Lab Instruments, Passive Elements and Lab 1

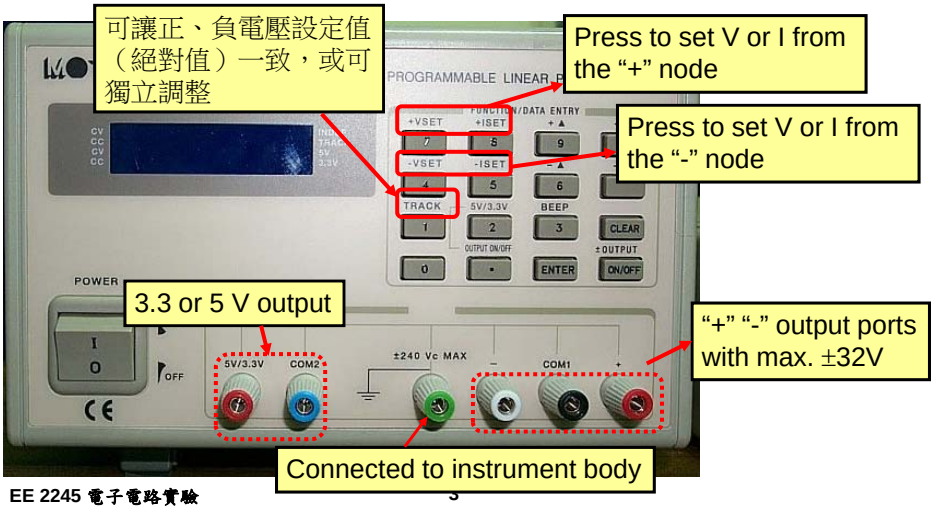
- Instruments:
  - DC power supply, function generator, digital multimeter (DMM) and digital oscilloscope
- Coding of resistor and capacitor
- Wires and protoboard
- Lab 1 includes
  - DC measurement: Superposition, Thévenin's Theorem, maximum power transfer and Norton's Theorem
  - AC measurement: RL and RLC circuits

Grounding（接地）

- Ground
  - As a zero potential reference
  - The individual ground of all instruments and circuits should be connected to produce a unified ground during measurement
  - The ground resistance is desired to be small

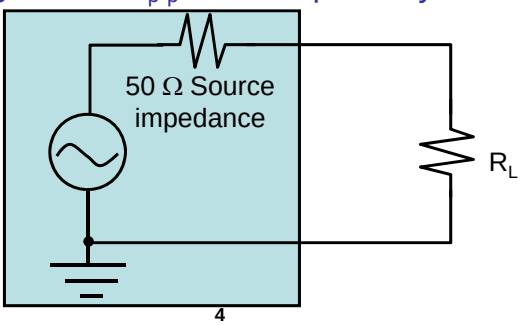
DC Power Supply 直流電壓、電流供應器

- 注意：如右下角所提供的電壓或電流是相對於COM1埠

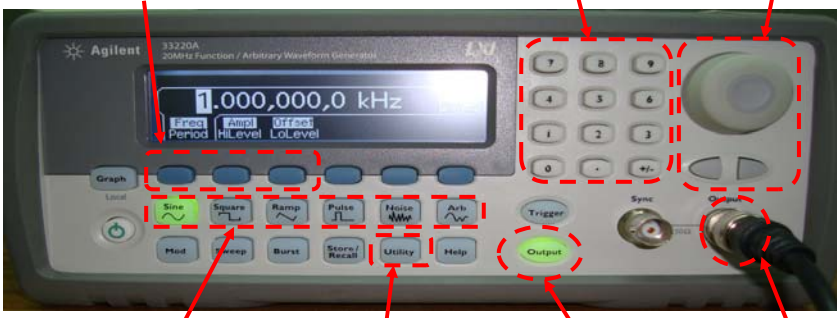


Function Generator（訊號產生器）

- It produces desired ac waveforms (sinusoidal, square wave, or triangle) as the input to circuit
- 本實驗室的訊號產生器本身有 50-Ω source impedance. 針對負載R_L，儀器有 R_L = 50 Ω及高負載(High Z)的選項(default = 50 Ω)
  - For R_L = 50 Ω : set 1 V_{p-p} as the output and you will get 2 V_{p-p} on the oscilloscope . Why?
  - For R_L = High Z: set 1 V_{p-p} as the output and you will get 1 V_{p-p}



