

AIC Lab

Tutorial---Hspice

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Outline

Hspice

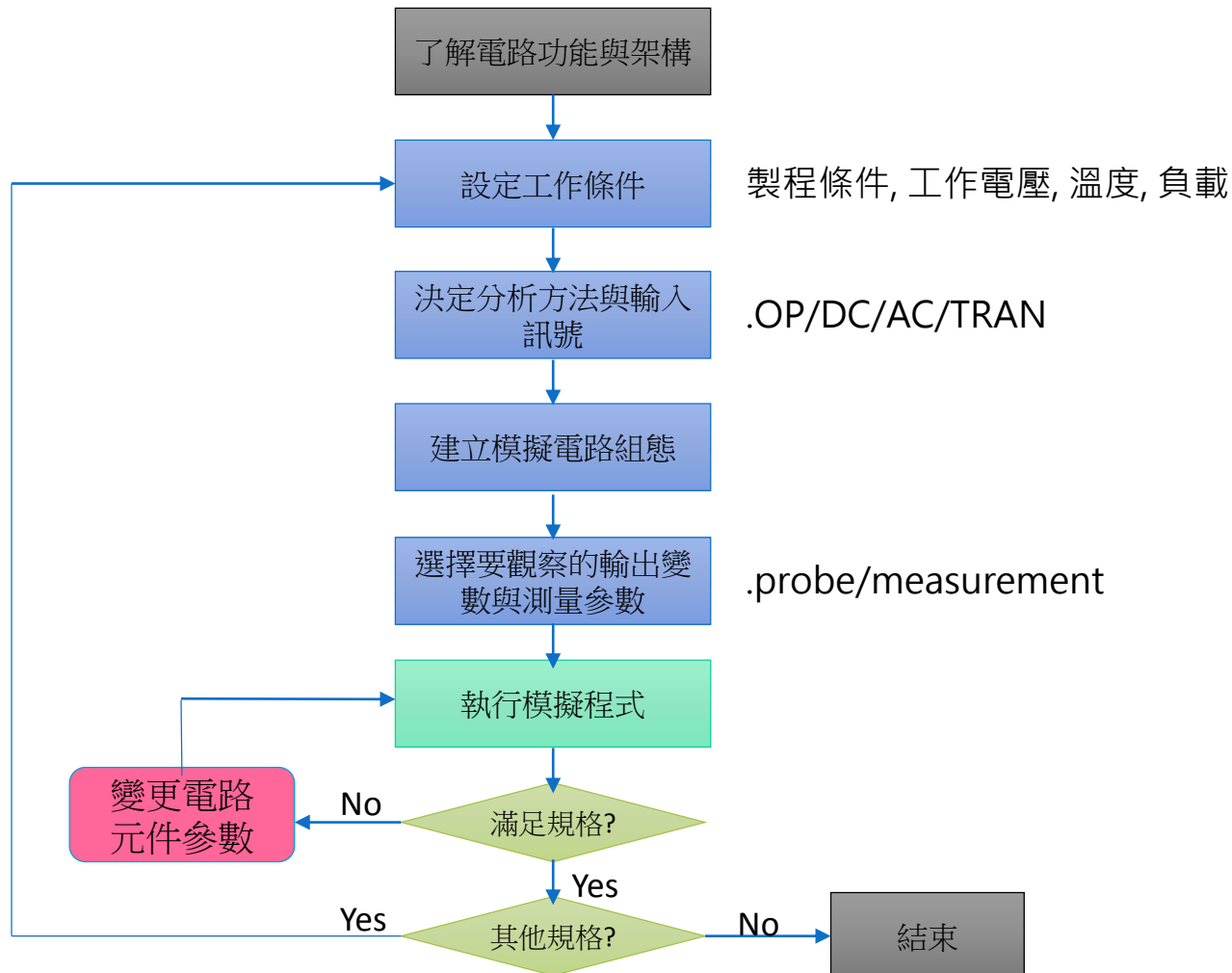
- Edit circuit netlist
- Run circuit simulation

WaveView

- Observe the waveform

Task	Software tool
Circuit design	Text editor/Wordpad/Notepad
<i>Circuit simulation</i>	<i>Hspice</i>
Waveform observation	WaveView

Spice Design Flow



Netlist format

Title	----->	Title Statement - Ignored during simulation
Controls	----->	.option nomod nopage
	----->	.tran 1 10
	----->	.print v(5) i(r1)
	----->	.plot v(3) v(in)
	----->	* voltage sources
Sources	----->	v3 3 0 dc 0 ac 0 0 pulse 0 1 0 0.1 0.1 4 8
	----->	vin in 0 sin(0 2 10k 0.5 0)
	----->	* Components
Components	----->	c2 2 0 2pf
	----->	r1 1 0 1k
	----->	m1 1 2 3 4 mod L=10u W=30u
	----->	x3 2 3 INV
	----->	*Model & Subcircuit
Models & Subckts	----->	.model... or .LIB or .Subckt
End file	----->	.end

.option : 控制參數的設定所要描述的資料記錄

* : 註解

.print/.plot : 數值記錄/簡易波形記錄

.op : 各個元件的工作情況

Naming Rules of Instances and Nodes

❑ Either Alphabetic Character or Numbers (EX. V1, V22)

❑ 0, GND, GND!, GROUND is Always Ground.

