Basic Elec. Engr. Lab

ECS 204

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Lab 4

- AC Circuit
- Time-varying Signal
- Oscilloscope
- Function generator

Time-varying periodic signal (voltage)

- Suppose the period is T.
- Instantaneous value at time t: $v(t)$ $[V]$
- Average value

$$\overline{v(t)} = \frac{1}{T}\int_{t_0}^{t_0+T} v(t)dt \quad [V]$$

- RMS value

$$\sqrt{\overline{v^2(t)}} = \sqrt{\frac{1}{T}\int_{t_0}^{t_0+T} v^2(t)dt} \quad [V_{rms}]$$

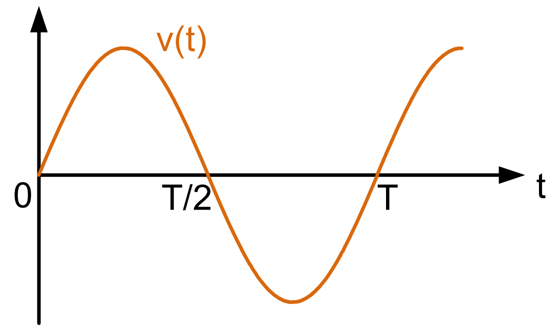
- Peak value

$$\max_{t_0 \le t \le t_0+T} v(t) \quad [V_p]$$

- Peak-to-peak value

$$\left(\max_{t_0 \le t \le t_0+T} v(t)\right) - \left(\min_{t_0 \le t \le t_0+T} v(t)\right) \quad [V_{p-p}]$$

Sinusoidal signal (voltage)



- The period is $T = \frac{1}{f} = \frac{2\pi}{\omega}$
- Instantaneous value at time t: $v(t) = A\cos(\omega t + \theta)$ $[V]$
- Average value

$$\overline{v(t)} = \frac{1}{T}\int_{t_0}^{t_0+T} v(t)dt \quad [V] \qquad = 0$$

- RMS value

$$\sqrt{\overline{v^2(t)}} = \sqrt{\frac{1}{T}\int_{t_0}^{t_0+T} v^2(t)dt} \quad [V_{rms}] \qquad = \frac{A}{\sqrt{2}}$$

- Peak value

$$\max_{t_0 \le t \le t_0+T} v(t) \quad [V_p] \qquad = A$$

- Peak-to-peak value

$$\left(\max_{t_0 \le t \le t_0+T} v(t)\right) - \left(\min_{t_0 \le t \le t_0+T} v(t)\right) \quad [V_{p-p}] \qquad = 2A$$

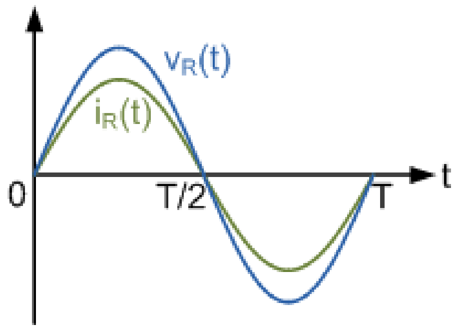
Steady-State AC Analysis

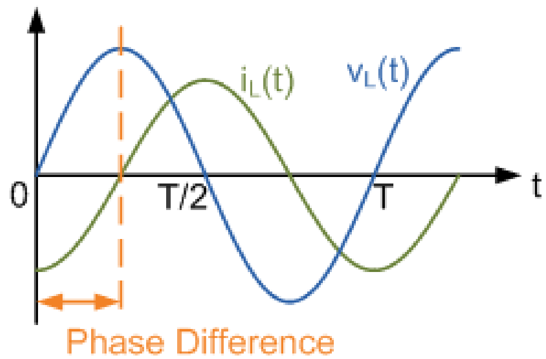
- Phasor Domain:

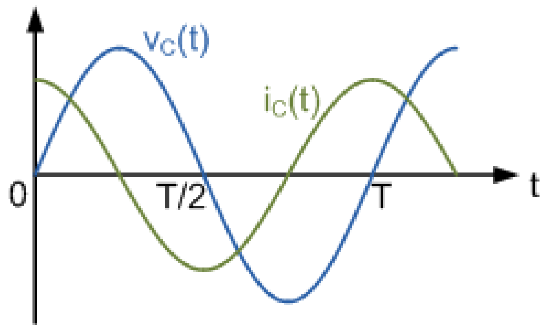
$$\mathbf{V} = Z\mathbf{I}$$

Resistor	Inductor	Capacitor
$Z = R$	$Z = j\omega L$	$Z = \dfrac{1}{j\omega C}$

- Time Domain:

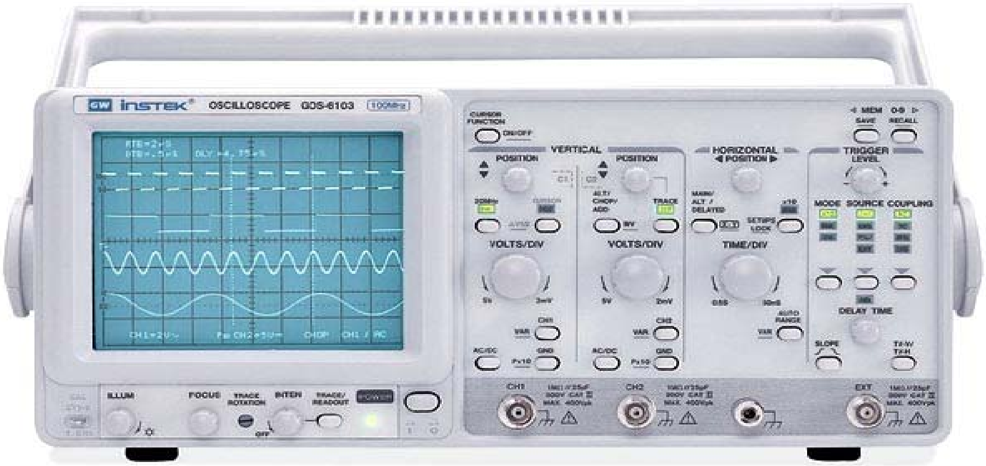






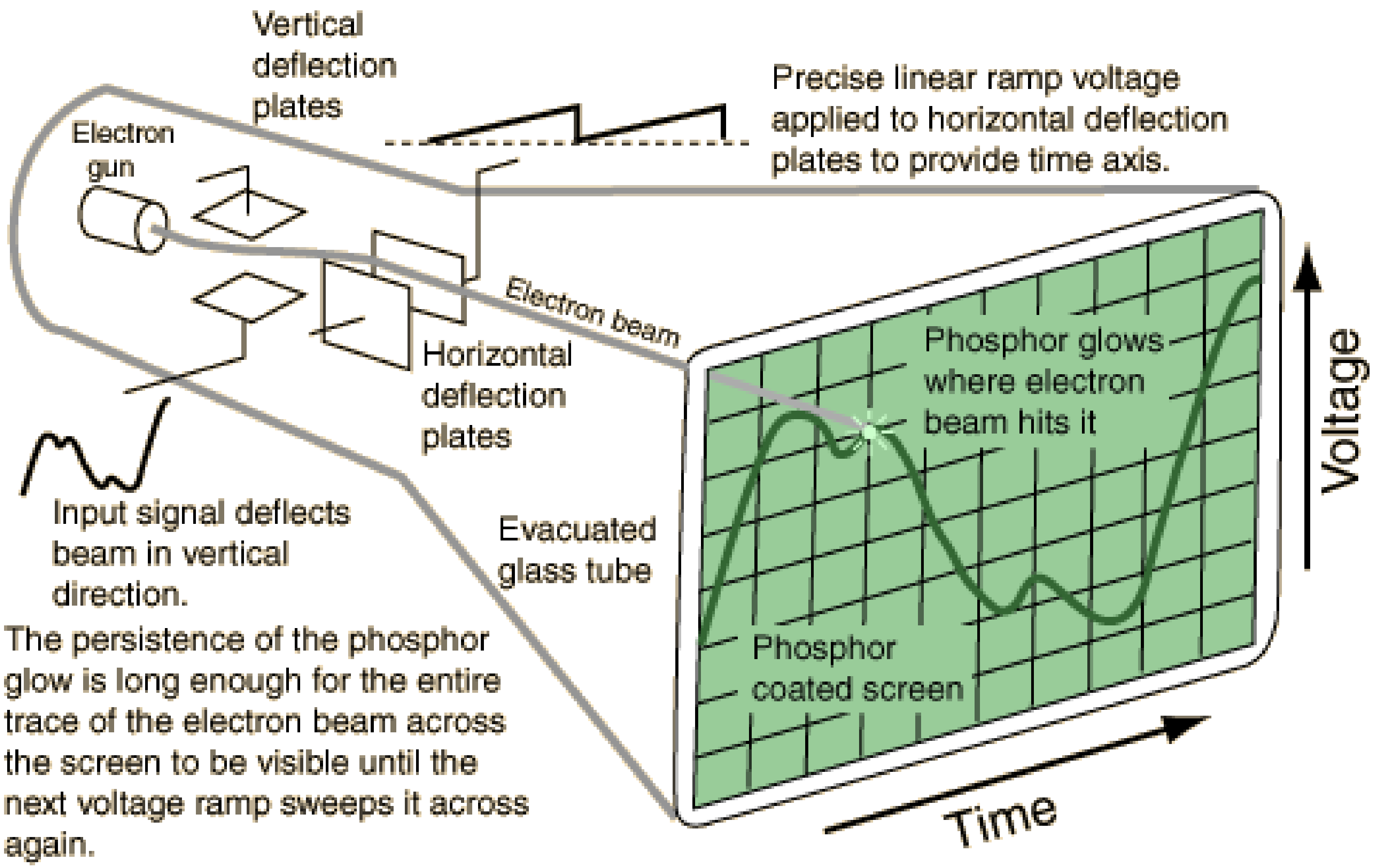
Oscilloscope

- Draw a graph of a voltage over time as a **trace** on its screen.
- **Cathode-ray oscilloscopes** (**CROs**)
  - Electron gun emits a beam of electrons (historically called "cathode rays", hence the name)
    - which is deflected according to the signal being measured.
  - The trace is produced by the electrons striking a phosphor screen, which glows green where they hit.



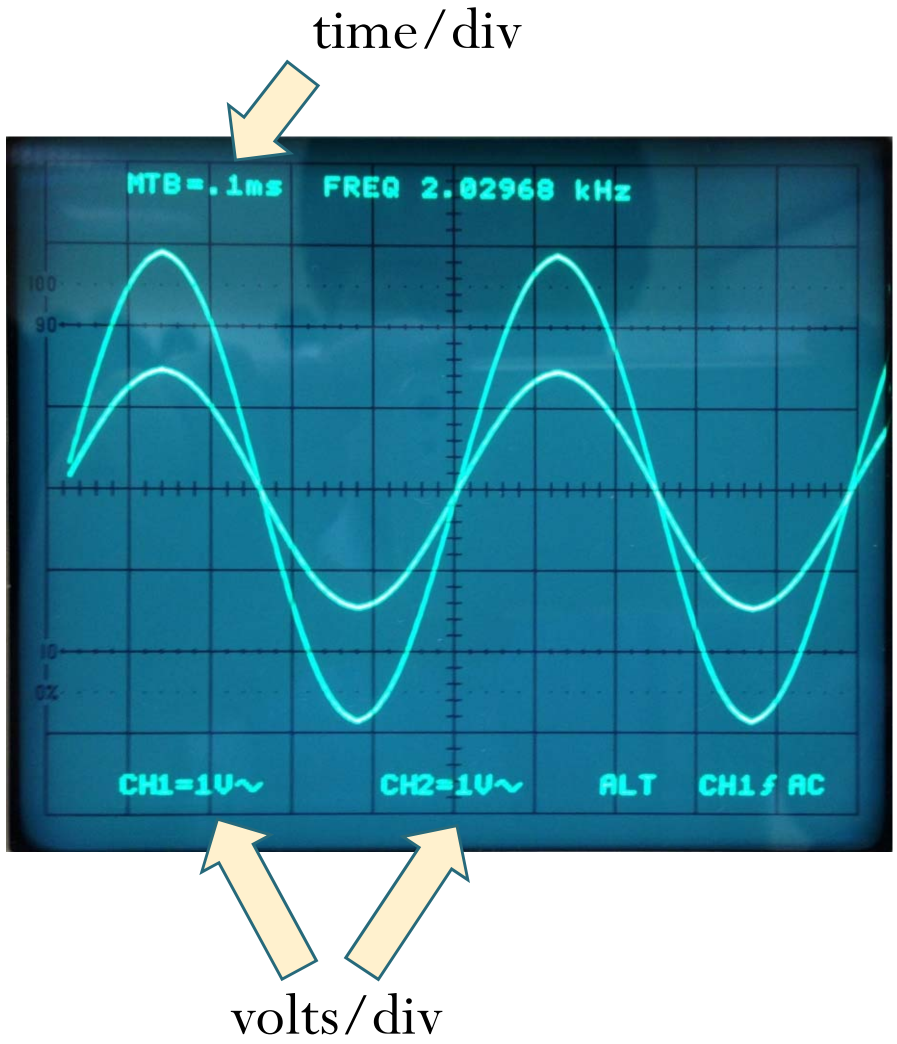
Demo 1: Cathode-ray oscilloscope (CRO)

Cathode-ray tubes: **ELECTRON GUN** and DEFLECTION SYSTEM.



