

## 第 2 講:RC 電路(時域分析)

參考文獻與網頁:

[1]蕭敏學，大學電子學實習(一):電子電路分析篇，台科大圖書，2013

[2]YouTube: 吳順德，應用電子電實驗(I3 RC 電路)，

<https://www.youtube.com/watch?v=2ZI7DckPalA&list=PLXxs-fSMcpYfBBswuFSBfefLbeBmOUbZ2&index=3>

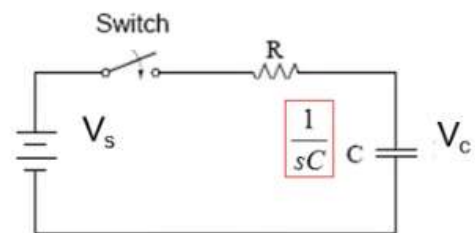
一、教學過程: 請參考[2]

### RC Circuit

By using voltage divider rule:

$$V_c = \frac{\frac{1}{sC}}{R + \frac{1}{sC}} V_s = \frac{1}{s + \frac{1}{RC}} V_s$$

$$\Rightarrow (s + \frac{1}{RC})V_c = \frac{1}{RC}V_s$$



The equivalent differential equation

$$\frac{dv_c}{dt} + \frac{1}{RC}v_c = \frac{1}{RC}v_s$$

圖 2-1 RC 電路

# First order differential equation

$$\frac{dy}{dt} + \frac{1}{\tau}y = K$$

homogeneous solution  $y_h(t) = Ae^{-\frac{t}{\tau}}$

particular solution  $y_p(t) = B$

Substitution Initial value and Final value condition into equation

$$y(0) = y_h(0) + y_p(0) = A + B \dots\dots (1)$$

$$y(\infty) = y_h(\infty) + y_p(\infty) = B \dots\dots (2)$$

$$(1) - (2) \Rightarrow A = y(0) - y(\infty)$$

Solution

$$y(t) = y_p(t) + y_h(t) = y(\infty) + (y(0) - y(\infty))e^{-\frac{t}{\tau}}$$

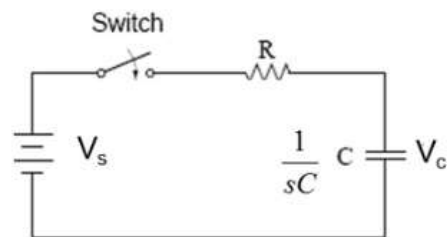
圖 2-2 一階微分方程式

# Time Response for RC circuit

Initial and final value

$$\frac{dv_c}{dt} + \frac{1}{RC}v_c = \frac{1}{RC}v_s$$

$$\begin{cases} v_c(0) = v_0 \\ v_c(\infty) = v_s \end{cases}$$



$$v_c(t) = v_s + (v_0 - v_s)e^{-\frac{t}{\tau}}$$

where

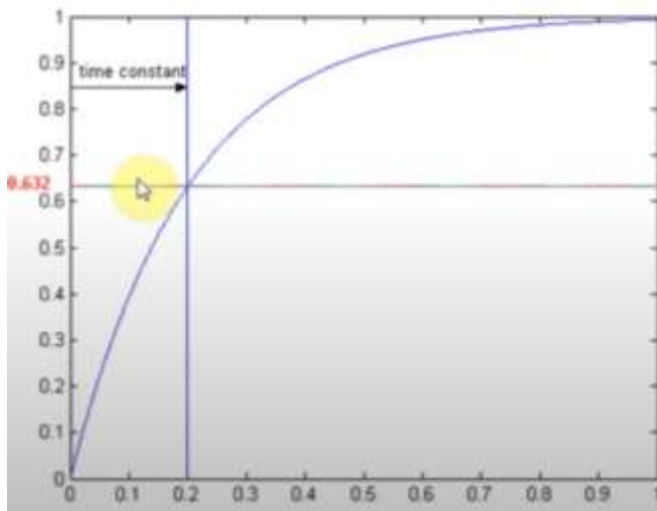
$$\tau = RC$$

圖 2-3 RC 電路時間反應

## Time Constant

$$y(t) = y(\infty) + (y(0) - y(\infty))e^{-\frac{t}{\tau}}$$

$$\text{if } y(0) = 0, y(\infty) = 1 \Rightarrow y(t) = 1 - e^{-\frac{t}{\tau}}$$



when  $t = \tau$



$$y(t) = 1 - e^{-1} = 0.632$$

圖 2-4 RC 電路時間常數

二、RC 電路時域分析，請參考[2]

- 建立 RC 電路如下圖(圖 2-5)