❑ 數字前的"0"以及數字後的"字元"是被忽略的

EX. 01=1、0025=25、15AB=15、8C=8B=8AB=8

❑ 不同階層的電路中，節點的名稱可以重複

❑ 利用 **.GLOBAL** 可以統一宣告各層節點名稱 EX. .GLOBAL VDD VSS

❑ 英文字母不分大小寫 EX. N1=n1, GND=gnd

Instance and Element Names

Alphabetic Character	Instance
C	Capacitor
D	Diode
E,F,G,H	Dependent Current and Voltage Controlled Sources
I	Independent Current source
J	JFET
K	Mutual Inductor
L	Inductor
M	MOSFET
Q	BJT
R	Resistor
V	Independent Voltage source
X	Subcircuit

Description of Elements

●Element:

- 元件名稱 <節點1 節點2 ... 節點N> <model name> <參數1=參數值> + <參數2=參數值> ... <並聯個數>

Ex. M1 2 3 0 0 N_18 L=10u W=50u *指定MOS長=10 μ m、寬=50 μ m

Ex. R1 AA BB 10k *指定電阻R=10k Ω

- 電阻R單位為Ohm (Ω) (Ex. R1 n1 n2 1K)
- 電容C單位為Farad (F) (Ex. C1 n3 n4 1e-12)
- 電感L單位為Henry (H) (Ex. L1 n5 n6 1e-9)
- Scale factors :

F	1e-15
P	1e-12
N	1e-19
U	1e-6
M	1e-3

K	1e3
Meg	1e6
G	1e9
T	1e12
DB	20log ₁₀

Examples:

1pF
1nH
10Meg Hz
vdb(v3)

Description of Source and Stimuli (1/6)

●Source type:

✓ 固定值獨立電源

提供固定偏壓或固定驅動電源

✓ 時變 獨立電源

提供變動的地壓或電流輸入

✓ 時變 壓控/源控 相依電源

提供可控制的電壓或電流源

Voltage Controlled Voltage Source (VCVS)

Voltage Controlled Current Source (VCCS)

Current Controlled Voltage Source (CCVS)

Current Controlled Current Source (CCCS)

Description of Source and Stimuli (2/6)

● Independent Source

■ Syntax :

```
Vxxx n+ n- <<DC=>dcval> <tranfun> <AC=acmag, <acphase>>
lyyy n+ n- <<DC=>dcval> <tranfun> <AC=acmag, <acphase> <M=val>
```

■ Examples of DC & AC Sources :

```
V1 1 0 DC=5V
V2 2 0 5V
I3 3 0 5mA
```

```
V4 4 0 AC=10V, 90
V5 5 0 AC 1.0 180
```

***AC or Freq. Response Provide Impulse Response**

■ Examples of Mixed Sources :

```
V6 6 0 5V AC=1V, 90
V7 7 0 0.5V AC 1.0 SIN (0 1 1Meg)
```

Description of Source and Stimuli (3/6)

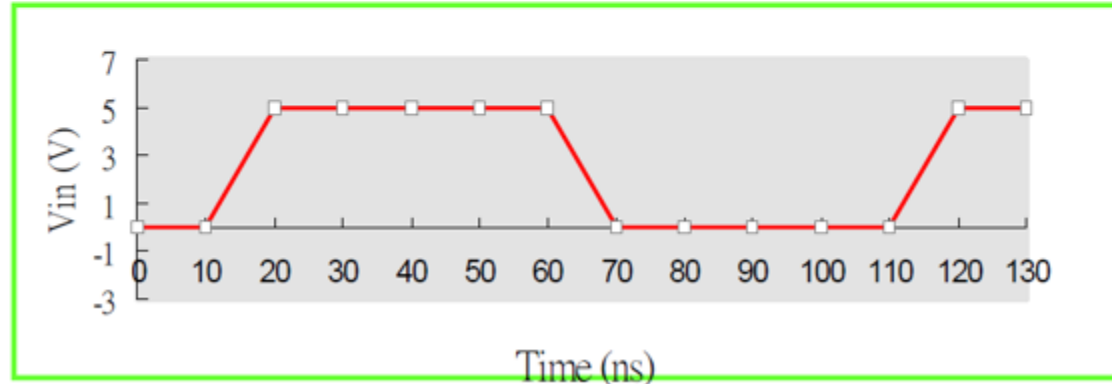
● Pulse source

■ Syntax :

PULSE (V1 V2 < Tdelay Trise Tfall Pwidth Period >)

■ Example :