Caution: An overly bright trace can damage the phosphor of the screen if the dot is moving too slowly.

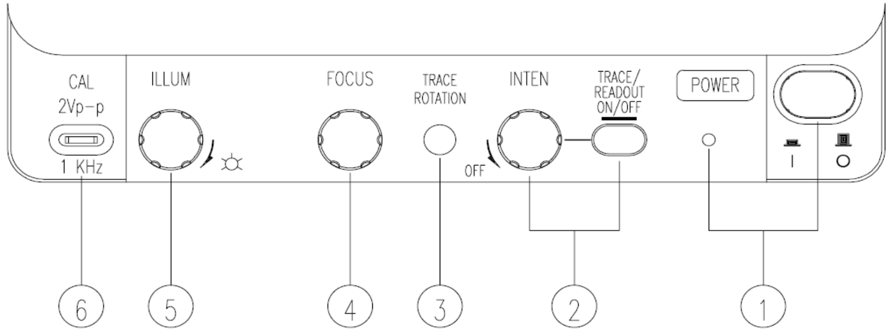
Oscilloscope: Display

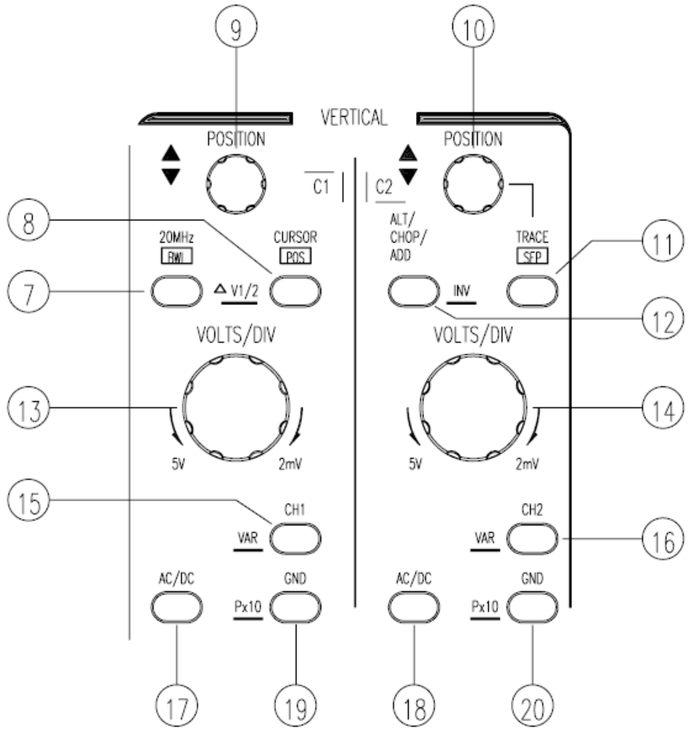


- Notice the grid markings on the screen.
- These markings create the **graticule**.
- Each vertical and horizontal line constitutes a **major division**.
- The graticule is usually laid out in an 8-by-10 division pattern.
- The readout for volts/div and time/div always refer to major divisions.
- The tick marks on the center horizontal and vertical graticule lines are called **minor divisions**.
- Dual-channel Oscilloscope: Can handle two signals at once.

Oscilloscope Preparation

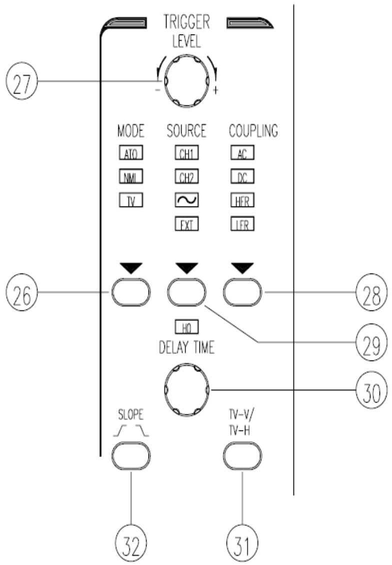
- Follow III.3 and III.4.
- POWER (1)
- INTEN control (2)
- FOCUS control (4)
- CH1 (15) and CH2 (16)
- CH 1's GND (19) and CH 2's GND (20)

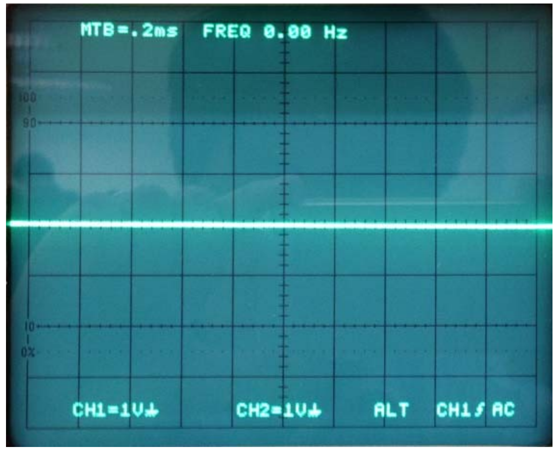




Oscilloscope Preparation

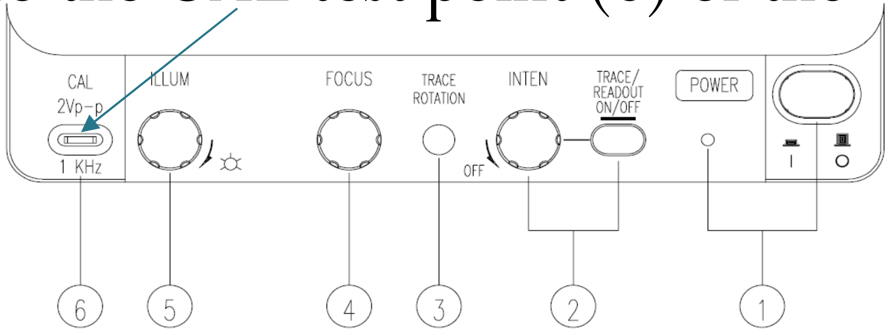
- Make sure that the TRIGGER MODE (26) is set to ATO mode, otherwise the trace will not be shown.
- Use the CH1 and CH2 POSITION controls ((9) and (10)) to align both traces on the center graticule.