Front Panel按鍵與功能



Parameters
（含頻率、振幅等）

設定所需的值
(method 2)

設定所需的值
(method 1)

Waveform selection
（正弦、三角波等）

按鈕後，有選項
可調整負載阻抗

Enable/Disable
the output
亮燈才有輸出波形

Main
output

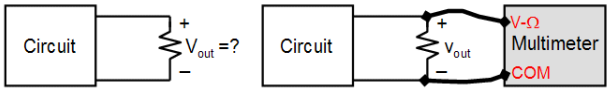
Digital Multimeter (DMM) 數位三用電表

- Capabilities: measure dc and ac electrical voltage, current, and resistance（一般以量直流為主）
  - The ac value is the root-mean-square (rms) value

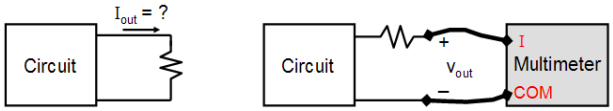
$$v_{RMS} = \left[\frac{1}{T}\int_0^T v^2(t)dt\right]^{0.5}$$

Connections for Measurements (V, I, and R)

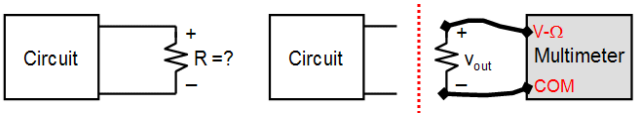
- Measurement of voltage: The multimeter connected in parallel



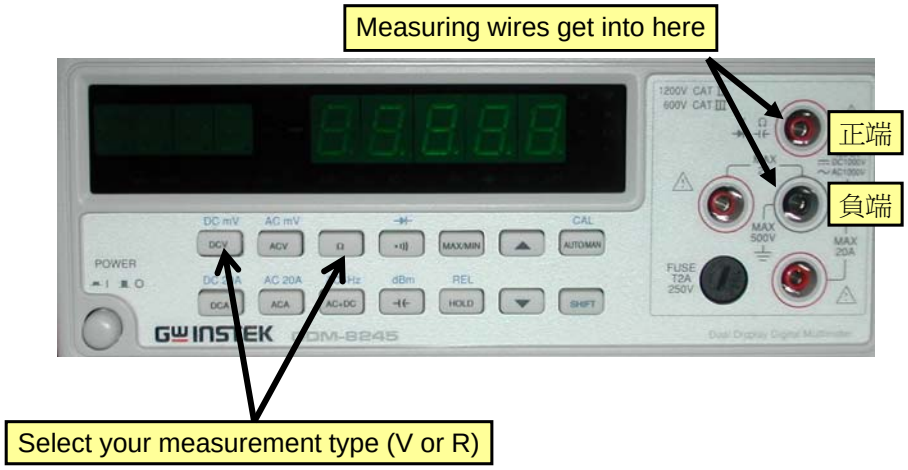
- Measurement of current: The multimeter connected in series



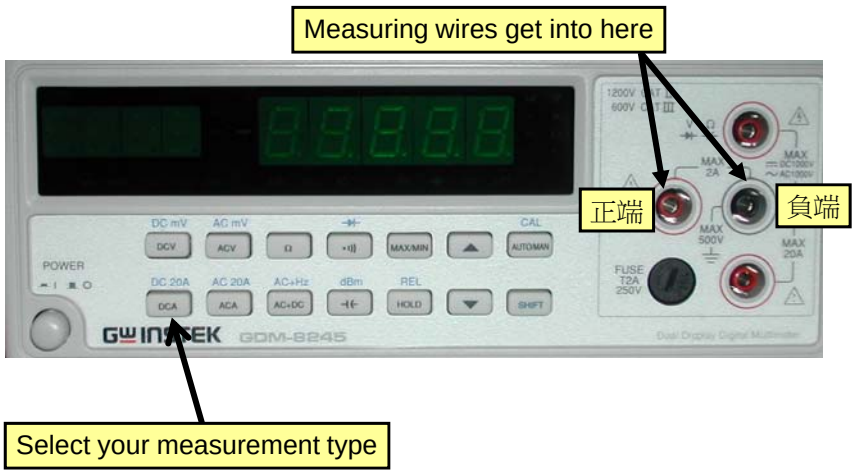
- Measurement of resistance: The resistor to be measured must be disconnected from the circuit



