\Delta\theta = 151.2°$

$V_{R1} = 65mV_{pp}$

$V_{R2} = 850mV_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 30kHz)



$1T = 3.3칸 \times 10uSec$
$= 33uSec$

$\Delta t = 1.8칸 \times 10uSec$
$= 18uSec$

$33uSec : 18uSec$
$= 360° : \Delta\theta$

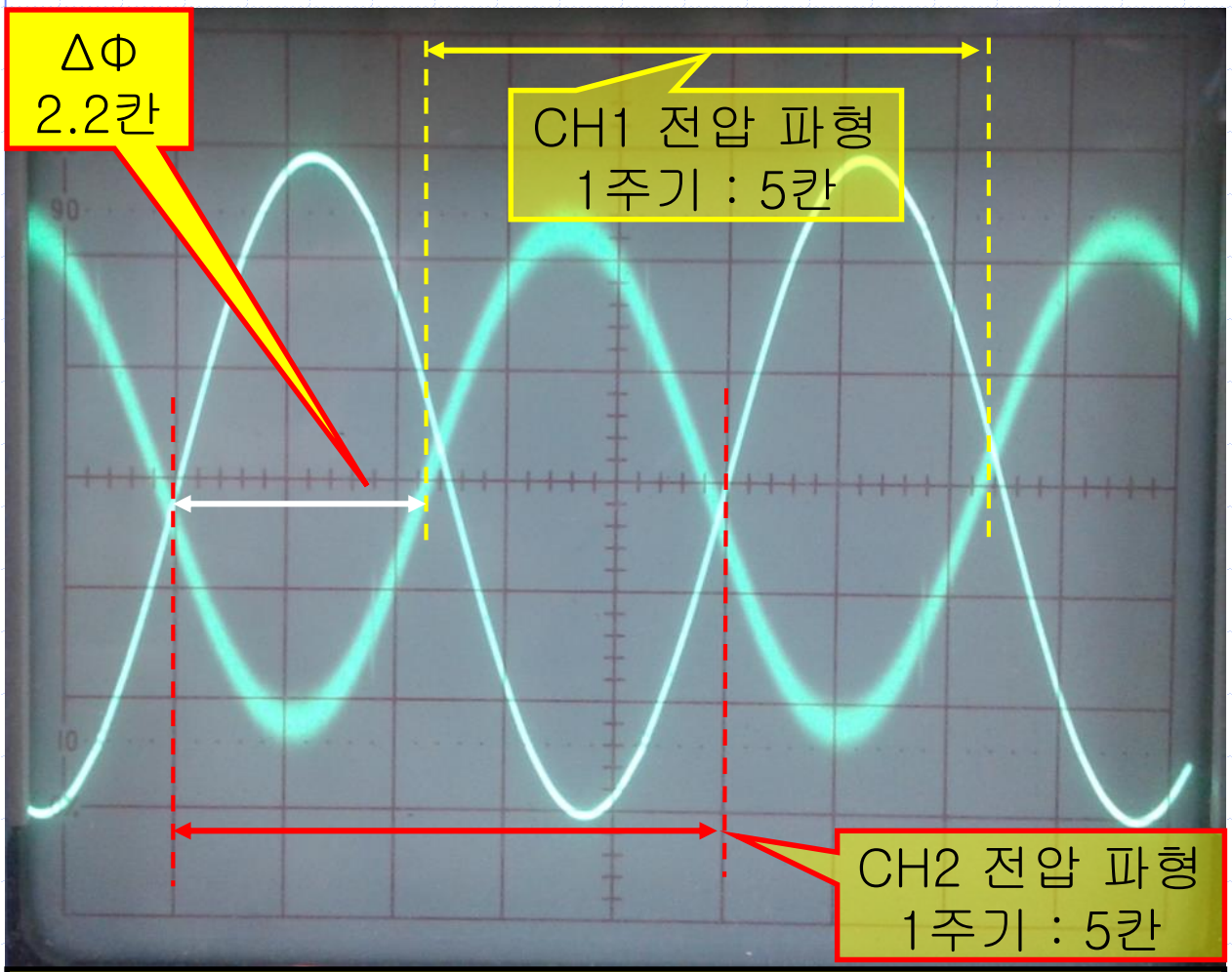
$\Delta\theta = 196.4°$

$V_{R1} = 38mV_{pp}$

$V_{R2} = 1.1V_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 40kHz)