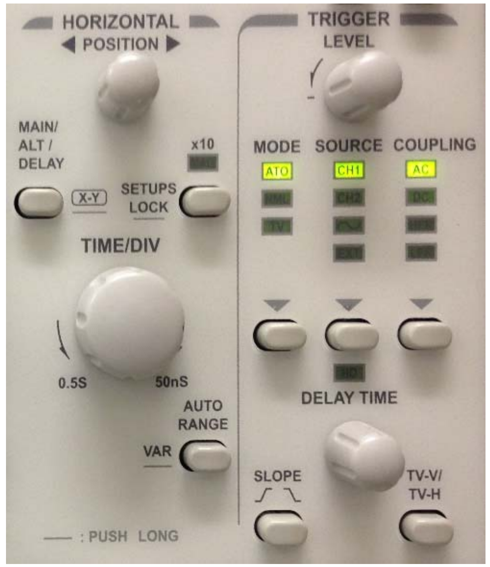


Oscilloscope Preparation

- Connect the probe tips to the CAL test point (6) of the oscilloscope.

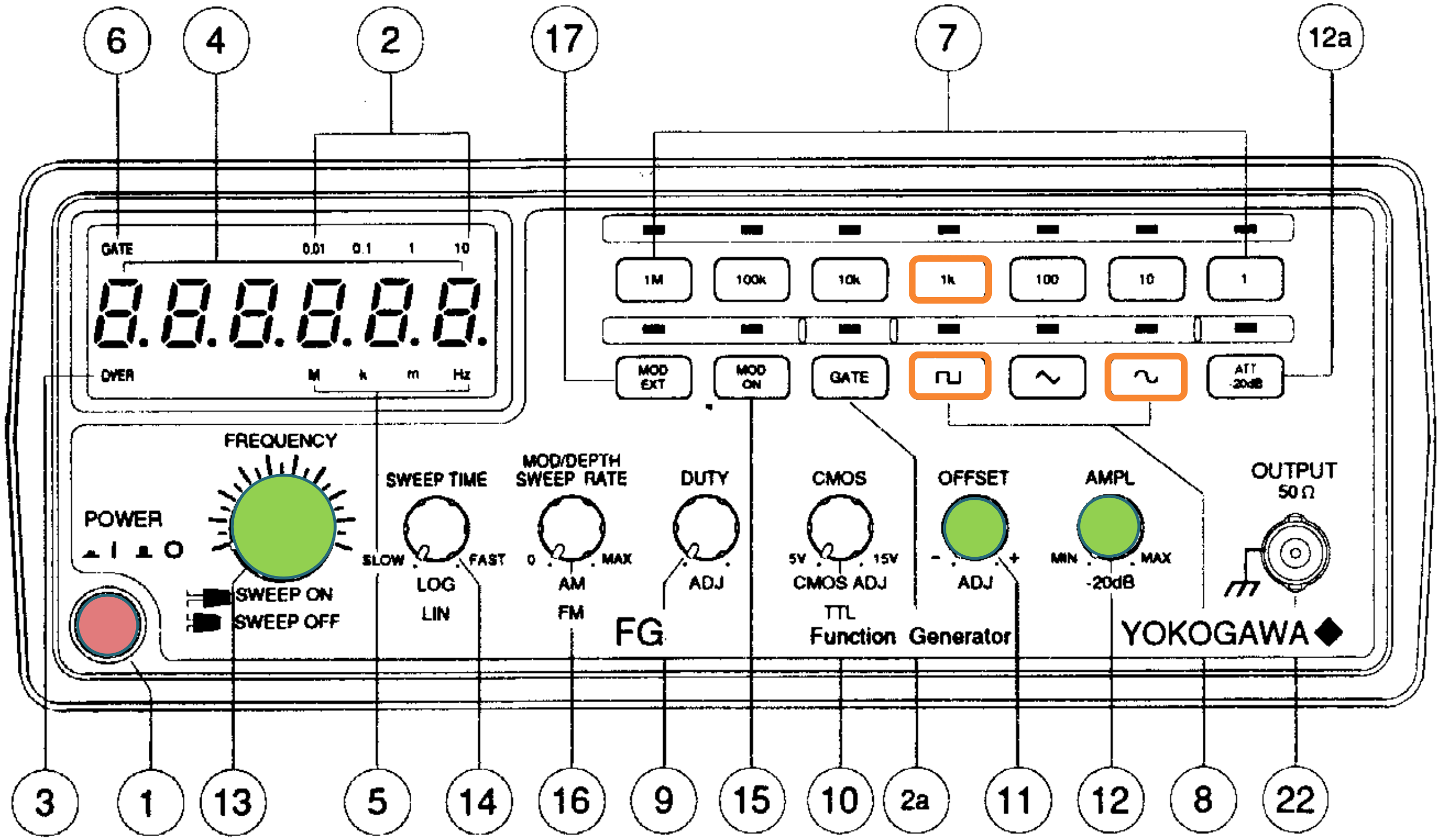


VERTICAL:	VOLTS/DIV ((13) and (14))	1V
	COUPLING ((17) and (18))	DC
	ALT/CHOP/ADD (12)	CHOP or ALT
HORIZONTAL:	MODE (22)	MAIN
	TIME/DIV (21)	0.5ms
TRIGGER:	MODE (26)	ATO
	SOURCE (29)	CH1
	COUPLING (28)	AC