Voltage or Resistance Measurement

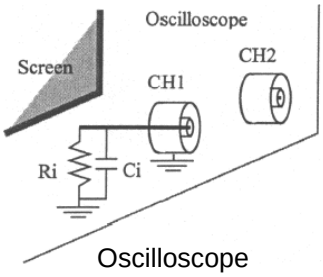


Current Measurement

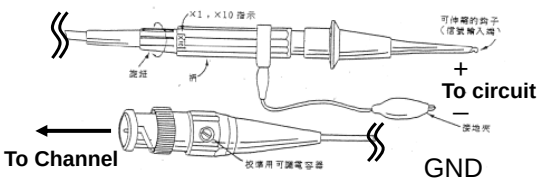


Oscilloscope（示波器）

- To display the voltage waveforms with respect to time
- 至少two channels（可顯示輸入及輸出波形）
- Analog type and digital type（現在幾乎都是數位示波器）
- 一般示波器（頻率在數十MHz等級）看進去的輸入電阻阻抗在MΩ以上(why?)；更高頻的示波器輸入電阻阻抗則有50 Ω的選項

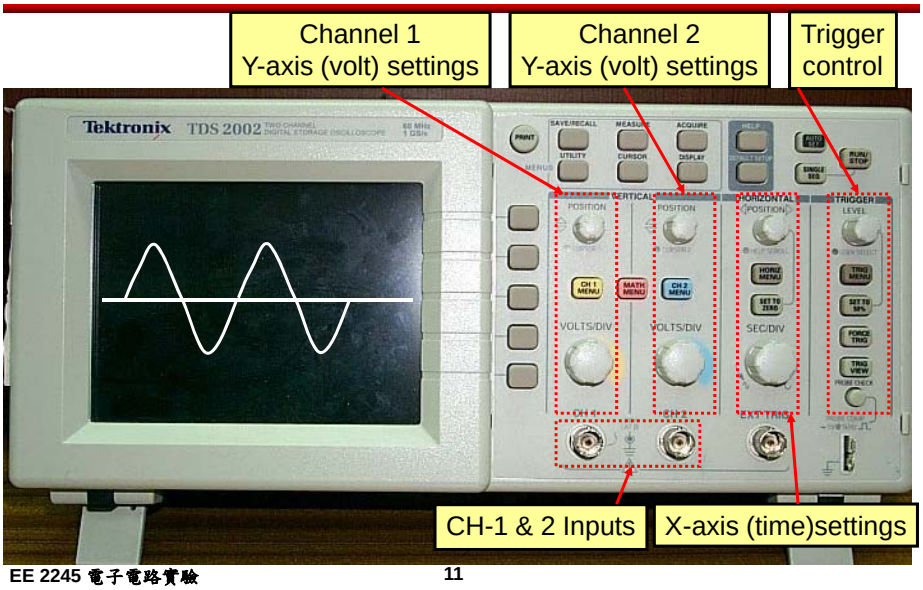


Oscilloscope



Measuring probe

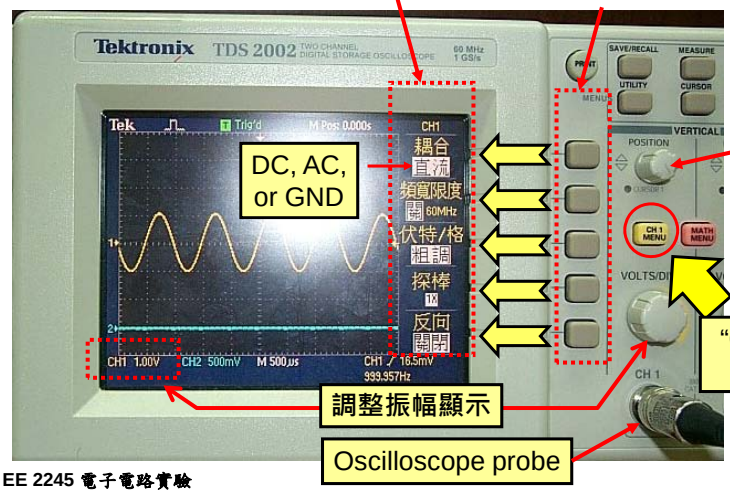
Front Panel 功能與按鍵



To Display the Waveform Properly, You Should:

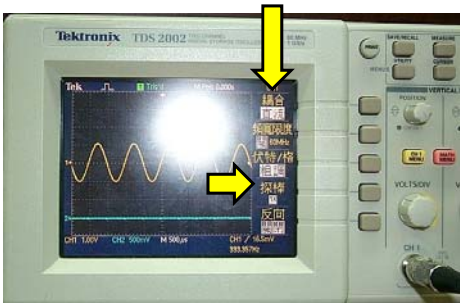
- Have the proper X (time) and Y (voltage) settings
- Have the correct triggering settings（重要：根據以往經驗，超過百分之八十修過課的同學不會用trigger，對於以後做研究量測訊號會有影響）

Y-axis (Voltage) Settings：（耦合及探棒的選項最常需要注意到）

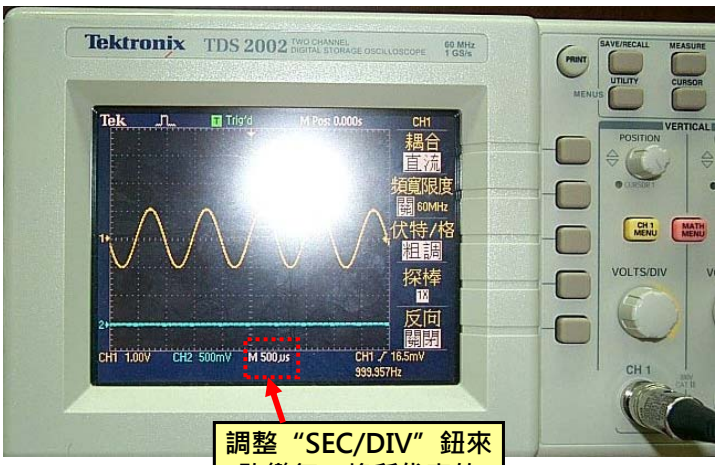


Cont'd: 耦合及探棒的選項

- 耦合:
  - 直流耦合: 將波形的直流與交流完整輸出
  - 交流耦合: 將波形的直流去除，僅輸出交流波形
  - 接地耦合: 顯示接地(0 V)，不顯示波形
- 探棒：示波器的選項(1X, 10X等）必須和量測用探棒你所選的選項(1X, 10X等）相同，不然你會觀察到量測波形振幅有十倍落差