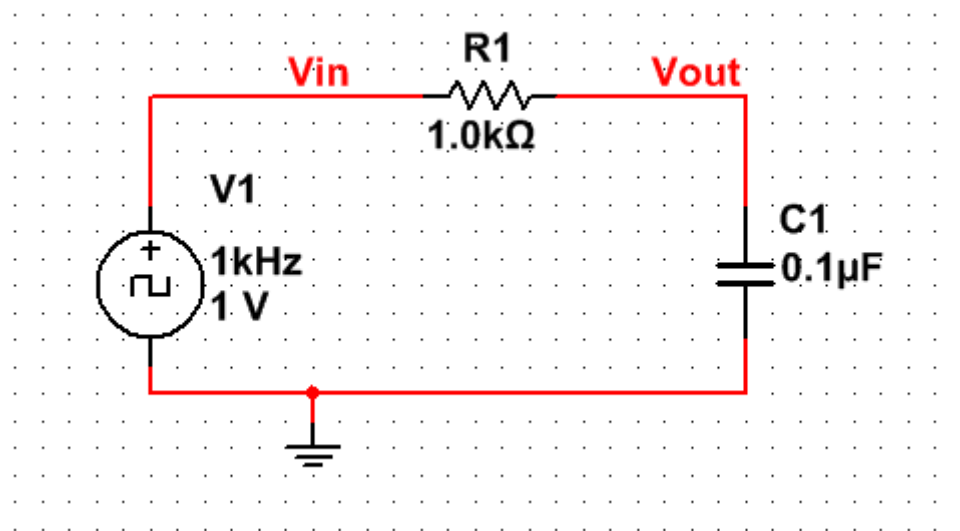
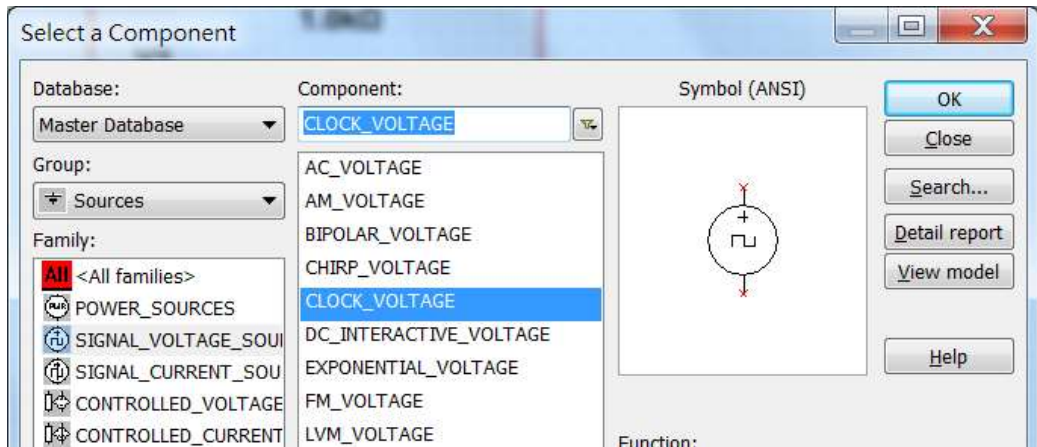