Vin 1 0 PULSE (0V 5V 10ns 10ns 10ns 40ns 100ns)



Description of Source and Stimuli (4/6)

● Sinusoidal source

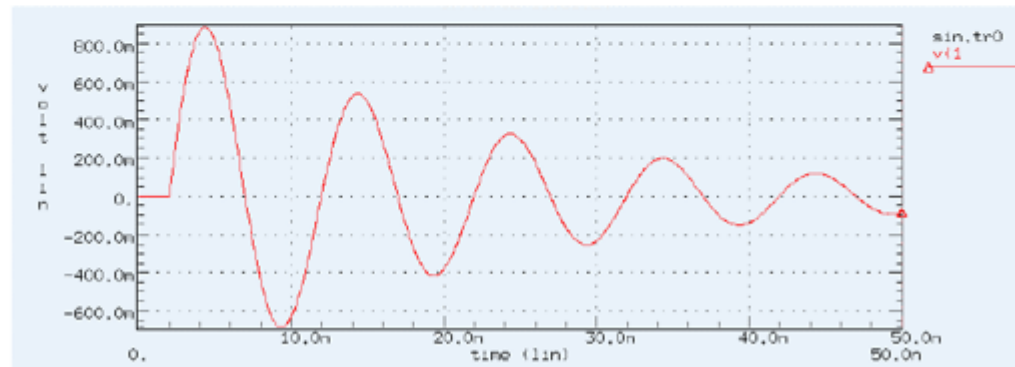
■ Syntax :

SIN (Voffset Vacmag < Freq Tdelay Dfactor >)

Voffset + Vacmag * e^{-(t-TD)} * Dfactor * sin(2π Freq(t-TD))

■ Example :

Vin 3 0 SIN (0V 1V 100Meg 2ns 5e7)



Description of Source and Stimuli (5/6)

●PWL source

■ Syntax :

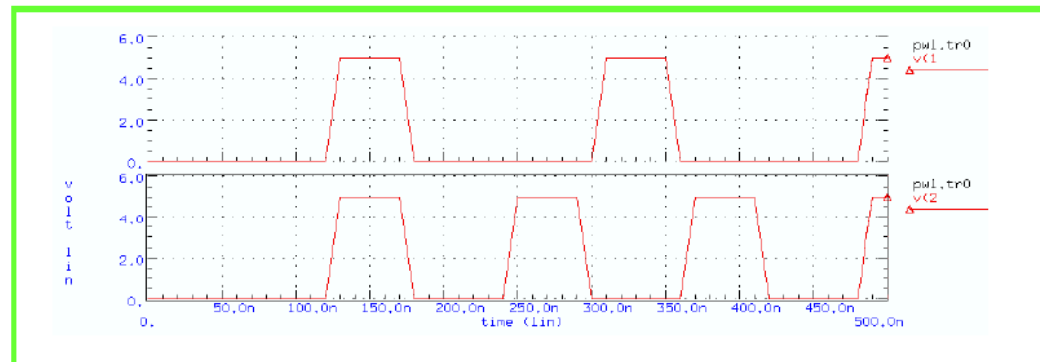
PWL (*<t1 v1 t2 v2* *<R<=repeat>* *<Tdelay=delay>*)

\$ R=repeat_from_what_time TD=time_delay_before_PWL_start

■ Example :

V1 1 0 PWL 60n 0v, 120n 0v, 130n 5v, 170n 5v, 180n 0v, R 0

V2 2 0 PL 0v 60n, 0v 120n, 5v 130n, 5v 170n , 0v 180n , R 60n



Description of Source and Stimuli (6/6)

● Dependent source

■ Four Typical Linear Controlled Sources :

Voltage Controlled Voltage Sources (VCVS) --- **E** Elements
 Voltage Controlled Current Sources (VCCS) --- **G** Elements
 Current Controlled Voltage Sources (CCVS) --- **H** Elements
 Current Controlled Current Sources (CCCS) --- **F** Elements

<i>E(name)</i>	<i>N+</i>	<i>N-</i>	<i>NC+</i>	<i>NC-</i>	<i>(Voltage Gain Value)</i>
<i>Eopamp</i>	3	4	1	2	1e6
<i>Ebuf</i>	2	0	1	0	1.0

- Voltage Controlled Resistor (VCR) and Capacitor (VCCAP)
- Polynomial Controlled Sources **POLY(1)**, **POLY(2)**, **POLY(3)**

Description of Subcircuit

■ .SUBCKT Syntax

.SUBCKT *subname* *n1* <*n2 n3...*> <*param=val...*>

n1 ... Node Number for External Reference; Cannot be **Ground node (0)**
Any Element Nodes Appearing in Subckt but not Included in this list are Strictly **LOCAL**, with these **Exceptions** :

- (1) **Ground Node (0)**
- (2) Nodes Assigned using **.GLOBAL** Statement
- (3) Nodes Assigned using **BULK=node** in MOSFET or BJT Models

param Used **ONLY** in Subcircuit, **Overridden** by Assignment in Subckt Call or by values set in **.PARAM** Statement