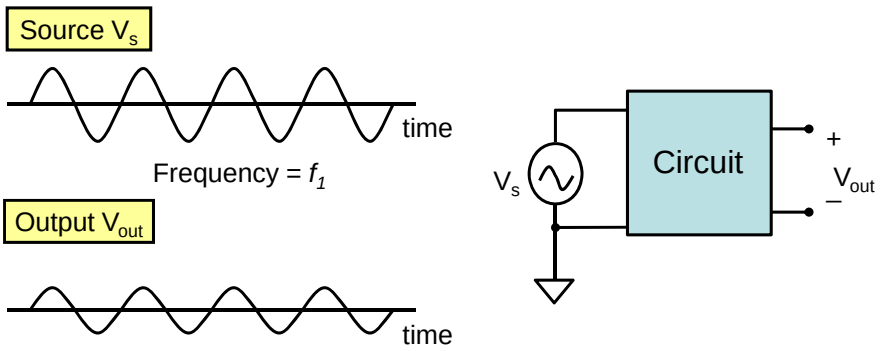


X-axis (Time) Settings



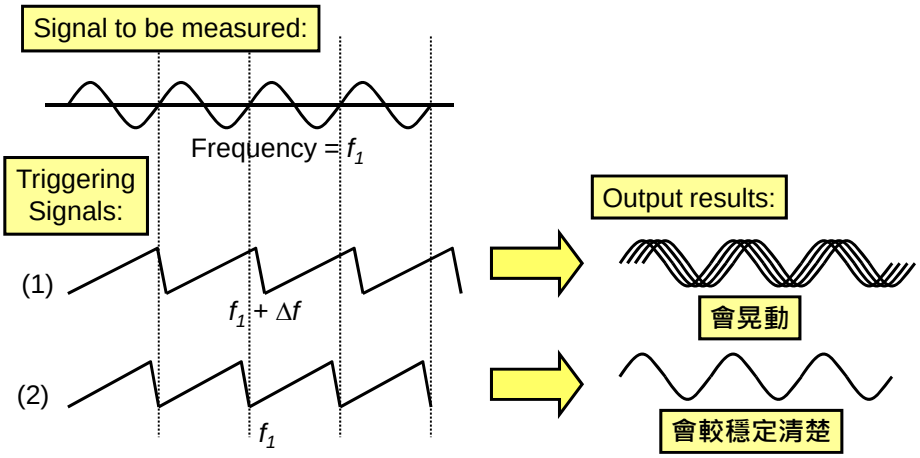
Trigger

- 一般常用電路的ac source (V_s)作為觸發訊號源(trigger)，以便在示波器上得到輸出波形V_{out}（因為V_s及具V_{out}相同頻率、且V_{out}是來自於V_s）
  - 因為每一台的ac source其訊號頻率相位會隨時間作少許漂移，所以，你不能用另外一台具相同頻率的ac source作觸發訊號源

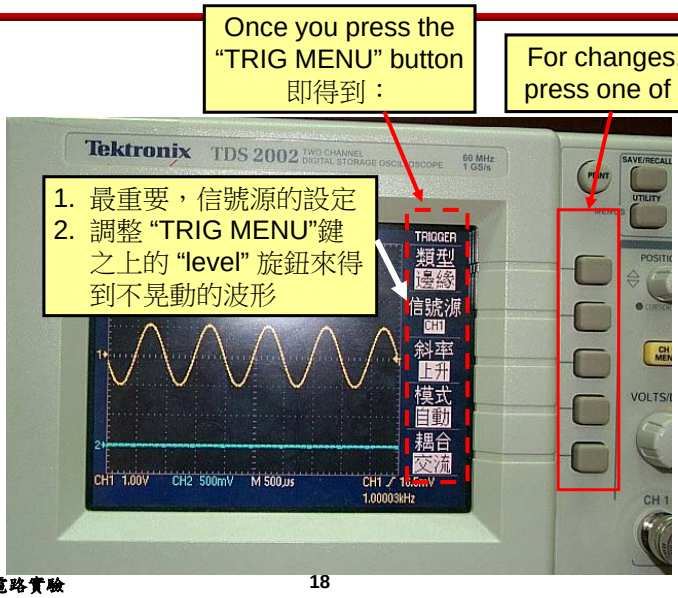


Cont'd

- 有了相同頻率(f_1)的訊號作trigger，可得到較固定清晰的量測波形

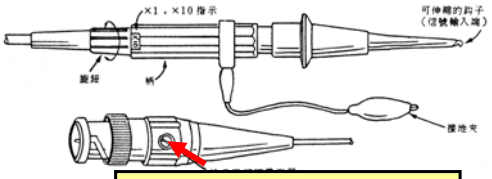


Trigger Control

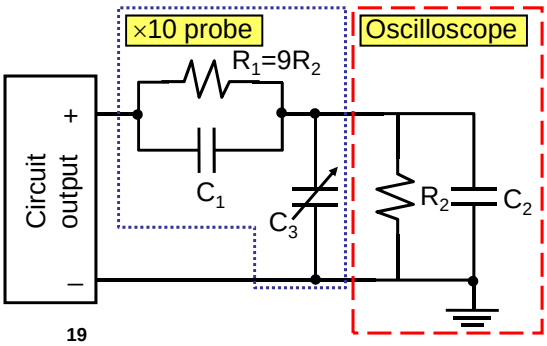


Oscilloscope Probe

- Two options: “×1” and “×10”（可在probe上調整）
- The “×10” probe is intended the lower the loading effect to the circuit under test
  - 10 times attenuation
- 請確認示波器及探針對於×1或×10的設定是一致，否則你會量到差十倍的訊號