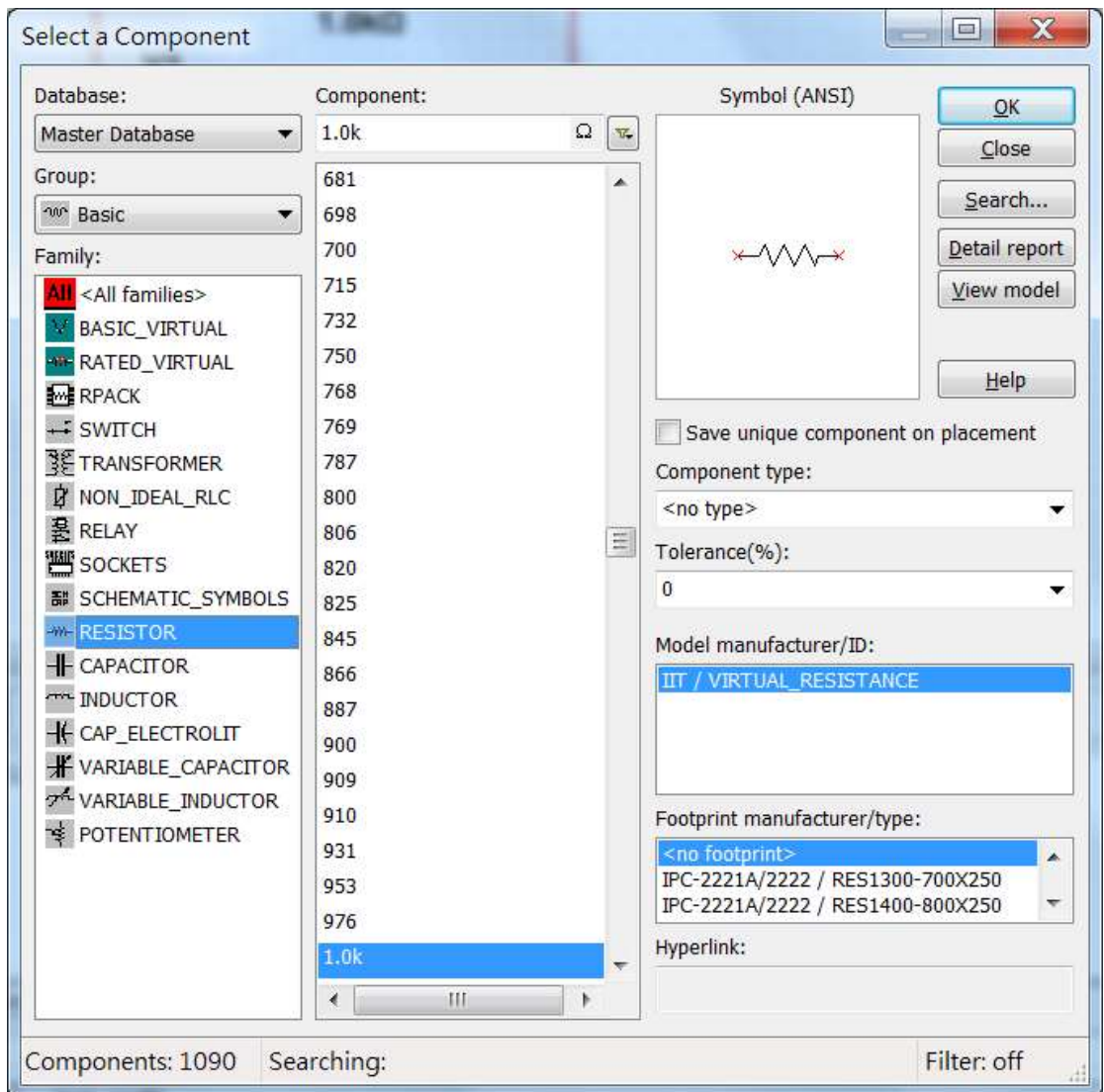
圖 2-5 RC 電路

- 方波訊號源:

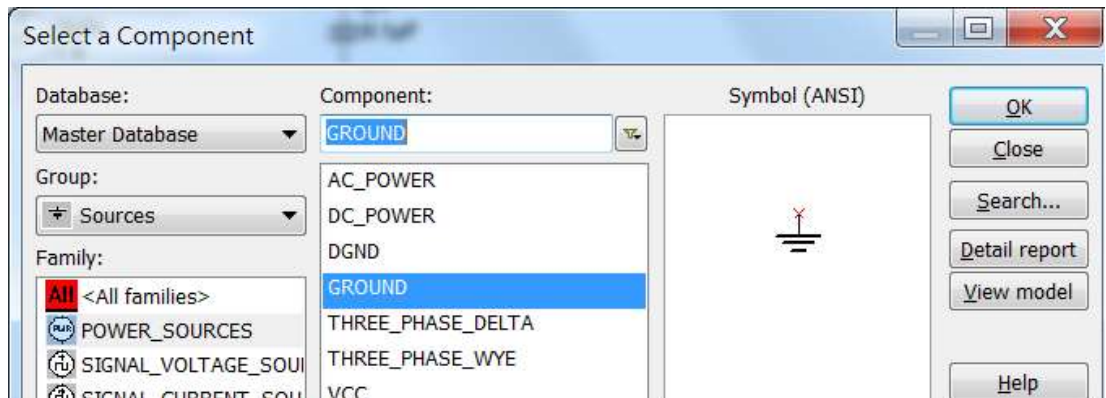
Place→Component→Sources→SIGNAL\_VOLTAGE\_SOURCES→CLOCK\_VOLTAGE



