Introduction to VLSI Design HW4

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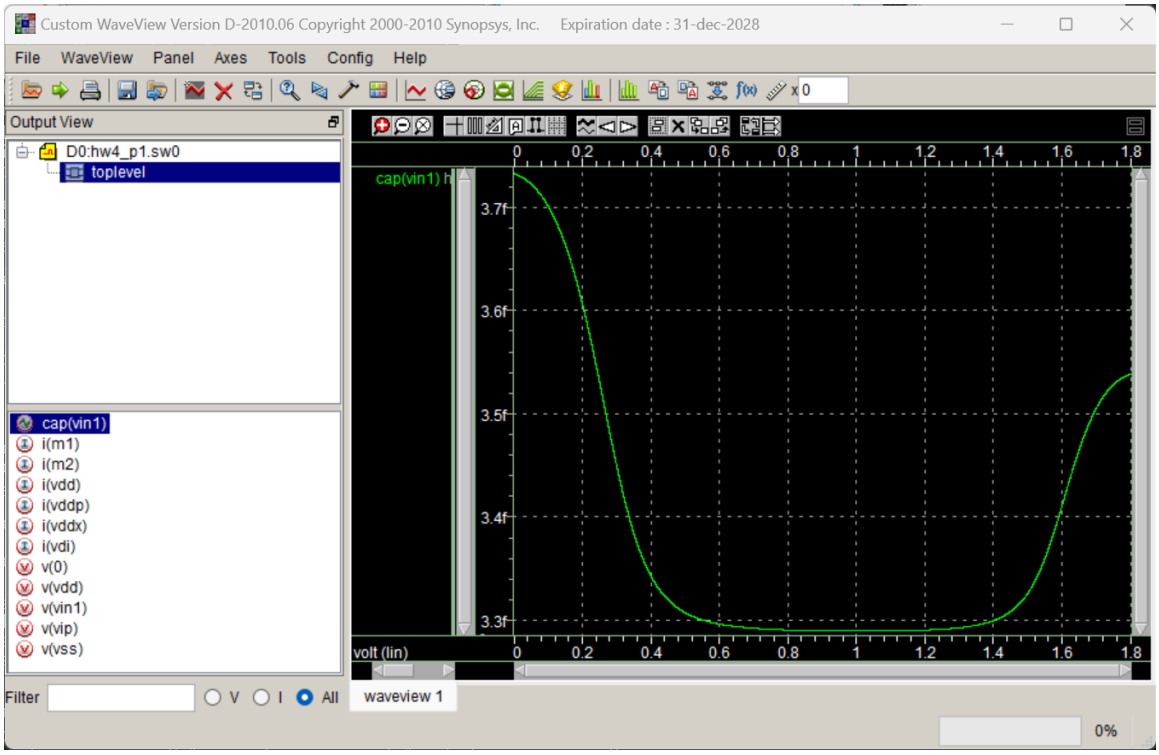
1.

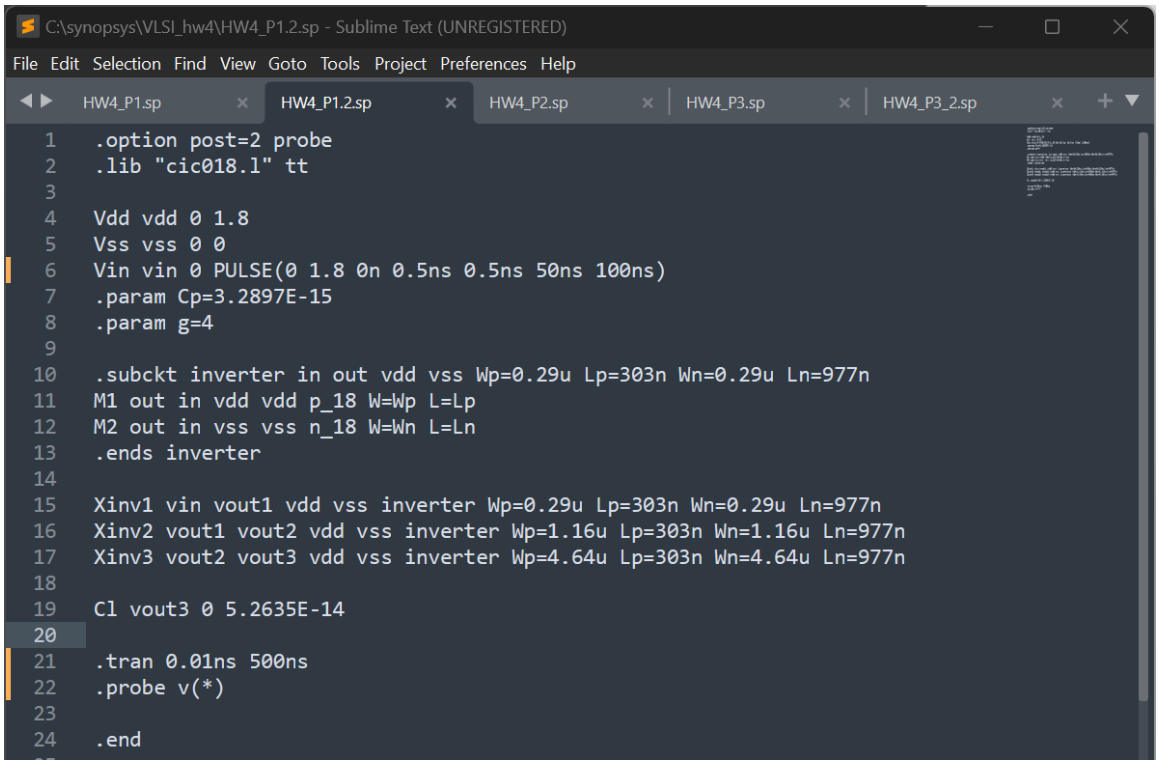
HW4_P1.sp | HW4_P1.2.sp | HW4_P2.sp | HW4_P3.sp | HW4_P3_2.sp