■ Subcircuit Calls (X Element Syntax)

.Xyyyy *n1* <*n2 n3...*> *subname* <*param=val...*> <*M=val*>

.XNOR3 1 2 3 4 **NOR** WN=3u LN=0.5u M=2

● .SUBCKT Statement : Examples

```
.GLOBAL VDD
VDDA VDD 0 VALUE
.PARAM VALUE=5V
:
:
.TRAN 1n 100n
*
.SUBCKT INV IN OUT WN=2u WP=8u
M1 OUT IN VDD VDD P L=0.5u W=WP
M2 OUT IN 0 0 N L=0.5u W=WN
R1 OUT 4 1K
R2 4 5 10K
.ENDS INV
*
X1 1 2 INV WN=5u WP=20u
X2 2 3 INV WN=10u WP=40u
*
.PRINT TRAN V(2) V(X1.4) I(X2.M1)
```

Description of .ALTER and .TEMP (1/2)

- .ALTER : 一次模擬可連續執行不同狀況之分析
- .DEL LIB : 移除先前指定的Library內容
- .TEMP : 設定環境溫度

● Example:

*file2: alter2.sp	alter examples	\$ Title Statement
.lib 'mos.lib'	normal	
.param wval=50u	Vdd=5V	
r4	4 3 100	
:		
.alter		
.del lib 'mos.lib'	normal	\$ remove normal model lib
. lib 'mos.lib'	fast	\$ get fast model lib
.alter		
.temp	-50 0 50	\$ run with different temperature
r4	4 3 1K	\$ change resistor value
c3	3 0 10p	\$add the new element
.param wval=100u	Vdd=5.5V	\$ change parameters
.end		

Description of **.ALTER** and **.TEMP** (2/3)

● **.ALTER Statement : Limitations**

■ **CAN Include:**

- ➔ Element Statement (Include Source Elements)
- ➔ **.DATA, .LIB, .INCLUDE, .MODEL** Statements
- ➔ **.IC, .NODESET** Statement
- ➔ **.OP, .PARAM, .TEMP, .TF, .TRAN, .AC, .DC** Statements

■ **CANNOT Include:**

- ➔ **.PRINT, .PLOT, .GRAPH**, or any I/O Statements

Description of .ALTER and .TEMP (3/3)

● .TEMP Statement: Description

- When TNOM is not Specified, it will Default to 25 °C for HSPICE

When TNOM is not Specified, it will Default to 27 °C for SBTSPICE

- Example 1:

```
.TEMP 30 $ Ckt simulated at 30 °C
```

- Example 2:

```
.OPTION TEMP = 30 $ Ckt simulated at 30 °C
```

- Example 3:

```
.TEMP 100
```

```
D1 n1 n2 DMOD DTEMP=30 $ D1 simulated at 130 °C
D2 n3 n4 DMOD $ D2 simulated at 100 °C
R1 n5 n6 1K
```

HSPICE : DTEMP

SBTSPICE : TEMP

Analysis Types

●Types :

❑DC Operating Point :

✓.OP *計算及產生完整的直流工作點資訊

❑DC Sweep and DC Small Signal Analysis :

✓.DC

❑AC Sweep and Small Signal Analysis :

✓.AC

❑Transient Analysis :

✓.TRAN

Analysis Type : .DC

● .DC Analysis : Syntax

```
.DC var1 start1 stop1 incr1 < var2 start2 stop2 incr2 > )
```

```
.DC var1 start1 stop1 incr1 < SWEEP var2 DEC/OCT/LIN/POI np start2 stop2 > )
```

● Examples :

```
.DC VIN 0.25 5.0 0.25
```

```
.DC VDS 0 10 0.5 VGS 0 5 1
```

```
.DC TEMP -55 125 10
```

```
.DC TEMP POI 5 0 30 50 100 125
```

```
.DC xval 1k 10k 0.5k SWEEP TEMP LIN 5 25 125
```

```
.DC DATA=datanm SWEEP par1 DEC 10 1k 100k
```

```
.DC par1 DEC 10 1k 100k SWEEP DATA=datanm
```

Analysis Type : **.AC**

● **.AC Analysis : Syntax**

```
.AC DEC/OCT/LIN/POI np fstart fstop  
.AC DEC/OCT/LIN/POI np fstart fstop < SWEEP var start stop incr > )
```

● **Examples :**

```
.AC DEC 10 1K 100MEG  
.AC LIN 100 1 100Hz  
.AC DEC 10 1 10K SWEEP Cload LIN 20 1pf 10pf  
.AC DEC 10 1 10K SWEEP Rx POI 2 5K 15K  
.AC DEC 10 1 10K SWEEP DATA=datanm
```