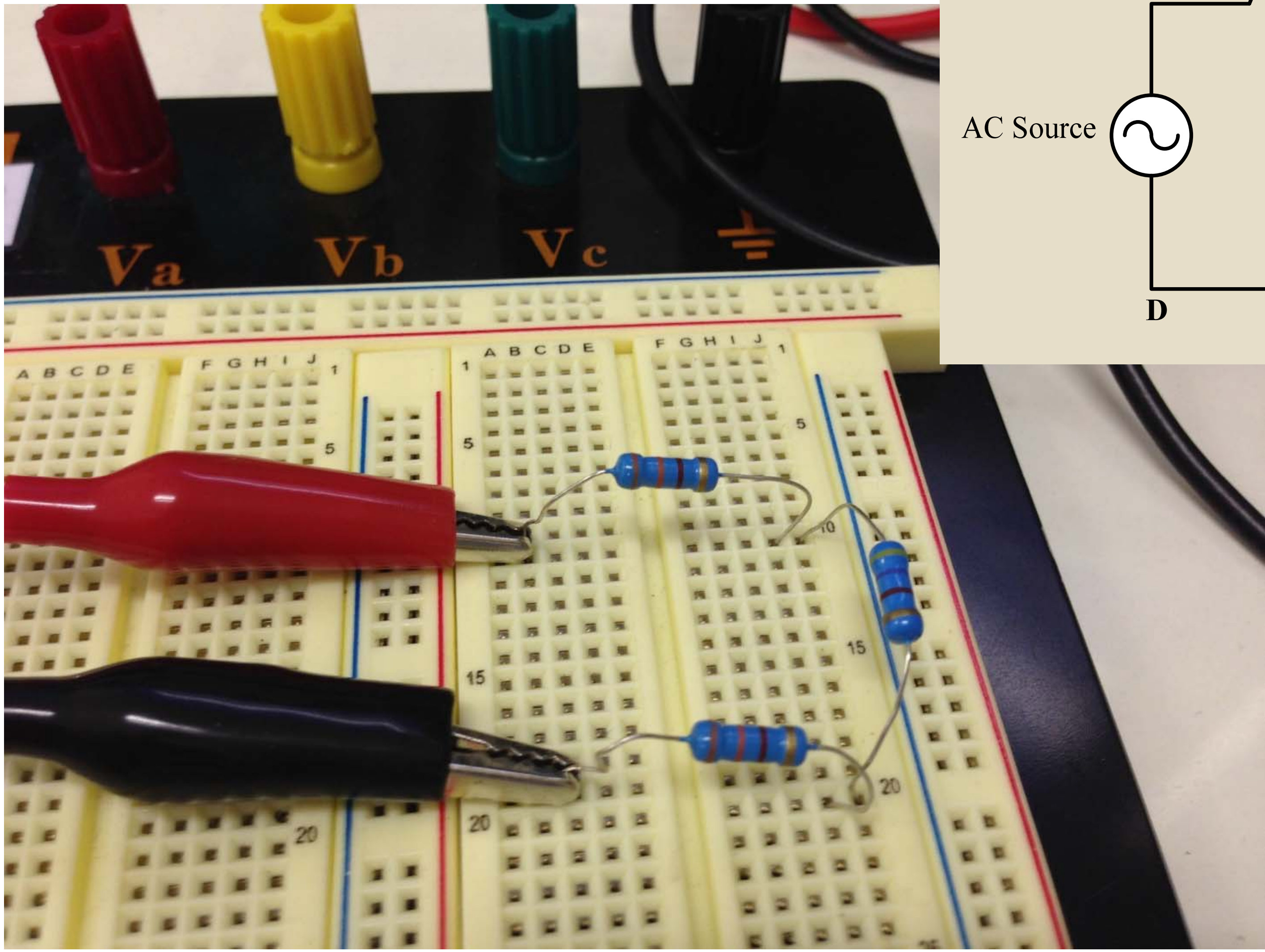


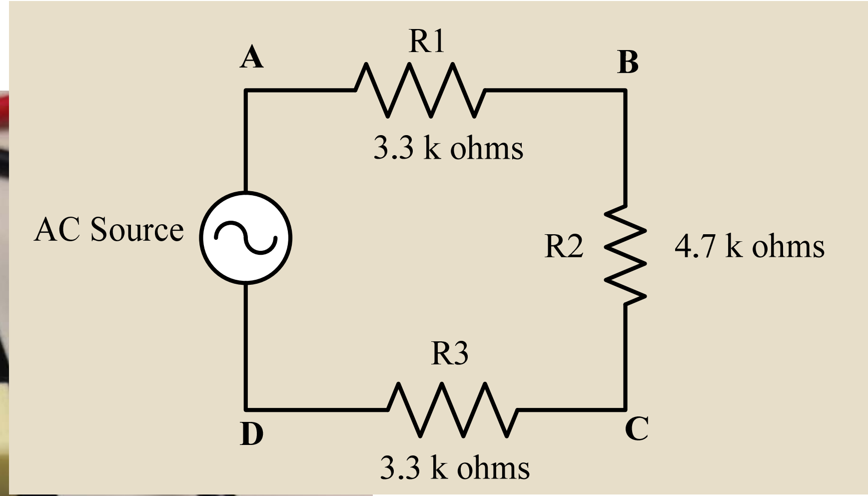
- The square wave of the calibrator signal will be displayed on the screen.