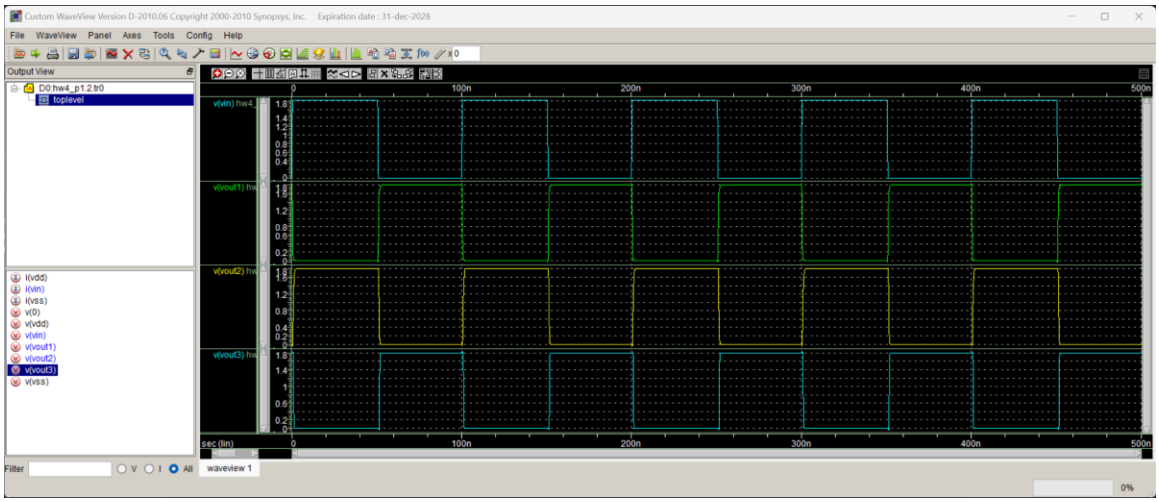
```
******Inverter Design**********
.temp 27
.option list node post
.lib "cic018.l" tt
.unprotect
.option captab=1
.option dccap=1
vdd vdd gnd 1.8
vddx vss gnd 0
vddp vip gnd 0.9
vdi vin1 gnd 0.9
M1     vip      vin1    vss    vss    n_18    W=0.29u      L=977.00n    m=1
M2     vip      vin1    vdd    vdd    p_18    W=0.29u    L=303.00n    m=2
**********************************************************
**********************************************************************
.dc vddp 0 1.8v 0.0001
.probe dc i(M2) i(M1)
.meas dc ix1 find i(M1) at = 0.9
.meas dc ix2 find i(M2) at = 0.9
.meas dc cp find cap(vin1) at=0.9
.end
```

```
*** mosfet element parameters
name          rd eff   rs eff   cdsat    cssat     vto      beta


      0:m1          7.17     7.17   1.3e-16  1.3e-16  534.23m  140.84u
      0:m2          3.59     3.59   1.6e-16  1.6e-16 -446.36m  752.46u
******
******inverter design**********

 ******  dc transfer curves tnom=  25.000 temp=  27.000 *****
  ix1=  1.0002E-05
  ix2= -1.0005E-05
  cp=  3.2897E-15

        ***** job concluded
```



Three inverter add with a 16*cp capacitance:

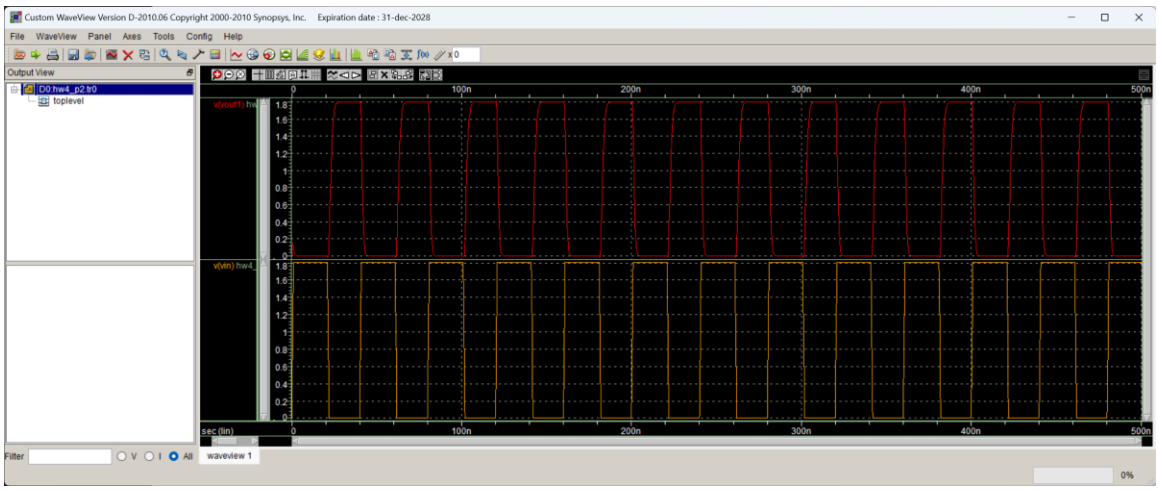




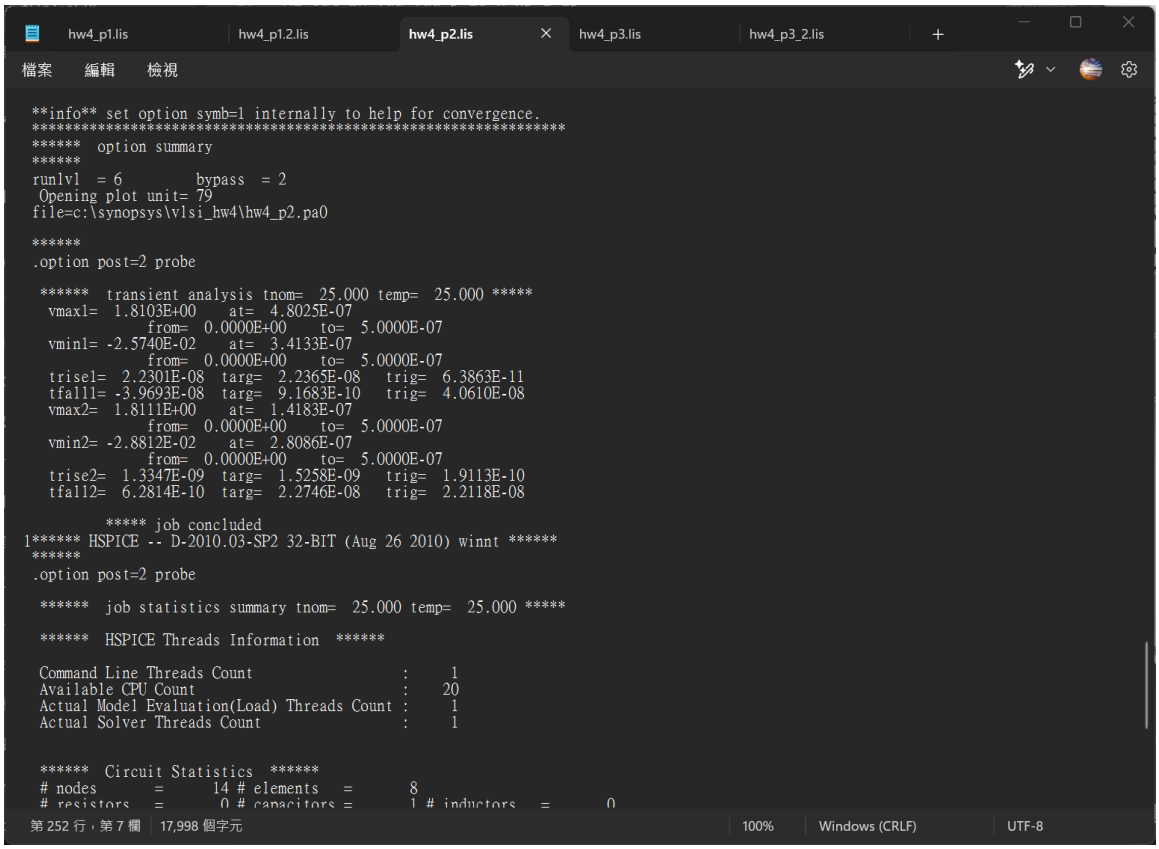
2.