Analysis Type : **.TRAN**

● **.TRAN Analysis : Syntax**

```
.TRAN tincr1 tstop1 < tincr2 tstop2 ..... > < START=val>  
.TRAN tincr1 tstop1 < tincr2 tstop2 ..... > < START=val> UIC <SWEEP..>
```

● **Examples :**

```
.TRAN 1NS 100NS  
.TRAN 10NS 1US UIC  
.TRAN 10NS 1US UIC SWEEP TEMP -55 75 10 $ step=10  
.TRAN 10NS 1US SWEEP load POI 3 1pf 5pf 10pf  
.TRAN DATA=datanm
```

HSPICE

目前模擬的檔案

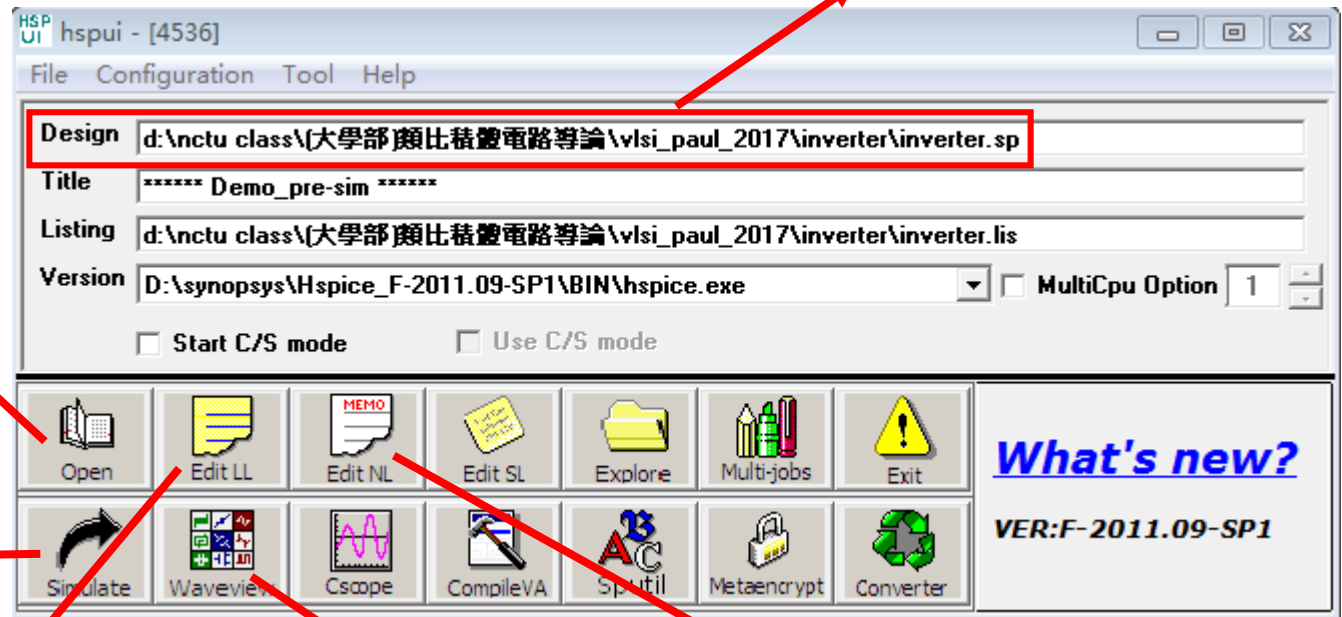
選擇模擬檔案

執行模擬

Open XXX.lis
(電路模擬後的結果)

Waveview
觀察波形

Open XXX.sp



■ Grapg Data File (Waveview打開)

1. XXX.tr0：暫態波形資料
2. XXX.sw0：穩態波形資料
3. XXX.ac0：交流波形資料

■ Text Output File (文字編輯器打開)