Function Generator



Part A



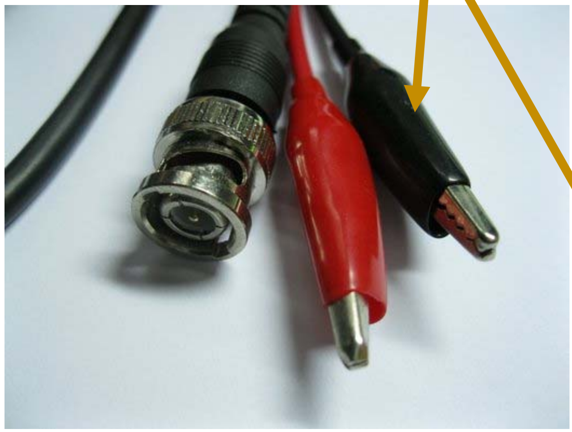


Demo 2

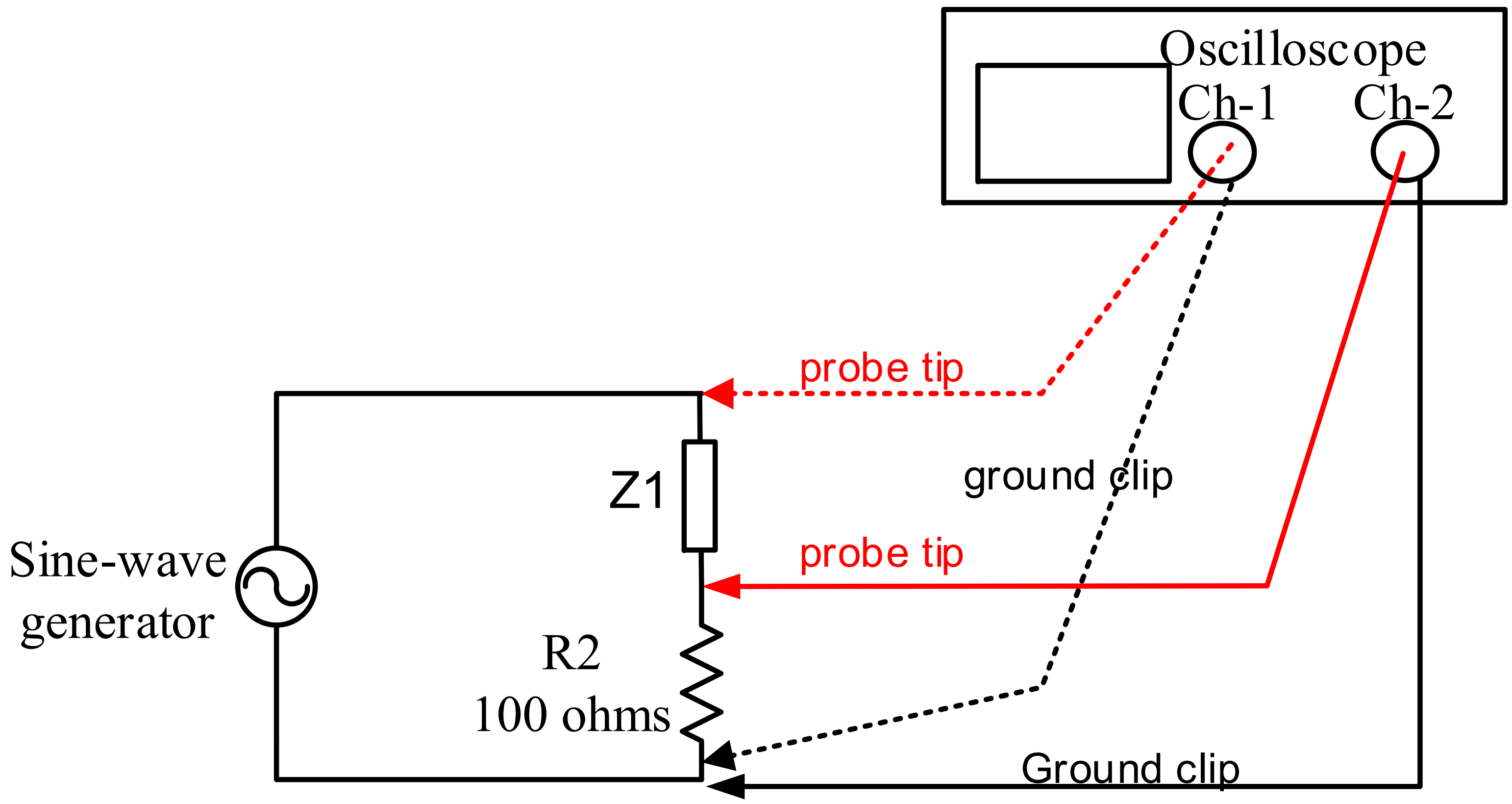
- 4 Vp-p Sinusoid
- DMM in AC Mode

Demo 3

- (Probe) ground clips

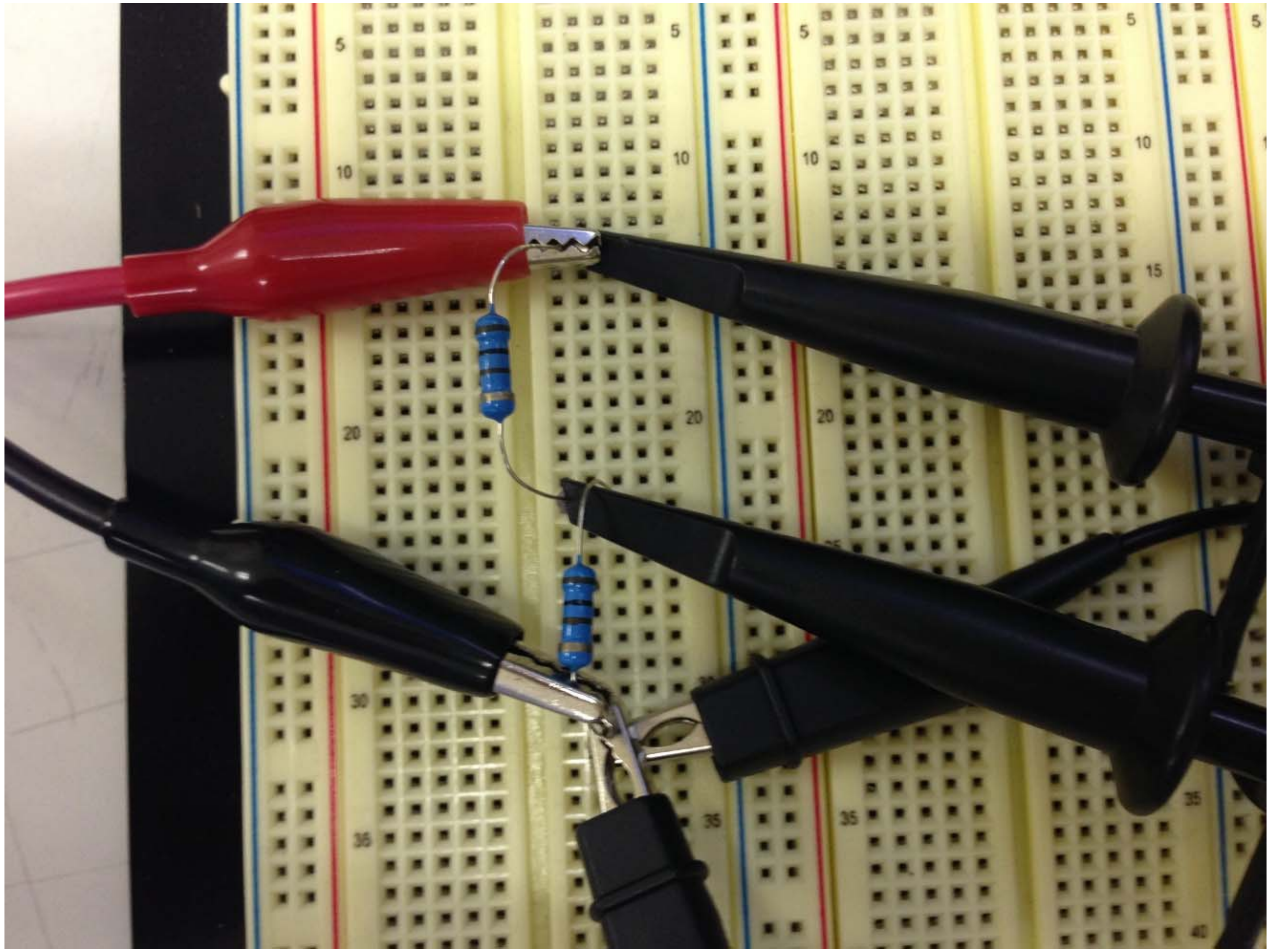


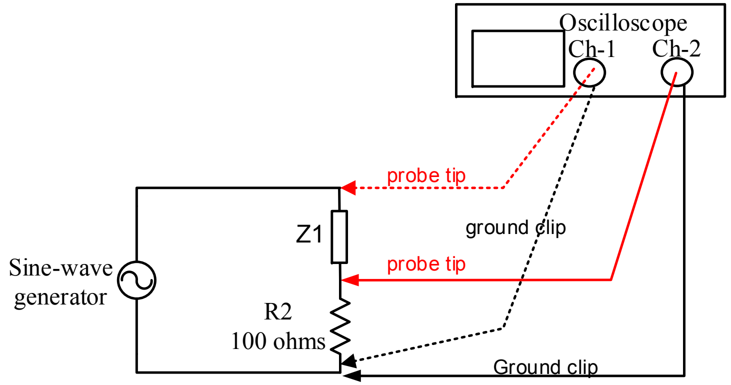
Part C



Oscilloscope
Ch-1
Ch-2
probe tip
ground clip
probe tip
Z1
Sine-wave
generator
R2
100 ohms
Ground clip