$1T = 5칸 \times 5uSec$

$= 25uSec$

$\Delta t = 2.2칸 \times 5uSec$

$= 11uSec$

$25uSec : 11uSec$

$= 360° : \Delta\theta$

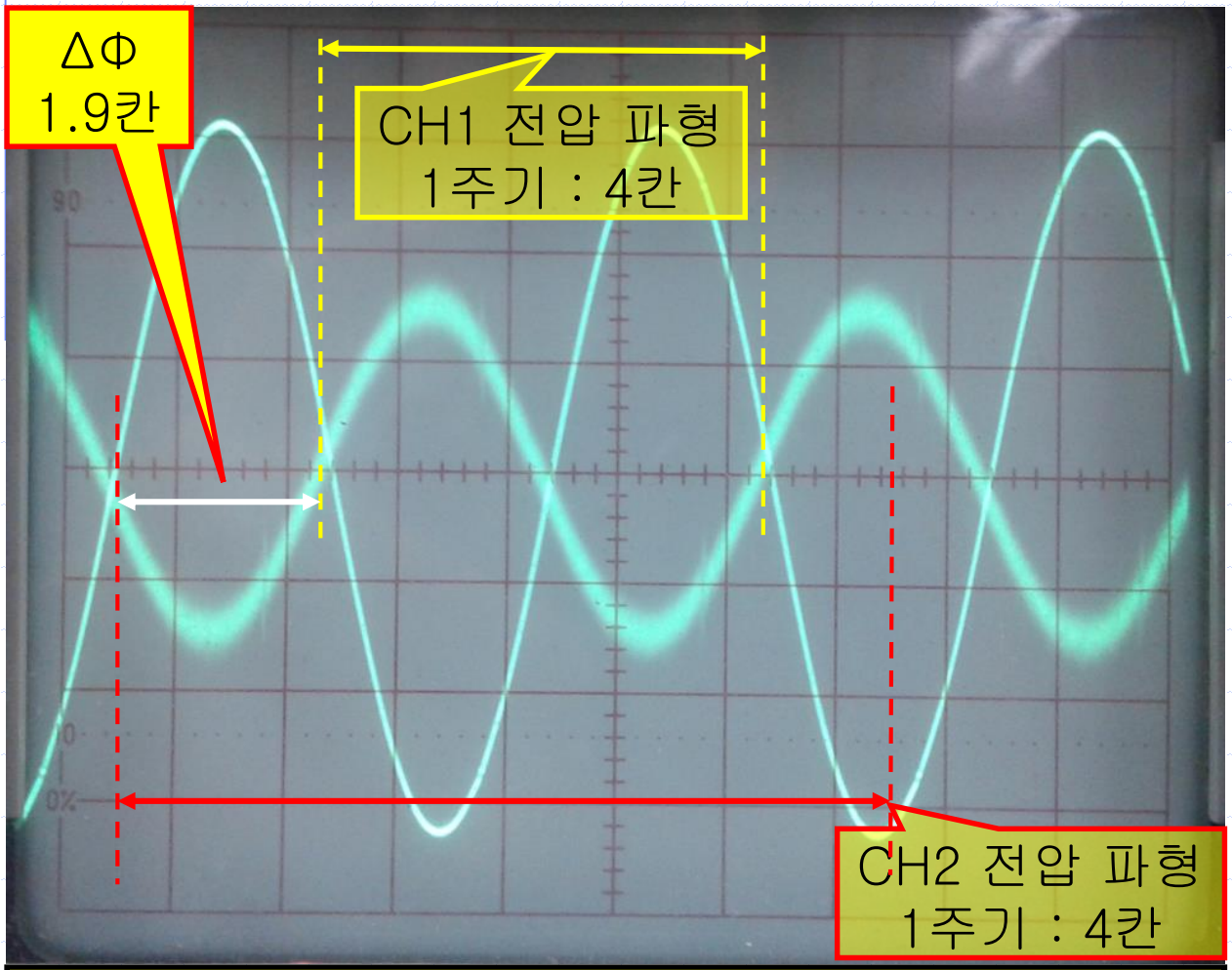
$\Delta\theta = 158.4°$

$V_{R1} = 25mV_{pp}$

$V_{R2} = 1.2V_{pp}$

15-8. 주파수에 따른 위상 변화

✓ 위상차 및 V_{R1} 과 V_{R2} 를 측정하라. (주파수 : 50kHz)