1. XXX.ic0
2. XXX.st0
3. XXX.ms0
4. XXX.mt0
5. XXX.ma0
6. XXX.pa0

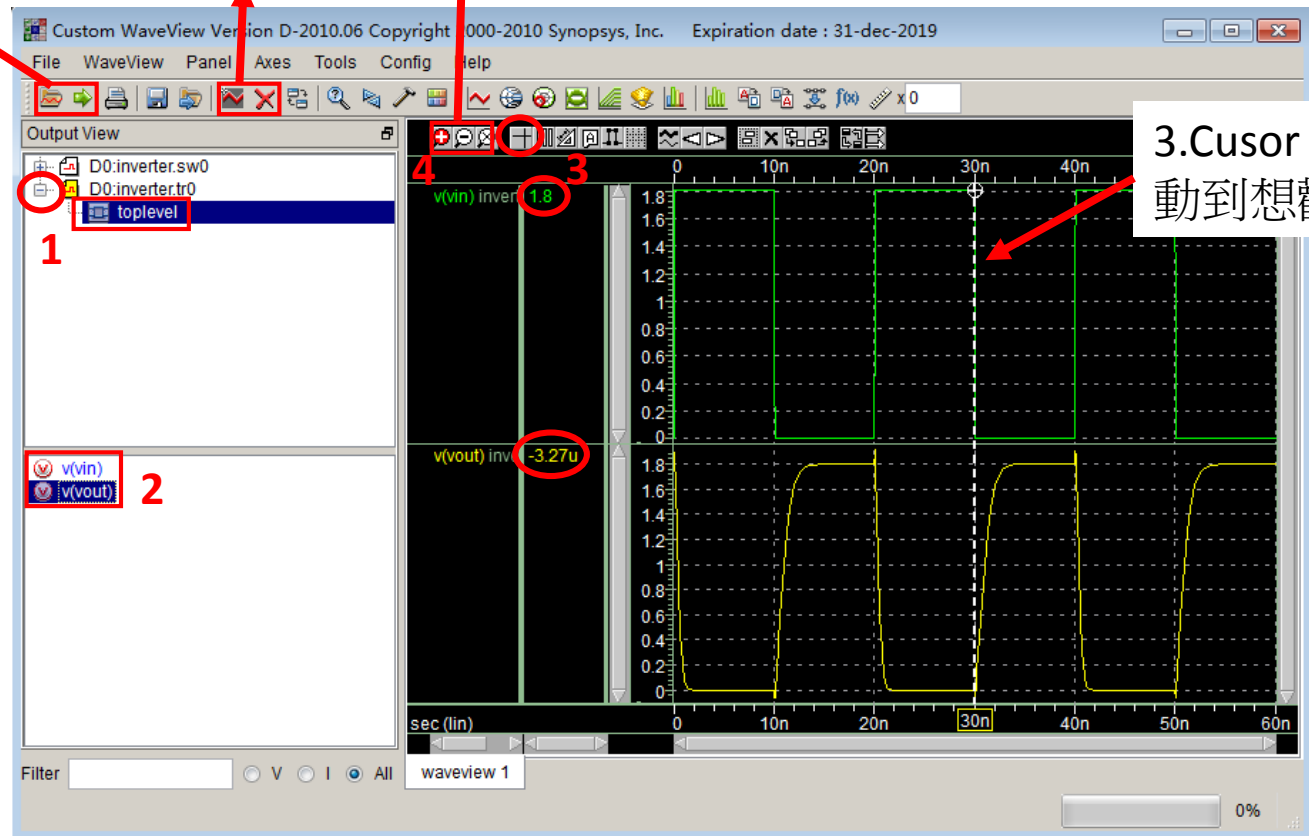
Waveview

- 打開檔案
- 重新載入模擬波形
- 開新Waveview
- 刪除Waveview

4.放大/縮小波形,點一下變垂直放大,在點一下變水平放大;縮小鍵同理