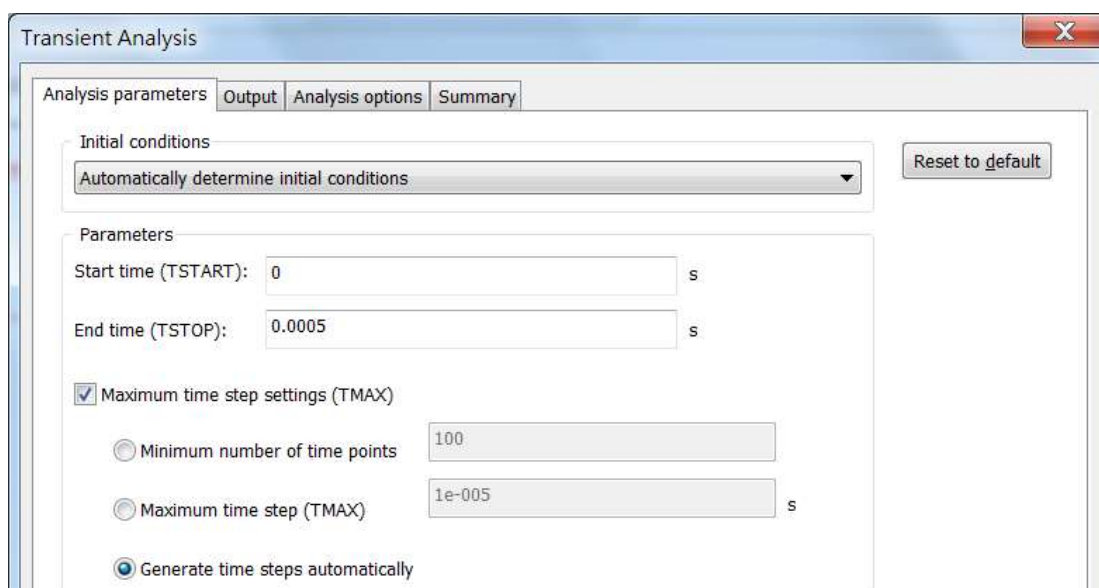
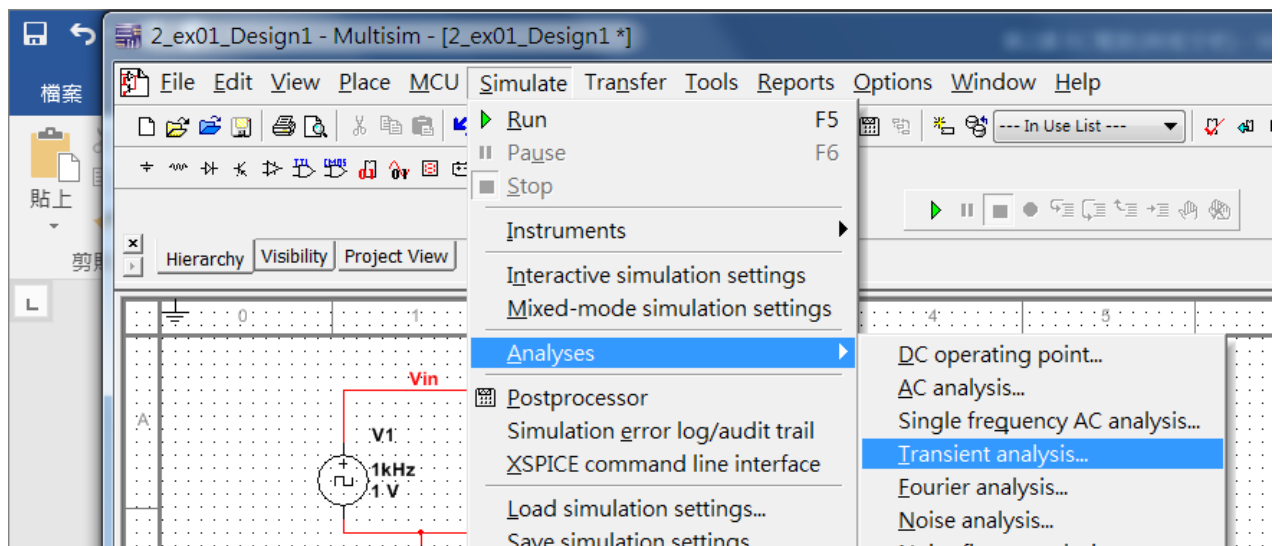
- 電阻: Place→Component→Basic →RESISTOR →1.0K