Calibration（用起子旋轉，以校正Probe）



Calibration of Measuring Probe--由示波器所觀察到的波形來校正

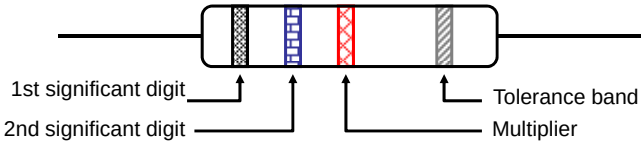
將量測探針的 “+” “-” 端接到這裡

將量測探針另端的接頭接到channel-1 or 2

OUTPUT PATTERNS

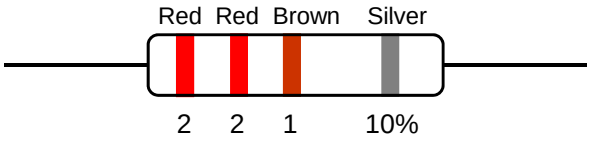
×　　Good　　×

Resistor Color Code – 由電阻上的顏色環得知電阻值



Color	1st and 2nd Digits	Multiplier	Tolerance (%)
Black	0	10^0	__
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	__
Yellow	4	10^4	__
Green	5	10^5	0.5
Blue	6	10^6	0.25
Purple	7	10^7	__
Gray	8	10^8	__
White	9	10^9	__
Silver	__	0.01	10
Gold	__	0.1	5
No Color	__		20

Example

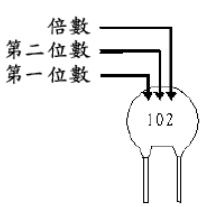


$R_{nominal} = 22 \times 10^1 = 220\ \Omega$

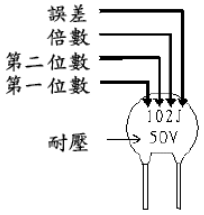
$\therefore R = 220 \pm (220 \times 10\%)\ \Omega = 198\ \Omega \text{ to } 242\ \Omega$

Capacitor—如何辨識電容值？

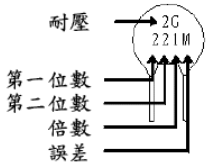
1. Use numbers. The minimum unit is pico-farad (1 pf = 10^{-12} F) for calculation



10×10^2 pF



10×10^2 pF ± 5%



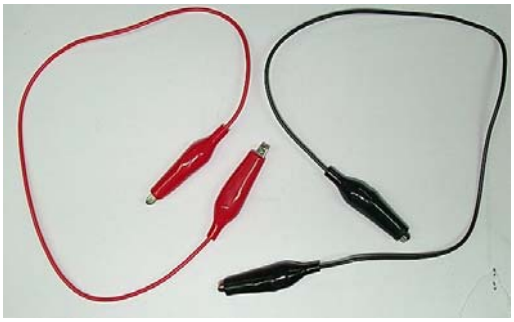
22×10^1 pF ± 20%

Code	H	J	K	L	M	N
Error (%)	3	5	10	15	20	30

2. Directly stamp on capacitors (for example: 0.1 μF)

Wires

Red to the "+" and Black to the "-"



Coaxial Cable with BNC Connector

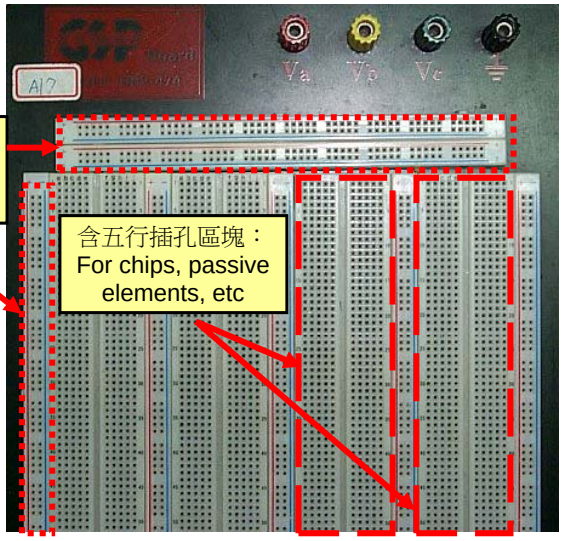
Coaxial cable: a type of wire that consists of a center wire surrounded by insulation and a grounded shield of braided wire. The shield minimizes electrical and radio-frequency interferences

