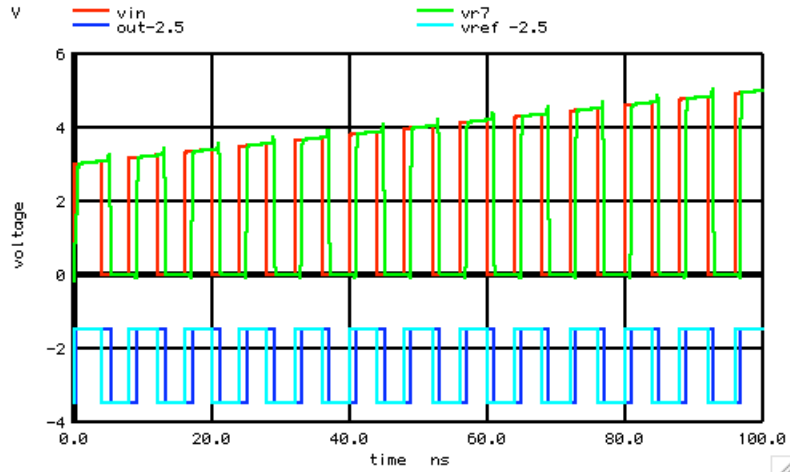


the supply and do a transient analysis on an array of inverters.

```
.OPTIONS GMIN=1e-18 METHOD=traps
VCC      VCC      0      PWL      ( 0 3 100n 5 )      DC 2
VCLK     VCLK     0      DC 0      PULSE( 0 1 1p 6p 6p 4n 8n )
BIN      VIN      0      V =      V(VCC)*u( V(VCLK)-.5)
XINVR1   VIN      VR2    VCC      INV_R
XINVR2   VR2     VR3    VCC      INV_R
XINVR3   VR3     VR4    VCC      INV_R
XINVR4   VR4     VR5    VCC      INV_R
XINVR5   VR5     VR6    VCC      INV_R
XINVR6   VR6     VR7    VCC      INV_R
BOUT     OUT     0      V =      2*u( V(VR7)-V(VCC)/2) -1
BREF     VREF    0      V =      2*u( V(VCLK)-.5) -1
*TRAN    TSTEP   TSTOP   TSTART   TMAX     ?UIC?
.tran    10p     100n   0        10p      UIC
*=====Run_Sim=====
.control
run
set      pensize = 2
plot     vin      vr7 out-2.5  vref -2.5
```

One might also want to scale the input signal to track VCC and perhaps to scale both input and output to unity to see the delay better.



Having access to the waveform data provides a better way to view the delay compared to looking at a plot.

```
*=====Create AnySize Arrays=====
compose anysize_r start = 0 stop = 99 step = 1
compose anysize_t start = 0 stop = 99 step = 1
compose anysize_v start = 0 stop = 99 step = 1
let num = length(out)-5
let i = 0
let t = 0
let n = 0
```

How many transitions happen at the output waveform may not be known. But say one knows it is less than 100.

```
*=====Find Edge Timing=====
repeat $num
if ( vref[i] < 0 & vref[i+1] > 0 )
let t = time[i]
let anysize_r[n]= t
let v = vcc[i]
let anysize_v[n]= v
echo n= $n out_rise_ref= $t vcc = $v
endif

if ( vref[i] > 0 & vref[i+1] < 0 )
let t = time[i]
let anysize_r[n]= t
```

```

let v = vcc[i]
let anysize_v[n]= v
echo n= $&n out_fall_ref= $&t vcc = $&v
endif

if ( out[i] < 0 & out[i+1] > 0)
let t = time[i]
let anysize_t[n]= t
echo n= $&n out_rise= $&t
let n = n +1
endif

if ( out[i] > 0 & out[i+1] < 0)
let t = time[i]
let anysize_t[n]= t
echo n= $&n out_fall= $&t
let n = n +1
endif
let i = i +1
endrepeat

let n3 = n -1