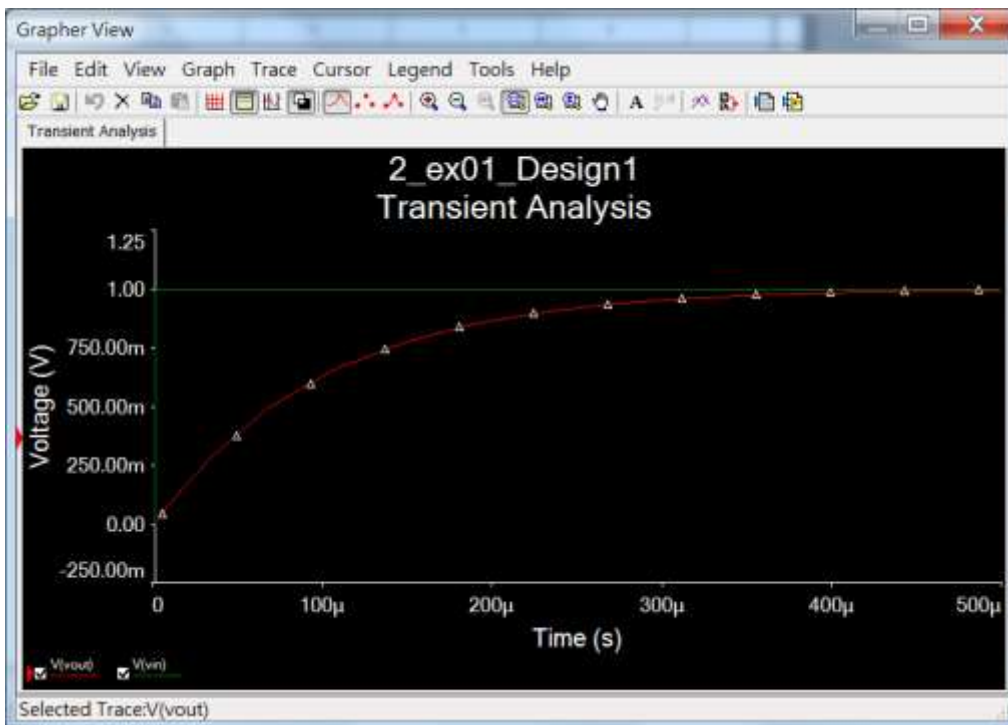
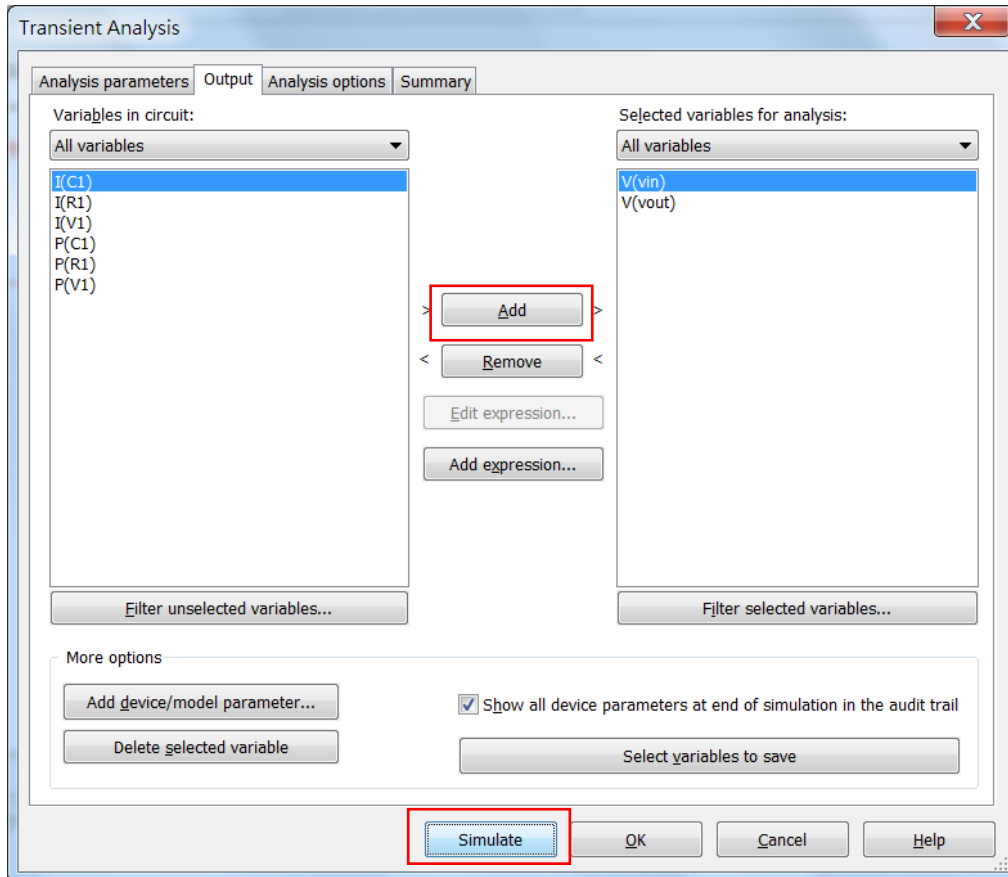
- 電容: Place→Component→Basic →CAPACITOR →1.0U (隨後修改為 0.1 UF)
- 接地: Place→Component→Sources→POWER\_SOURCES→GROUND