$1T = 4칸 \times 5uSec$
$= 20uSec$

$\Delta t = 1.9칸 \times 5uSec$
$= 9.5uSec$

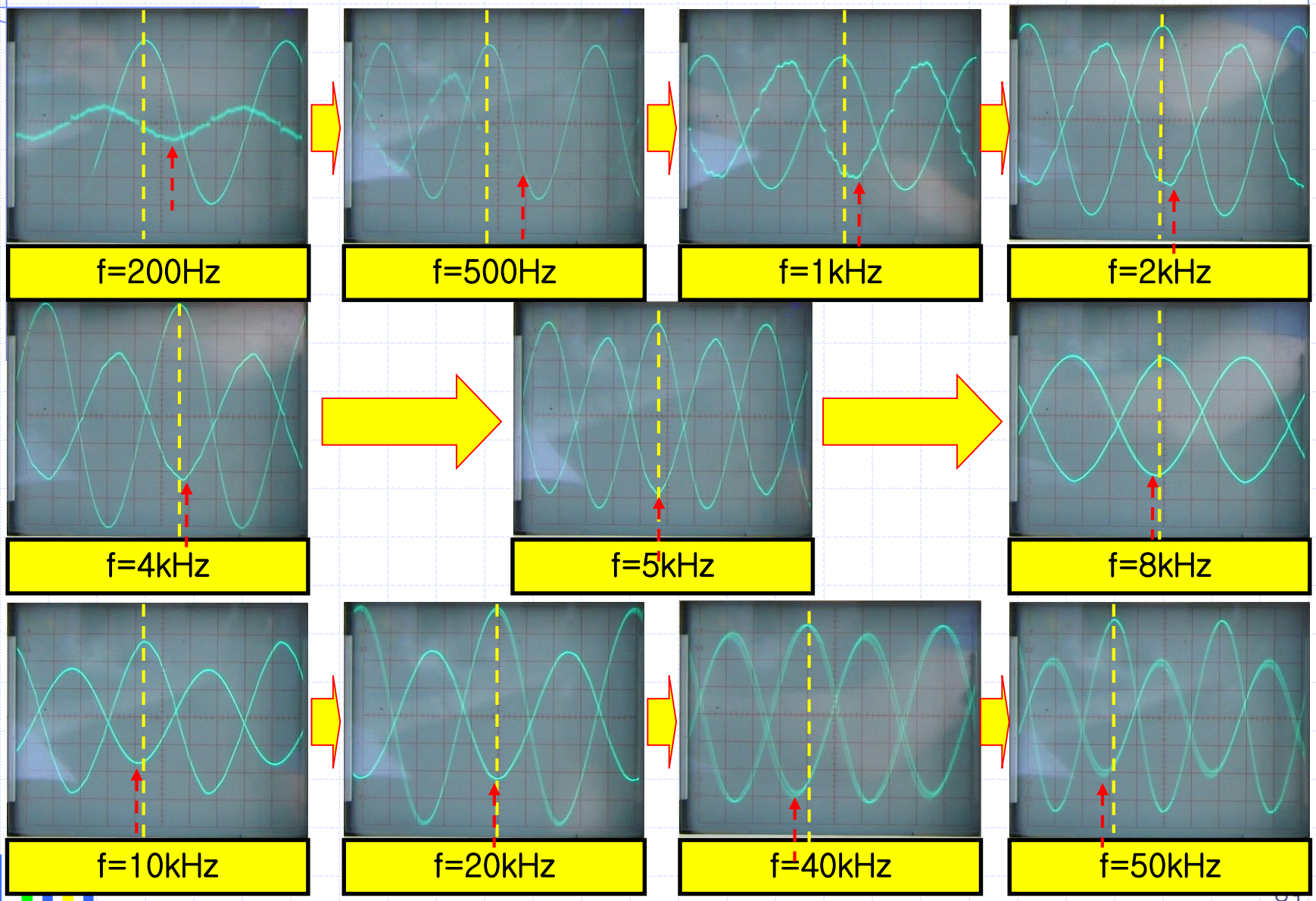
$20uSec : 9.5uSec$
$= 360° : \Delta\theta$