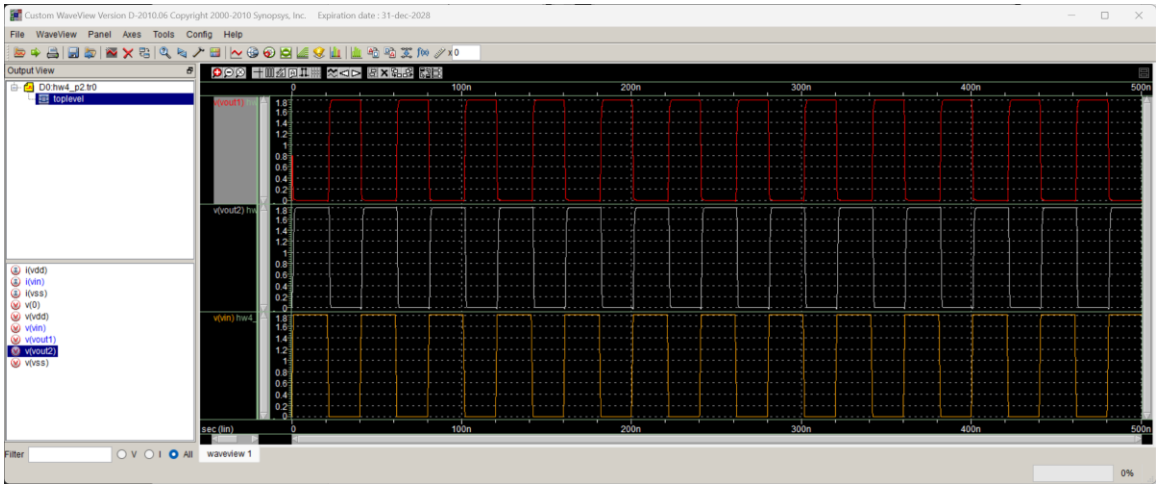
One inverter:

```
  ******
  .option post=2 probe

   ******  transient analysis tnom=  25.000 temp=  25.000 *****
    vmax1=  1.8035E+00    at=  4.0280E-08
                from=  0.0000E+00    to=  5.0000E-07
    vmin1= -1.1180E-02    at=  2.1407E-08
                from=  0.0000E+00    to=  5.0000E-07
    trise1=  2.5992E-09  targ=  2.4582E-08   trig=  2.1983E-08
    tfall1=  1.7994E-09  targ=  4.2651E-08   trig=  4.0851E-08

          ***** job concluded
1****** HSPICE -- D-2010.03-SP2 32-BIT (Aug 26 2010) winnt ******
  ******
  .option post=2 probe

   ******  job statistics summary tnom=  25.000 temp=  25.000 *****

   ******  HSPICE Threads Information  ******

   Command Line Threads Count                 :     1
   Available CPU Count                        :    20
   Actual Model Evaluation(Load) Threads Count :     1
   Actual Solver Threads Count                :     1


   ******  Circuit Statistics  ******
   # nodes       =       9 # elements   =       6
   # resistors   =       0 # capacitors =       1 # inductors   =       0
   # mutual_inds =       0 # vccs       =       0 # vcvs        =       0
```