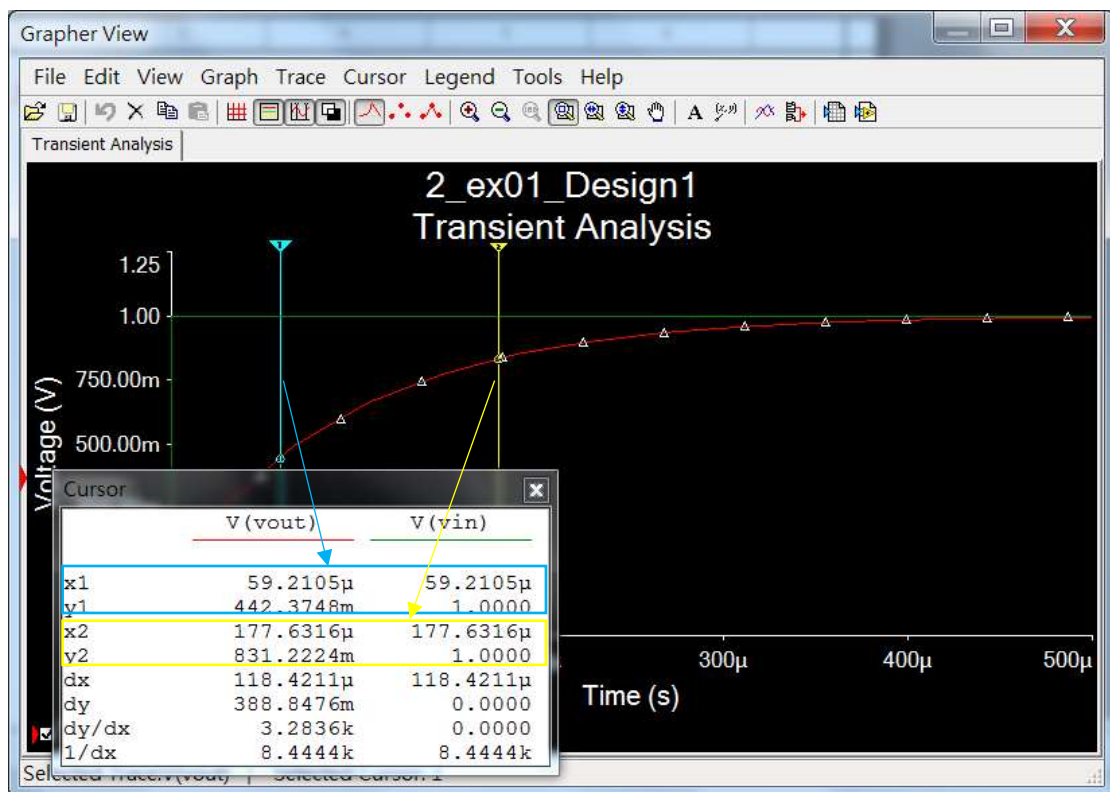
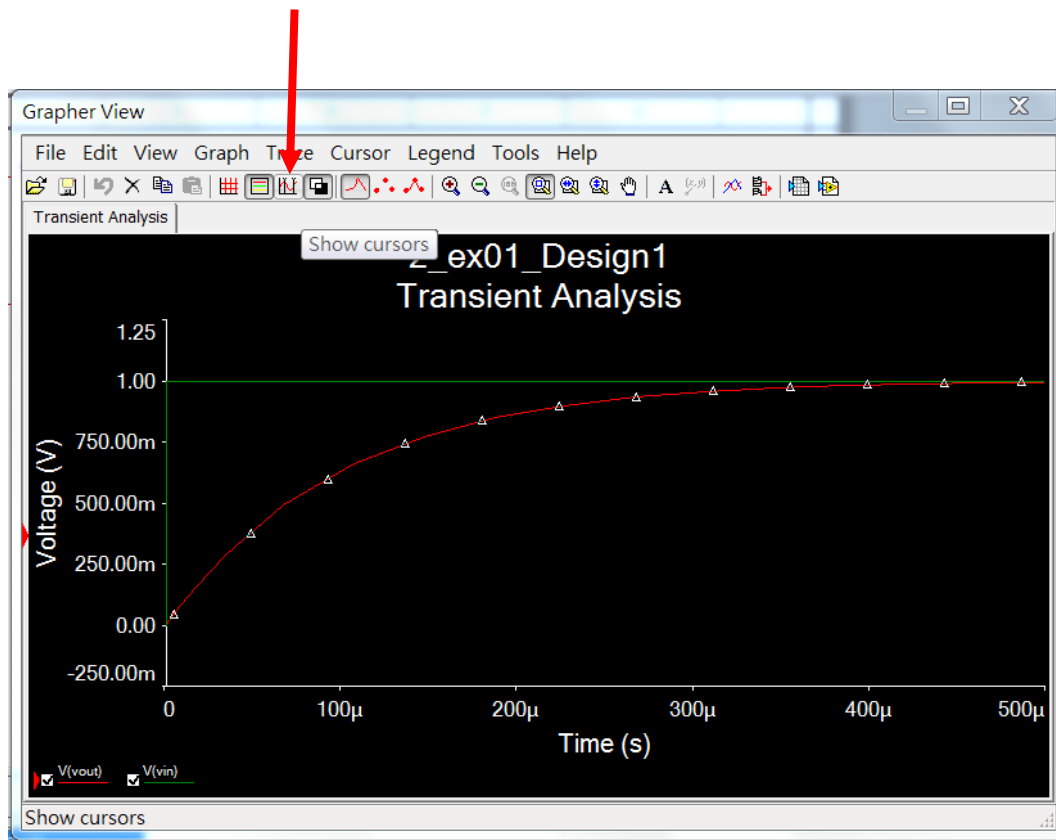
- 暫態分析設定