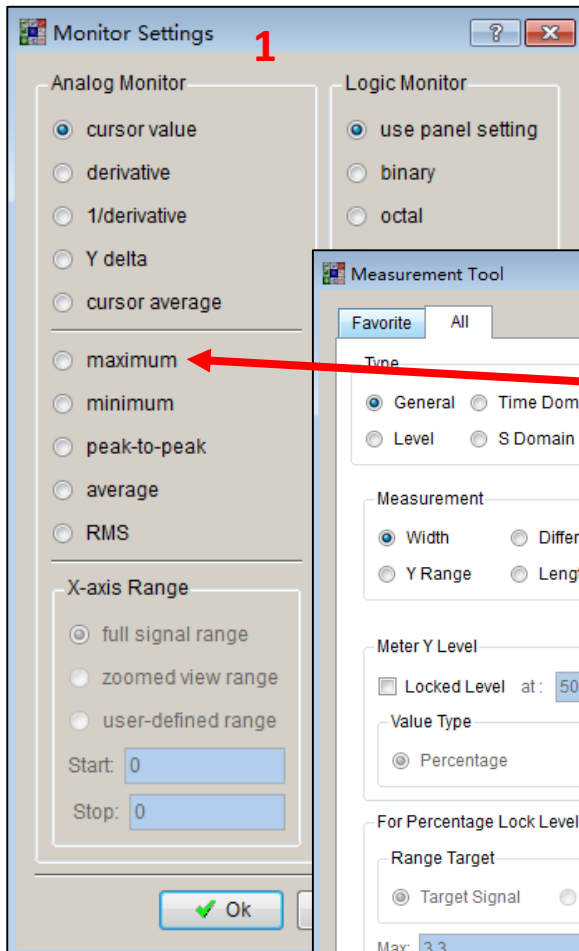
1.展開XXX.tr0後點兩下toplevel

2.點兩下要觀察的波形vin,vout



3.Cusor 可左右移動到想觀察的點

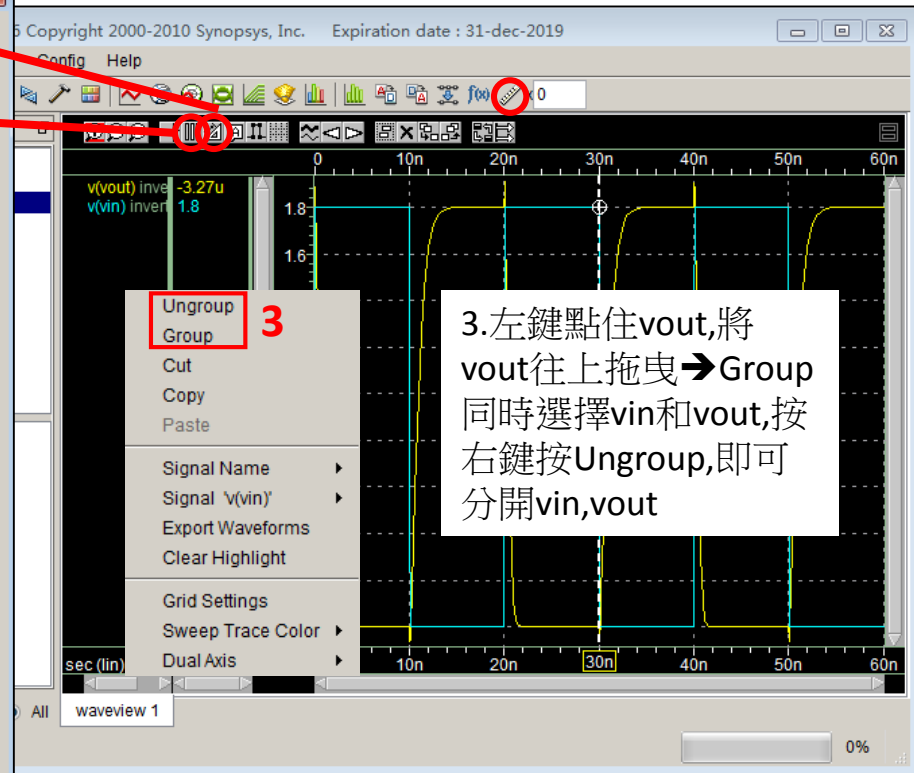
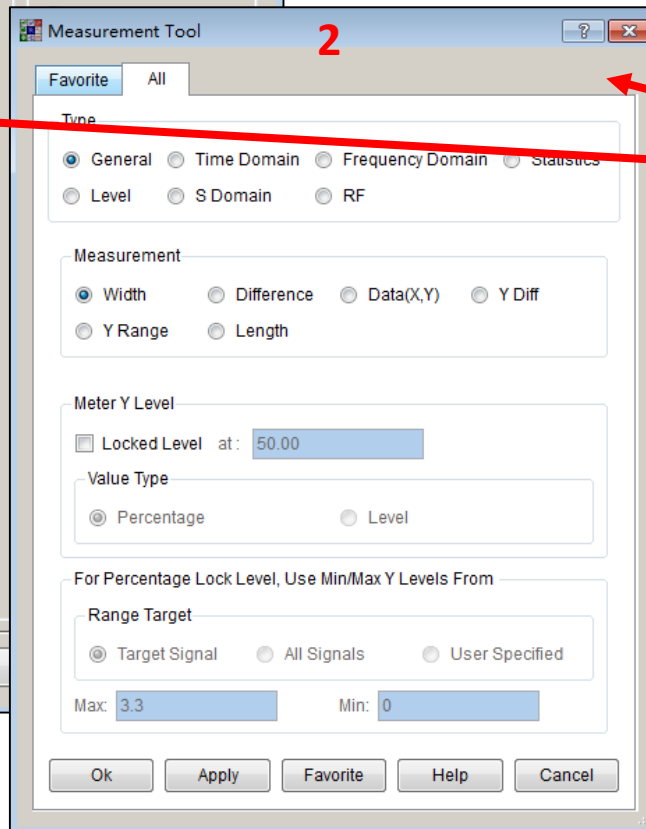
Waveview