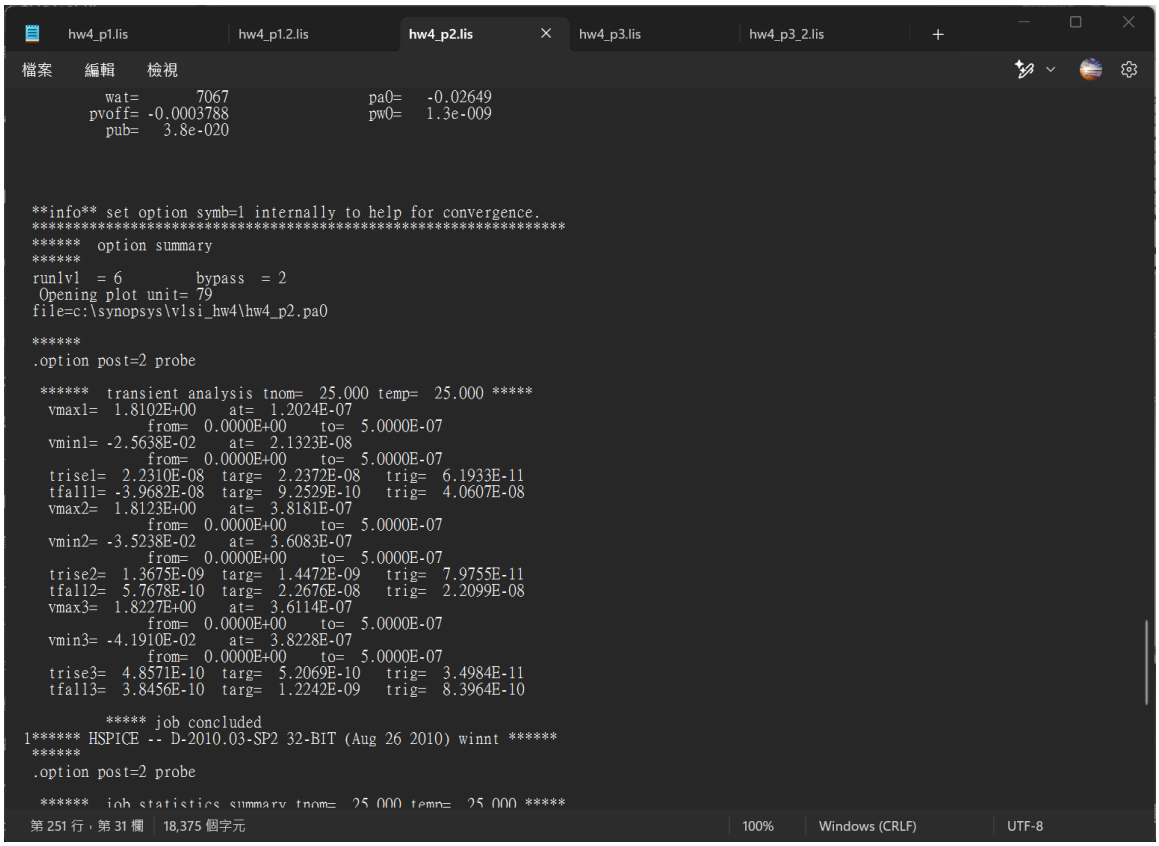


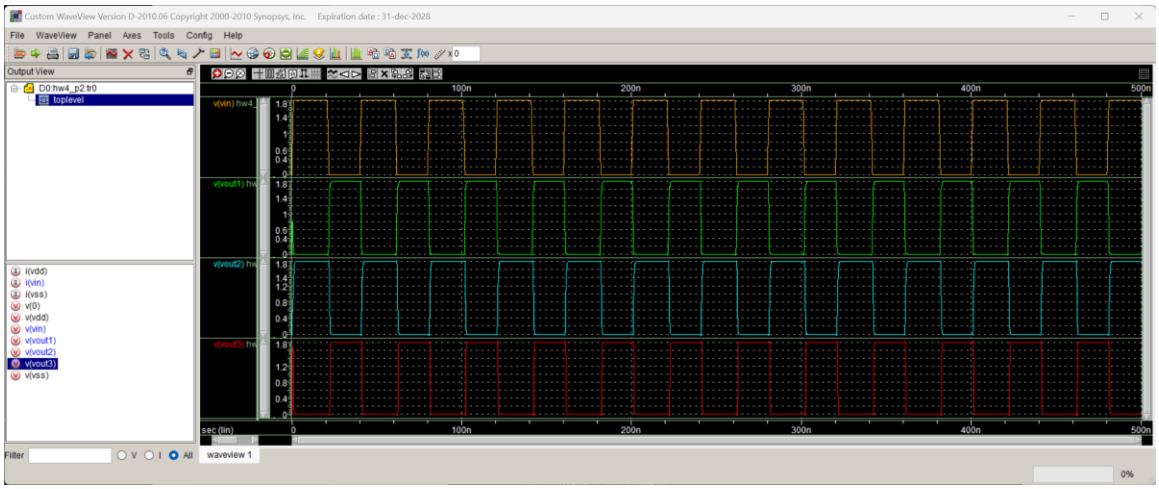
Two inverter:



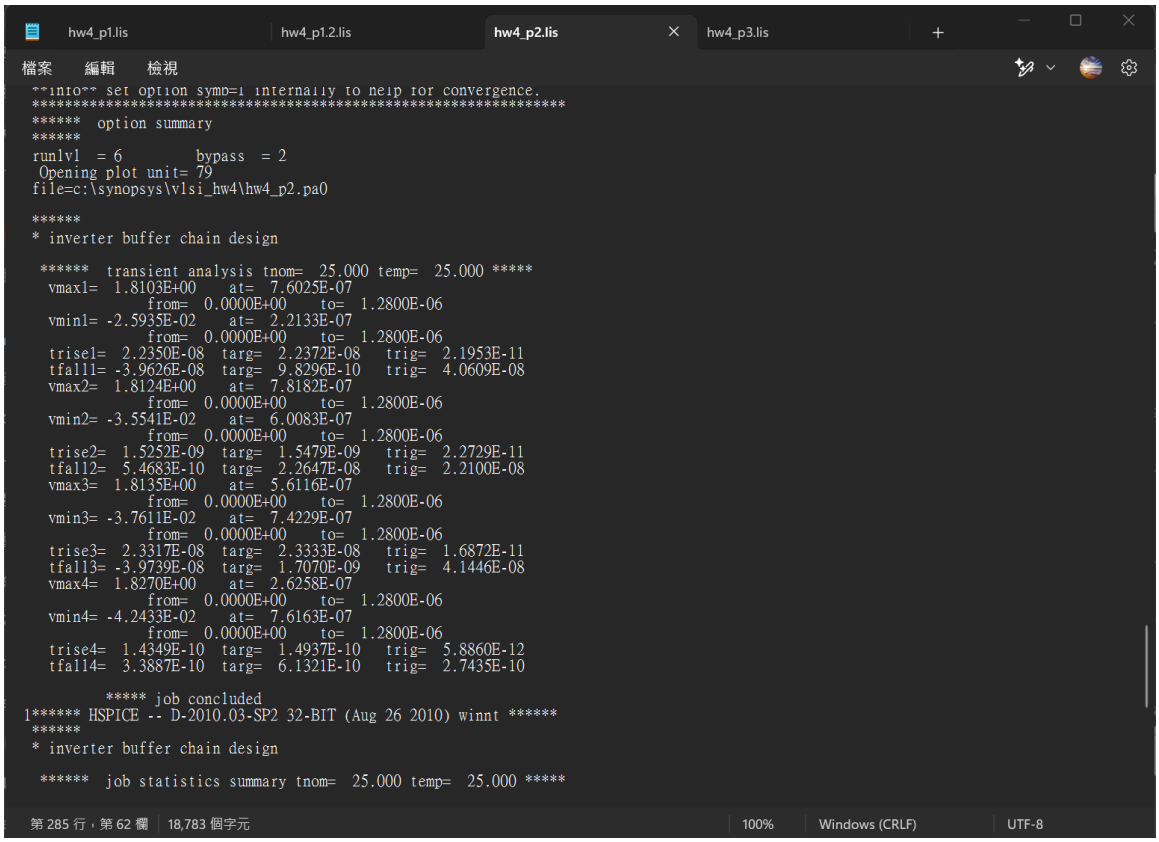


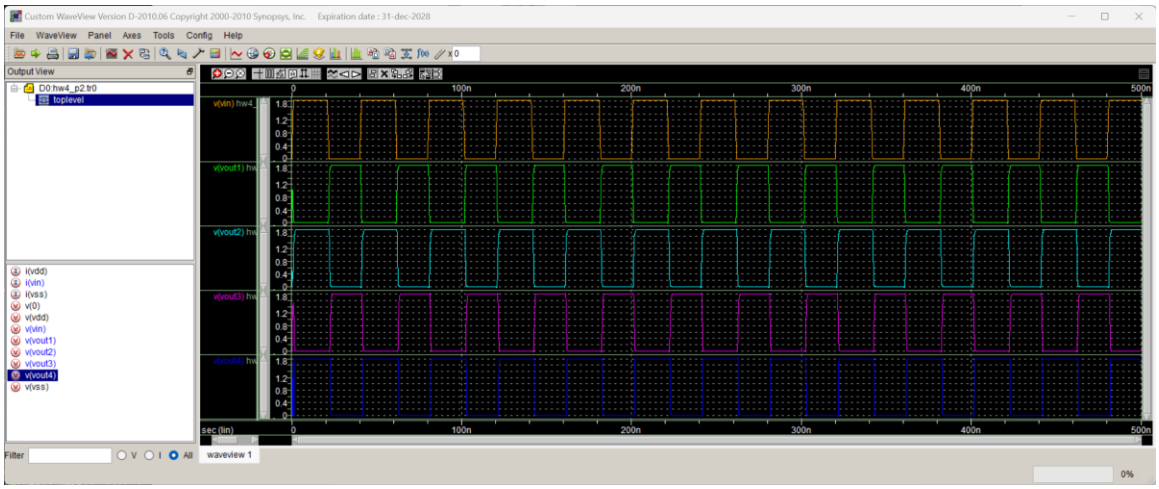
Three inverter:



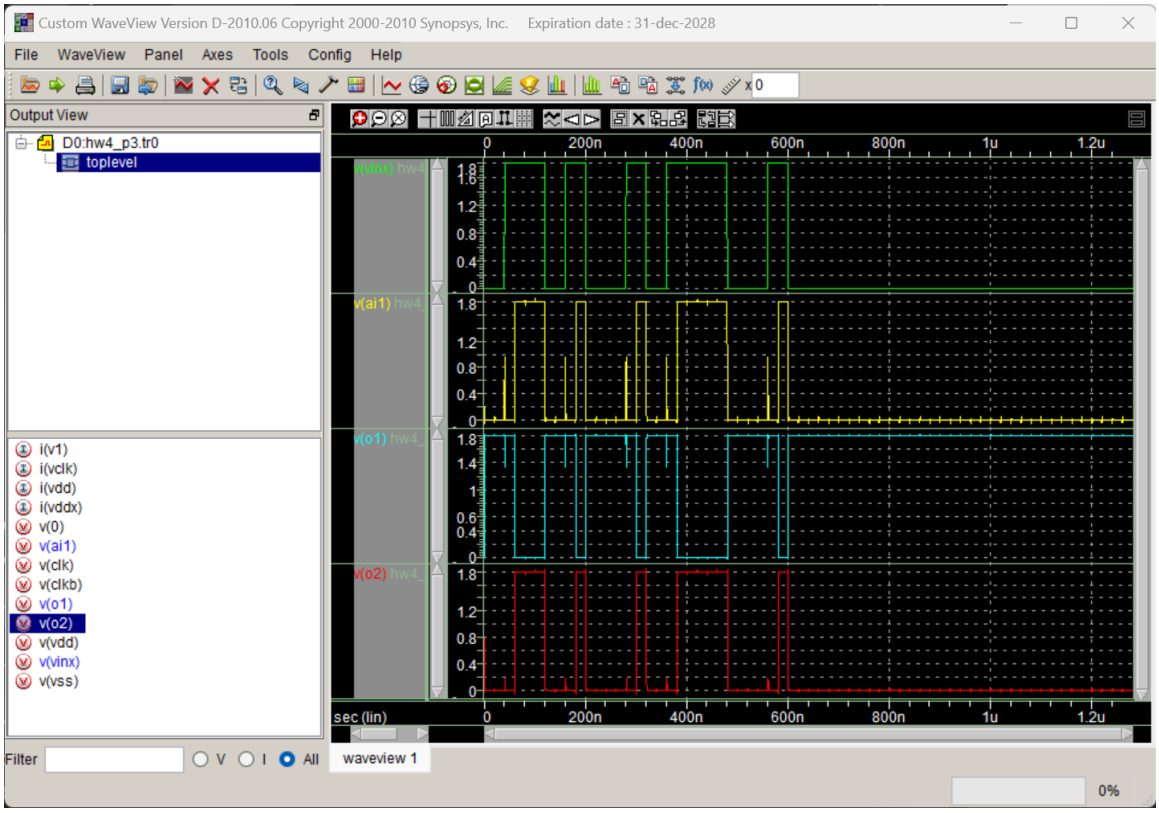


Four inverter:





3.(1)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v(o2)
v(vdd)
v(vinx)
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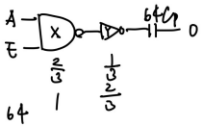
for AE

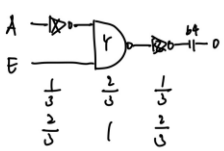


$N = 2$

$H = \frac{64}{1} = 64$

unfooted :	footed :
$g_1 = \frac{2}{3}$, $g_2 = \frac{1}{3}$	$g_1 = 1$, $g_2 = \frac{2}{3}$
$G = \frac{2}{9}$	$G = \frac{2}{3}$
$F = GBH = \frac{128}{9}$	$F = \frac{128}{3}$
$f = \sqrt{\frac{128}{9}} = 3.771$	$f = 6.532$
$3.771 = \frac{1}{3}\frac{64C_p}{Y}$	$6.532 = \frac{2}{3}\frac{64C_p}{Y}$
$Y = 5.657\ C_p$	$Y = 6.532\ C_p$
$3.771 = \frac{2}{3}\frac{Y}{X}$	$6.532 = \frac{Y}{X}$
$X = C_p$	$X = C_p$
$g_a = \sqrt{\frac{2}{9}} = 0.471$	$g_a = \sqrt{\frac{2}{3}} = 0.816$
$P_{inv} = \frac{2}{3}$	$P_{inv} = 1$
$P_{NAND} = 1$	$P_{NAND} = \frac{4}{3}$
$P_a = \sqrt{\frac{2}{3}}$	$P_a = \sqrt{\frac{4}{3}} = 1.155$

for others (for example : $\overline{A}E$)



$N = 2$

$H = \frac{64}{1} = 64$

unfooted :	footed :
$g_1 = \frac{1}{3}$, $g_2 = \frac{2}{3}$, $g_3 = \frac{1}{3}$	$g_1 = \frac{2}{3}$, $g_2 = 1$, $g_3 = \frac{2}{3}$
$G = \frac{2}{27}$	$G = \frac{4}{9}$
$F = GBH = \frac{128}{27}$	$F = \frac{256}{9}$
$f = \sqrt{\frac{128}{27}} = 1.680$	$f = 3.053$
$1.680 = \frac{1}{3}\frac{64C_p}{Z}$	$3.053 = \frac{2}{3}\frac{64C_p}{Z}$
$Z = 12.698\ C_p$	$Z = 13.995\ C_p$
$1.680 = \frac{2}{3}\frac{Z}{Y}$	$3.053 = \frac{Z}{Y}$
$Y = 5.039\ C_p$	$Y = 4.598\ C_p$
$1.680 = \frac{1}{3}\frac{Y}{X}$	$3.053 = \frac{2}{3}\frac{Y}{X}$
$X = C_p$	$X = C_p$
$g_a = 0.420$	$g_a = 0.763$
$P_{inv} = \frac{2}{3}$	$P_{inv} = 1$
$P_{NAND} = 1$	$P_{NAND} = \frac{4}{3}$
$P_a = 0.763$	$P_a = 1.101$