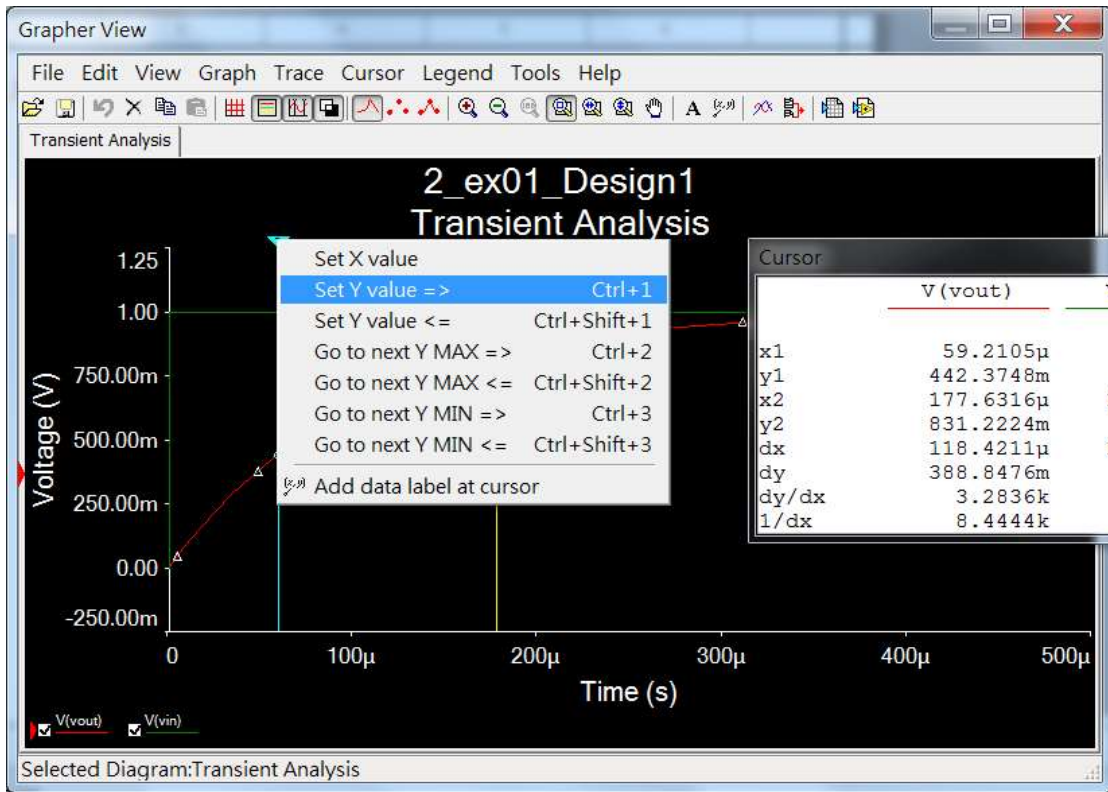
Add V(vin), V(vout) , 隨後 Simulate



使用 “Show cursors” 測量各點數值



針對 cursors 1，按下右鍵，為找 0V 升到 0.632V 的時間，選 Set Y value => 0.632



Set Y value => Ctrl+1 on Crosshair\_1

Value:

OK

Cancel

Cursor

	V (vout)	V (vin)
x1	100.4000μ	100.4000μ
y1	632.0000m	1.0000
x2	177.6316μ	177.6316μ
y2	831.2224m	1.0000
dx	77.2315μ	77.2315μ
dy	199.2224m	0.0000
dy/dx	2.5795k	0.0000
1/dx	12.9481k	12.9481k

$X1 = 100.4\mu s = (\text{近似於}) 1.0 k * 0.1\mu = 1000 \times 0.000001 = 0.001 = R * C (\text{time})$



constant, 時間常數)