Part C.1

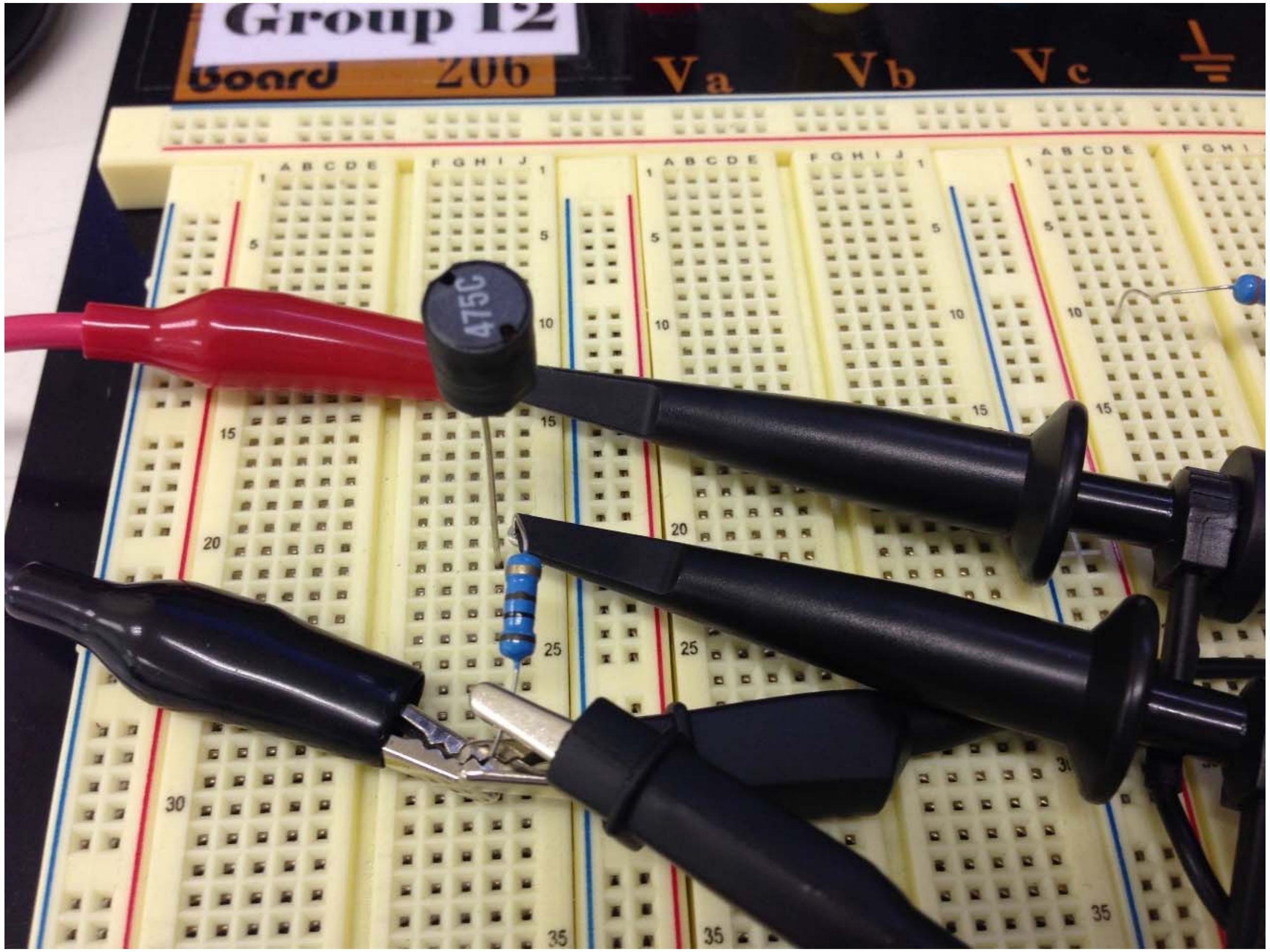


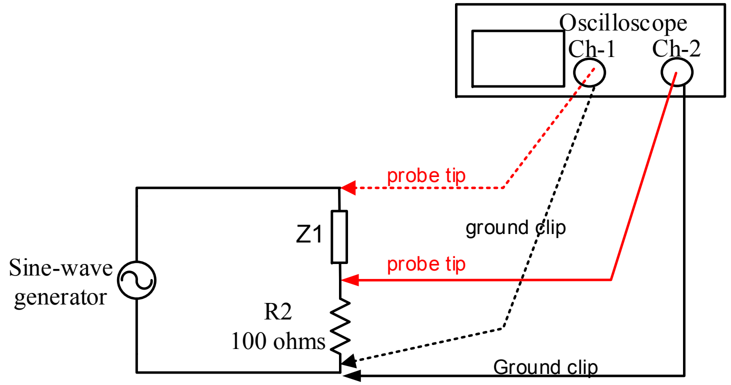


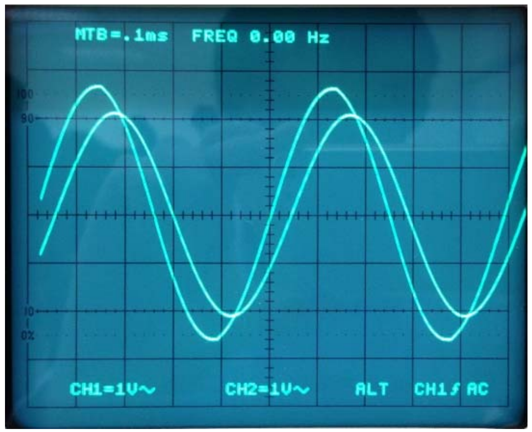
Oscilloscope
Ch-1
Ch-2
probe tip
Z1
ground clip
probe tip
Sine-wave generator
R2
100 ohms
Ground clip