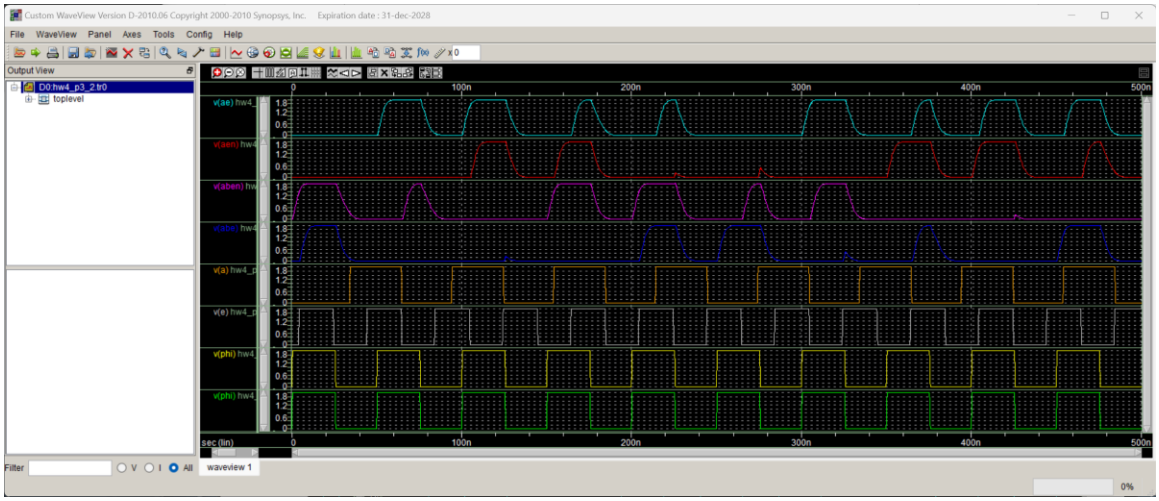
波形設定:

Vphi phi 0 PULSE(0 1.8 0n 0.5ns 0.5ns 25ns 50ns)

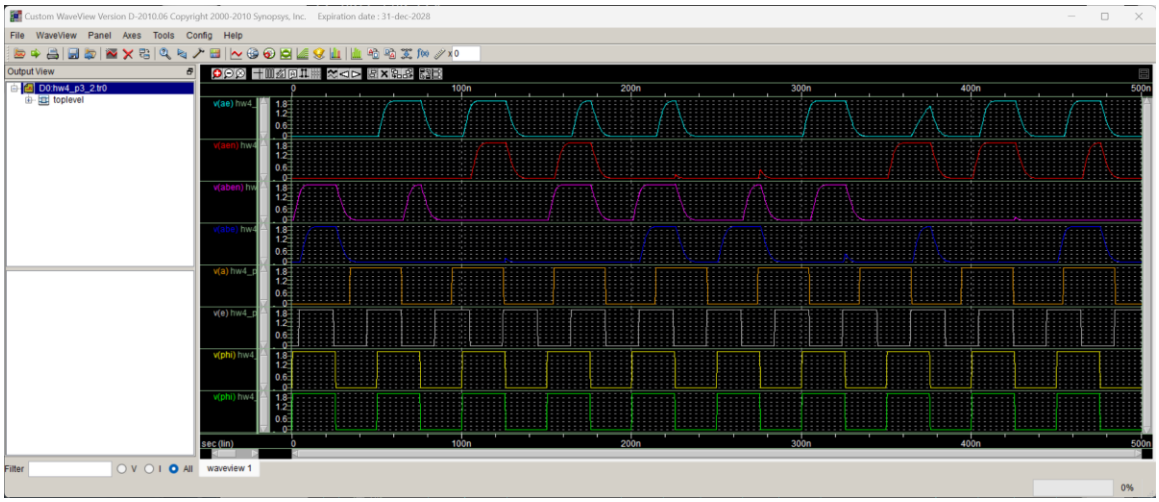
VA　A　0 PULSE(0 1.8 34ns 0.5ns 0.5ns 30ns 60ns)

VE　E　0 PULSE(0 1.8 4ns 0.5ns 0.5ns 20ns 40ns)

Unfooted:



Footed:



ae:AE

abe:$\bar{A}E$

aen:$A\bar{E}$

aben:$\bar{A}\bar{E}$