三、

- 作業 2-1:
  1. 完成下圖(圖 2-6A)
  2. 請推導  $V_{out}$  的數學式，如圖 2-6B

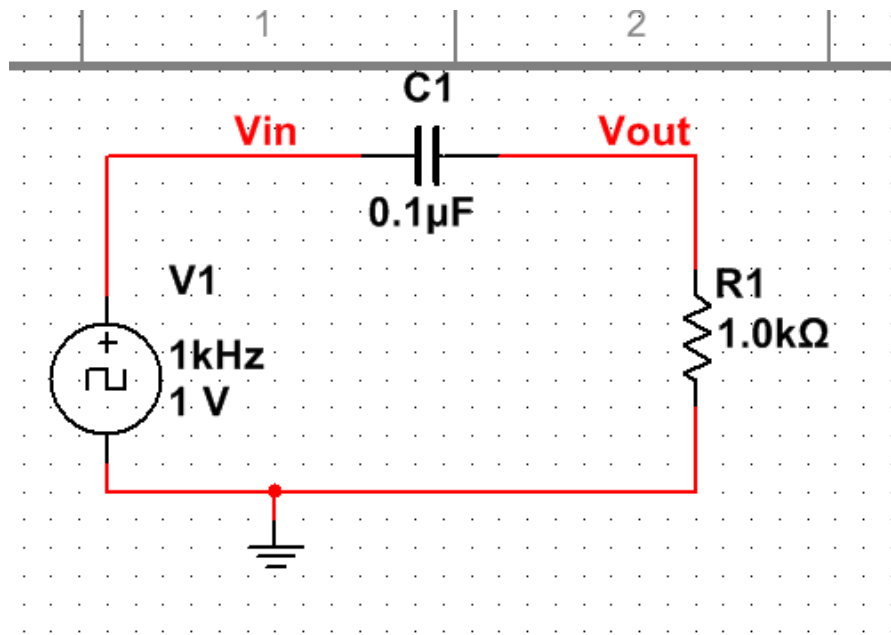


圖 2-6A 作業 2-1 電路

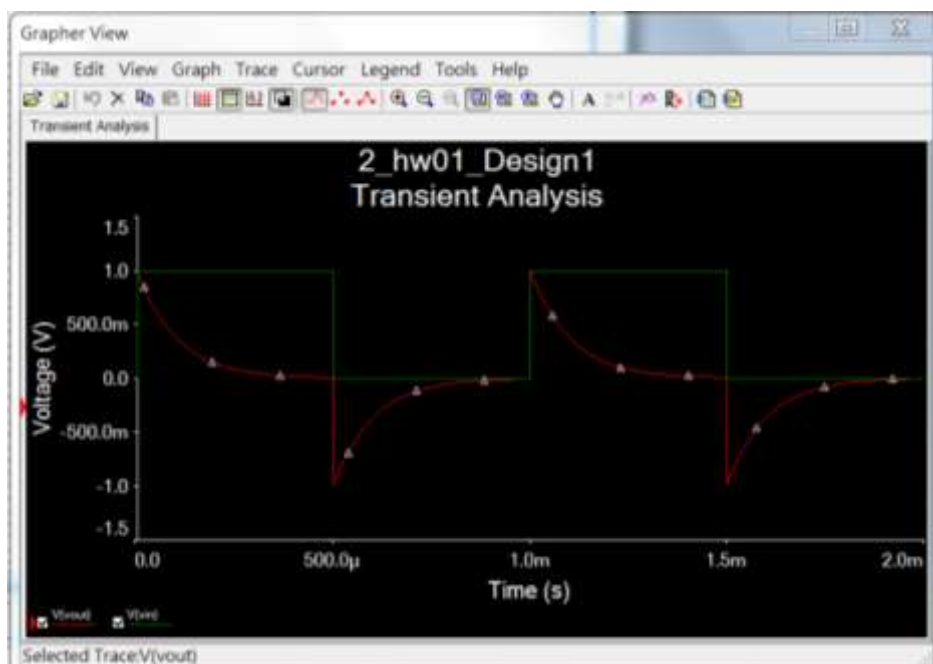


圖 2-6B 作業 2-1  $V_{out}$  波形

- 作業 2-2:
  1. 完成下圖(圖 2-7A)
  2. 請推導  $V_{out}$  的數學式，如圖 2-7B

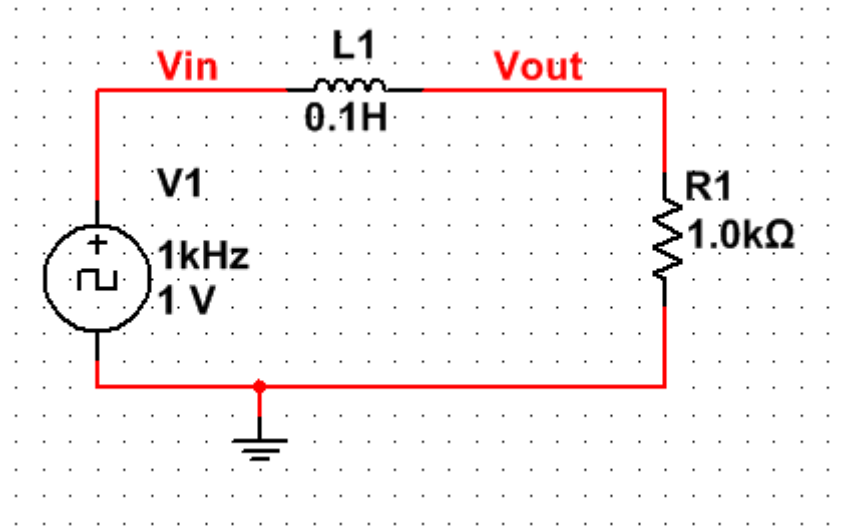


圖 2-7A 作業 2-2 電路

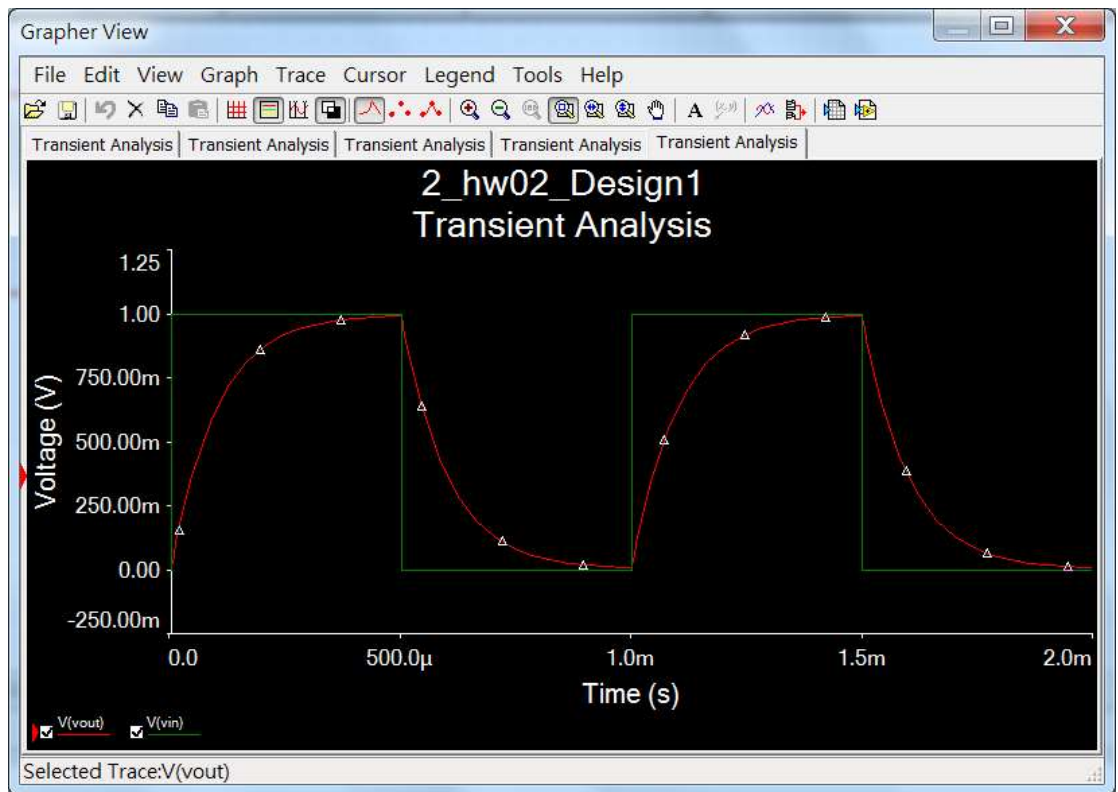


圖 2-7B 作業 2-2  $V_{out}$  波形