用途：常接到function generator來將訊號送給電路

千萬注意：這條線與示波器量測用的線長相類似，不要將此兩種線及用途混淆

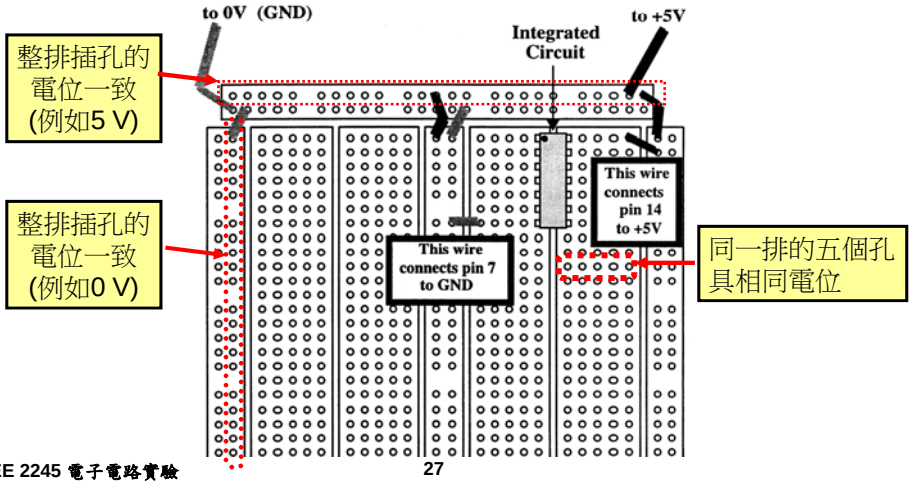
Bayonet Neill Concelman (BNC) Connector

Protoboard (Breadboard): Where You Build Circuits

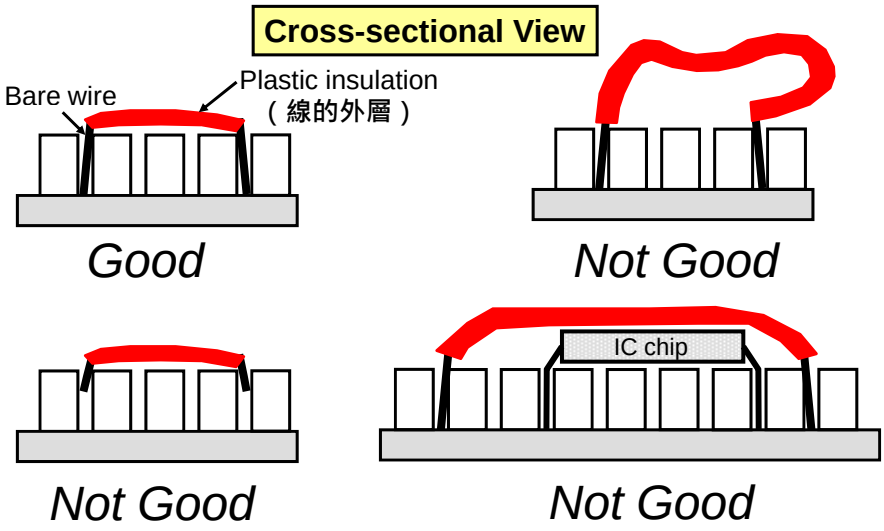


Example

- Protoboard is designed such that supplied voltages can be conveniently accessed by circuits