$\Delta\theta = 171°$

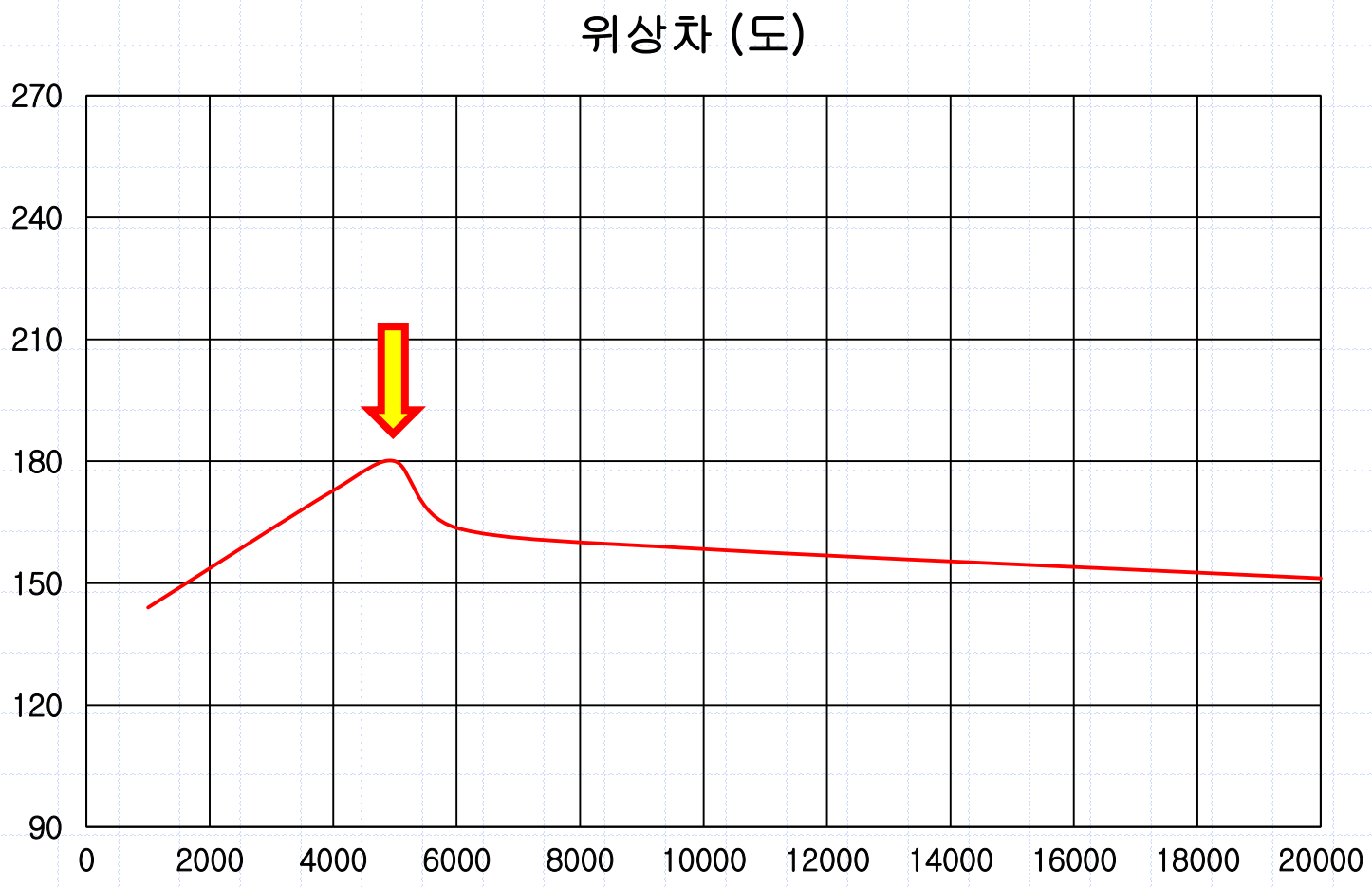
$V_{R1} = 15mV_{pp}$

$V_{R2} = 1.3V_{pp}$

15-8. 주파수에 따른 위상 변화



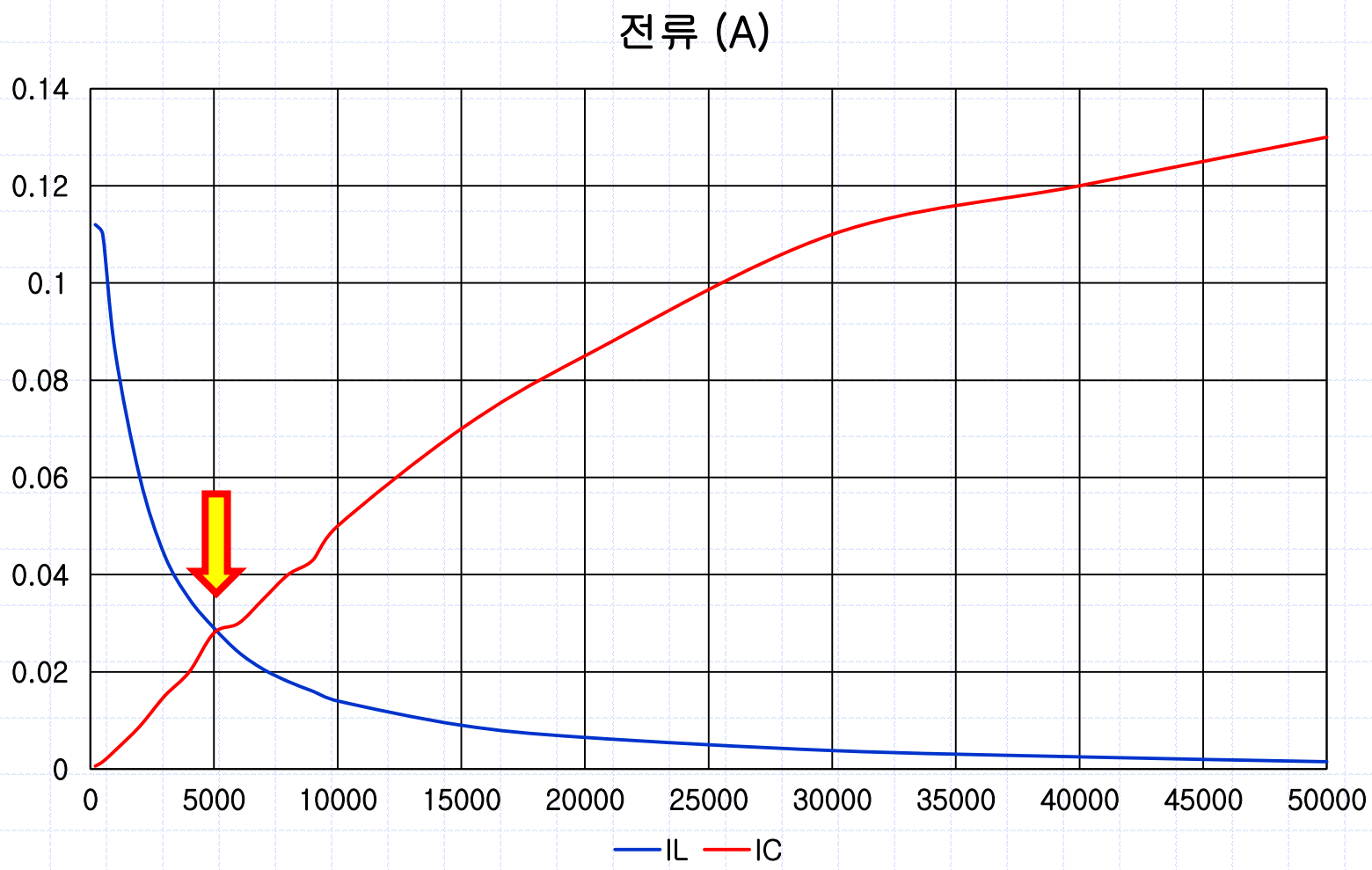
15-8. 주파수에 따른 위상 변화



15-9. 주파수에 따른 전류, 리액턴스

Frequency (Hz)	V_{R1} (Vpp)	I_L (mApp)	X_L (Ω)	V_{R2} (Vpp)	I_C (mApp)	X_C (Ω)
200	1.12	112	89.29	0.006	0.6	16666.67
500	1.1	110	90.91	0.015	1.5	6666.67
1,000	0.86	86	116.28	0.038	3.8	2631.58
2,000	0.6	60	166.67	0.088	8.8	1136.36
3,000	0.44	44	227.27	0.15	15	666.67
4,000	0.35	35	285.71	0.2	20	500
5,000	0.29	29	344.83	0.28	28	357.14
6,000	0.24	24	416.67	0.3	30	333.33
7,000	0.205	20.5	487.80	0.35	35	285.71
8,000	0.18	18	555.56	0.4	40	250
9,000	0.16	16	625	0.43	43	232.56
10,000	0.14	14	714.29	0.5	50	200
15,000	0.09	9	1111.11	0.7	70	142.86
20,000	0.065	6.5	1538.46	0.85	85	117.65
30,000	0.038	3.8	2631.58	1.1	110	90.91
40,000	0.025	2.5	4000	1.2	120	83.33
50,000	0.015	1.5	6666.67	1.3	130	76.92

15-9. 주파수에 따른 전류, 리액턴스



15-9. 주파수에 따른 전류, 리액턴스