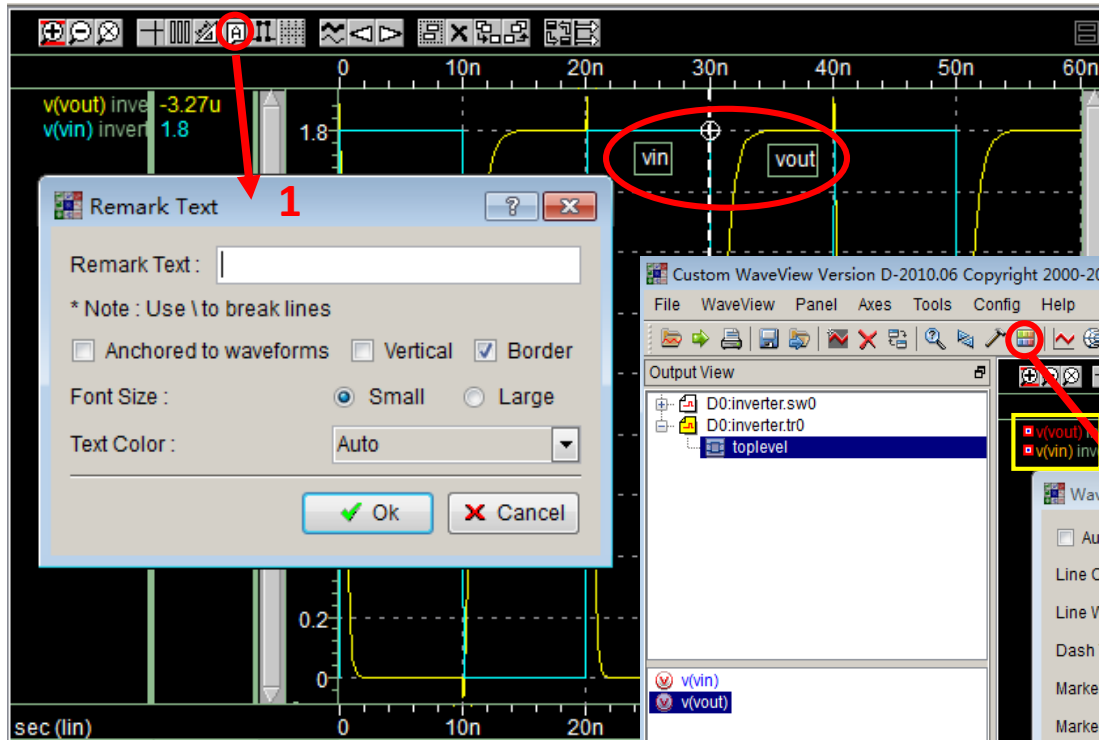
1. Monitor: 可顯示波形的max,min,Vp-p...等值



2. Measurement: 可計算波形的差值,range...等值

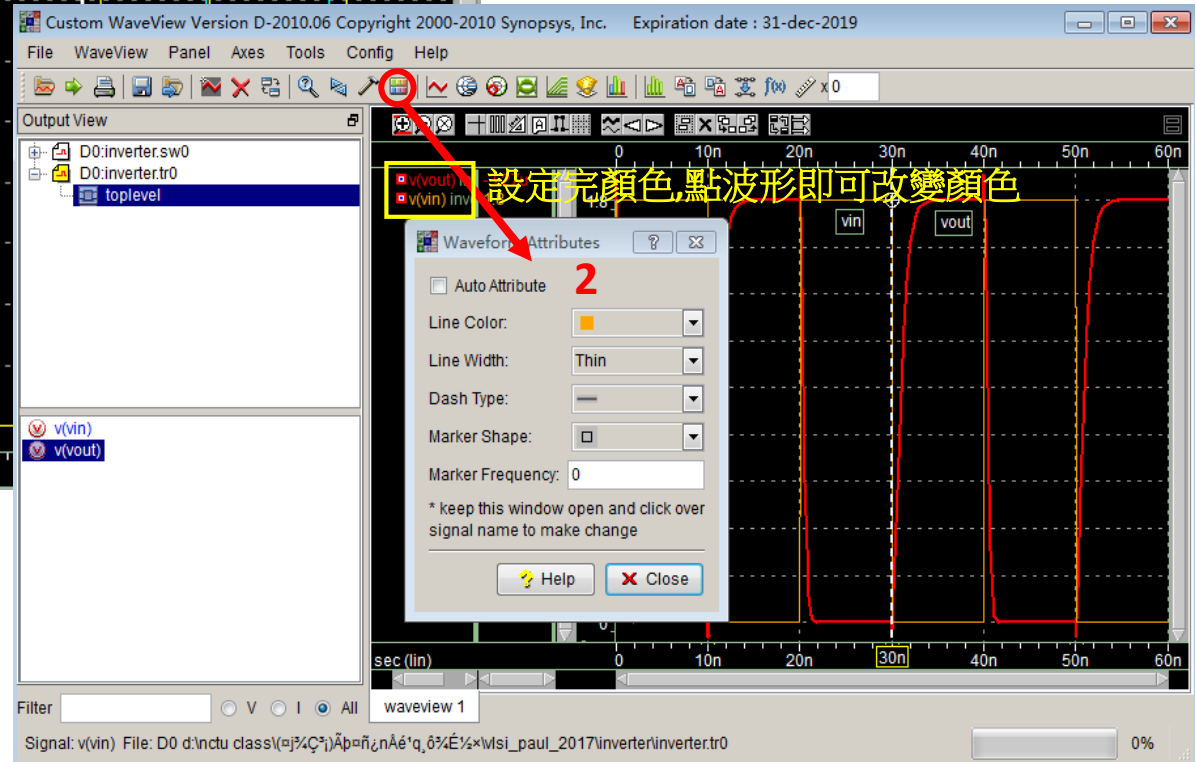


Waveview



1. Remark Text: 可標記波形名稱

2. Measurement: 可改變波形顏色, 粗細



END