Cont'd: Wiring on a Protoboard（請保持佈線的簡潔，以得到較佳的訊號品質）

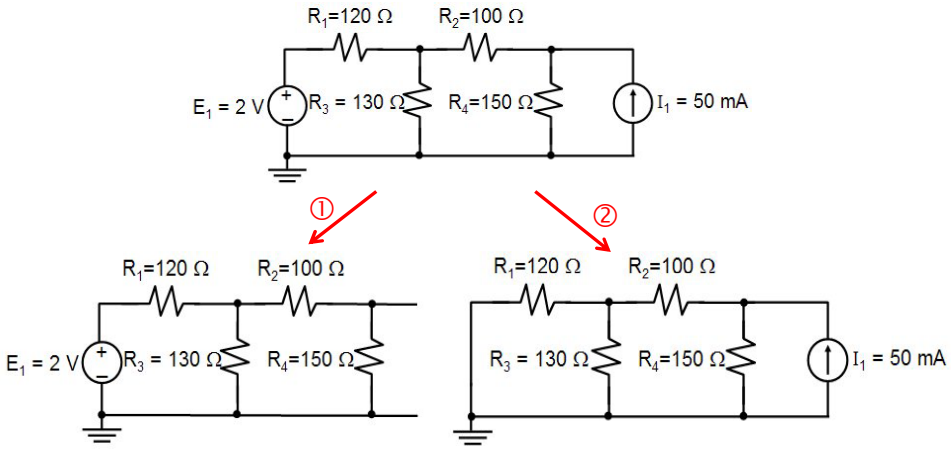


Lab 1

- DC measurement: Superposition, Thévenin's Theorem, maximum power transfer and Norton's Theorem
- AC measurement: RL and RLC circuits

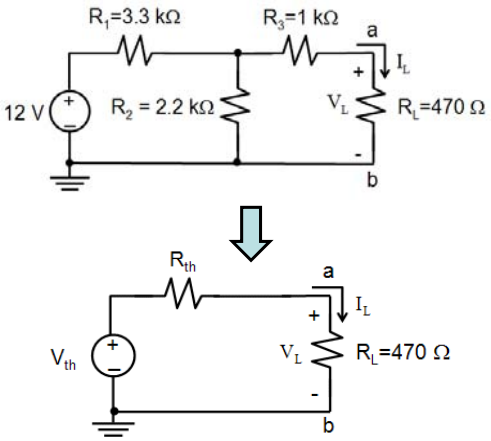
Superposition

- Verify the superposition principle: 分成①②各自計算電壓再加總



Thévenin's Theorem

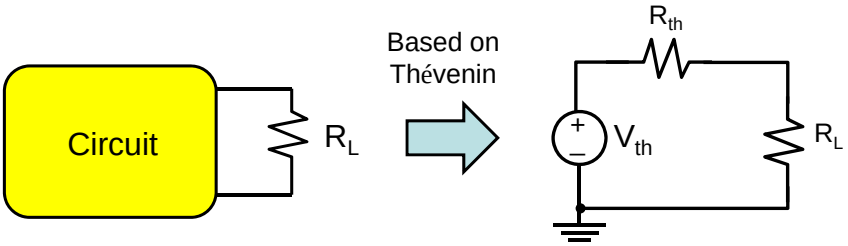
- Learn how to use the theorem to simplify the circuit



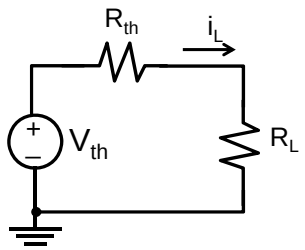
From Thévenin to Maximum Power Transfer (DC Case)

- Find out the value of load resistance R_L to achieve maximum power transfer

$$R_L = R_{th}$$



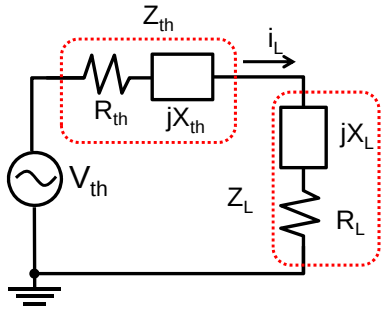
Cont'd



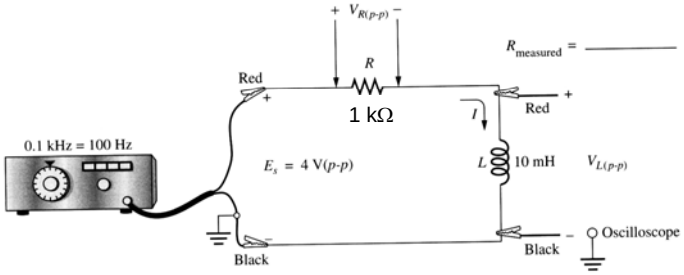
- The power absorbed by the load:

$$p_L =$$

Cont'd: AC Case



RL Circuit



- Understand the phase difference in the measured V_R and V_L waveforms at different frequencies
- Based on the measured waveform amplitudes, can you say $E_s = V_R + V_L$?