MTB=.1ms FREQ 2.02968 kHz
CH1=1V~
CH2=1V~
ALT
CH1 AC

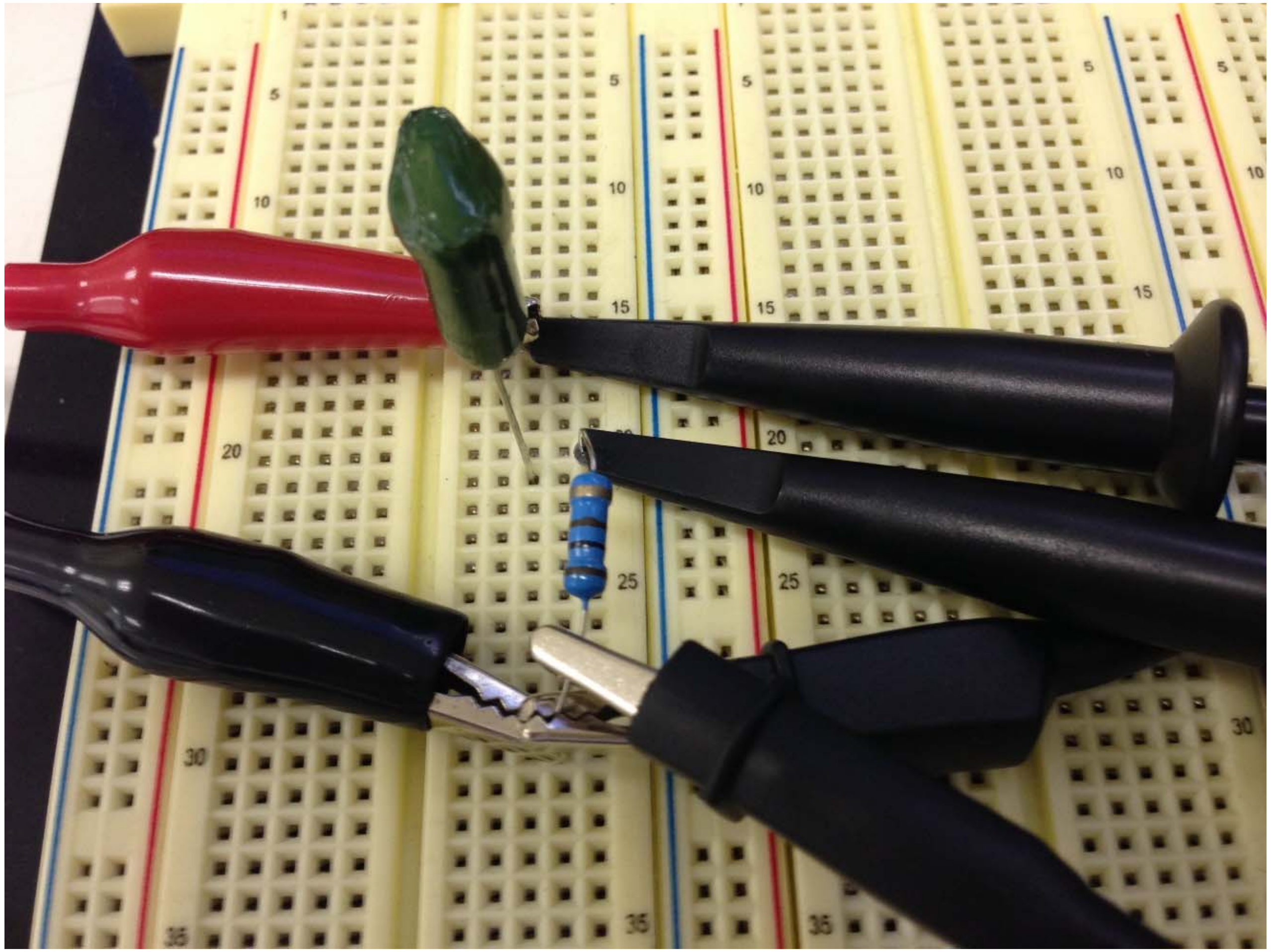
Part C.2

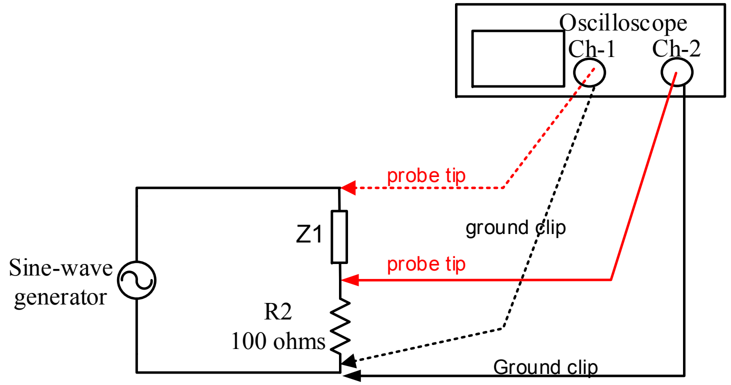

Group 12
Board
206
Va
Vb
Vc
475C


Oscilloscope
Ch-1
Ch-2
probe tip
ground clip
Z1
probe tip
Sine-wave
generator
R2
100 ohms
Ground clip

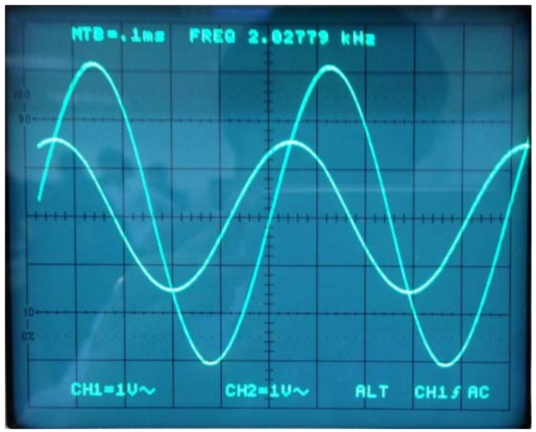

MTB=.1ms FREQ 0.00 Hz
CH1=1V~
CH2=1V~
ALT
CH1 AC

Part C.3





Oscilloscope
Ch-1
Ch-2
probe tip
Z1
ground clip
probe tip
Sine-wave
generator
R2
100 ohms
Ground clip



FREQ 2.02779 kHz
CH1=1V~
CH2=1V~
ALT

Reading Capacitor Code

Code	Value
102	0.001 μF
103	0.01 μF
104	0.1 μF
473	0.047 μF
474	0.47 μF

$$47\times10^4\,\text{pF} = 47\times10^4\times10^{-12}\,\text{F} = 47\times10^4\times10^{-6}\times10^{-6}\,\text{F}$$

$$= 47\times10^4\times10^{-6}\times10^{-6}\,\text{F} = 47\times10^{-2}\,\mu\text{F}$$

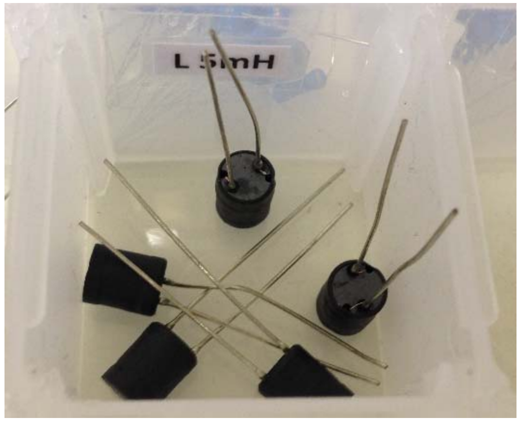
$$=0.47\,\mu\text{F}$$

Demo 4: Measuring Capacitance

- We can use DMM to measure capacitance.
- Special device (LCR meter) to measure inductance.

Capacitor and Inductor

- 5 mH Inductor



- 0.47 μF capacitor (474)