```

Some simple math can detect and printout each edge of the waveform. The following is the printout.

```

=====Find_Edge_Timing=====
n = 0 out_rise_ref = 2.984E-12 vcc = 3.00006
n = 0 out_rise = 3.28366E-10
n = 1 out_fall_ref = 4.0088E-09 vcc = 3.08018
n = 1 out_fall = 5.25173E-09
n = 2 out_rise_ref = 8.004E-09 vcc = 3.16008
n = 2 out_rise = 9.121E-09
n = 3 out_fall_ref = 1.20088E-08 vcc = 3.24018
n = 3 out_fall = 1.31812E-08
n = 4 out_rise_ref = 1.60038E-08 vcc = 3.32008
n = 4 out_rise = 1.70992E-08
n = 5 out_fall_ref = 2.00088E-08 vcc = 3.40018
n = 5 out_fall = 2.11308E-08
n = 6 out_rise_ref = 2.4004E-08 vcc = 3.48008
n = 6 out_rise = 2.50205E-08
n = 7 out_fall_ref = 2.80088E-08 vcc = 3.56018
n = 7 out_fall = 2.90905E-08
n = 8 out_rise_ref = 3.2004E-08 vcc = 3.64008
n = 8 out_rise = 3.29786E-08
n = 9 out_fall_ref = 3.60088E-08 vcc = 3.72018
n = 9 out_fall = 3.70502E-08
n = 10 out_rise_ref = 4.0004E-08 vcc = 3.80008
n = 10 out_rise = 4.09482E-08
n = 11 out_fall_ref = 4.40088E-08 vcc = 3.88018
n = 11 out_fall = 4.50099E-08
n = 12 out_rise_ref = 4.8004E-08 vcc = 3.96008
n = 12 out_rise = 4.89125E-08
n = 13 out_fall_ref = 5.20088E-08 vcc = 4.04018
n = 13 out_fall = 5.29797E-08
n = 14 out_rise_ref = 5.60028E-08 vcc = 4.12006
n = 14 out_rise = 5.69421E-08
n = 15 out_fall_ref = 6.00088E-08 vcc = 4.20018
n = 15 out_fall = 6.09481E-08
n = 16 out_rise_ref = 6.40028E-08 vcc = 4.28006
n = 16 out_rise = 6.49121E-08
n = 17 out_fall_ref = 6.80088E-08 vcc = 4.36018
n = 17 out_fall = 6.89281E-08
n = 18 out_rise_ref = 7.2004E-08 vcc = 4.44008
n = 18 out_rise = 7.28411E-08
n = 19 out_fall_ref = 7.60088E-08 vcc = 4.52018
n = 19 out_fall = 7.69081E-08
n = 20 out_rise_ref = 8.00028E-08 vcc = 4.60006
n = 20 out_rise = 8.08688E-08
n = 21 out_fall_ref = 8.40088E-08 vcc = 4.68018
n = 21 out_fall = 8.48781E-08
n = 22 out_rise_ref = 8.80028E-08 vcc = 4.76006
n = 22 out_rise = 8.88483E-08
n = 23 out_fall_ref = 9.20088E-08 vcc = 4.84018
n = 23 out_fall = 9.28681E-08
n = 24 out_rise_ref = 9.6004E-08 vcc = 4.92008
n = 24 out_rise = 9.67813E-08

```

```

=====Create_Edge_Time_Arrays=====
compose vplus start = 0 stop = $&n3 step =1
compose td start = 0 stop = $&n3 step =1

```



```

*-----Process-----
+ tox=160e-10      xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72       nlx=0.12e-06
*-----Bulk-----
+ k1=1.04         k2=-1.209E-01
+ cdsc=-2.4E-4    cdsd=-1.506E-04  cdsb=-2.219E-04
*-----mobility-----
+ u0=678          ua=8.964e-10
+ ub=1.472e-18   uc=-4.441E-17    vsat=86000
*-----Subthresshold-----
+ nfactor=1.8
+ cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01     dsub=0.7
*-----Hot electrons-----
* alpha0=1.61e-05 beta0=36.68
*-----VAF-----
+ lint=.12e-06    pclm=.19          pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pvag=0.4484
*-----Bulk_diode-----
+ js=5.858e-08
*-----Resistance-----
+ rsh=70          rdsw=375
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----Capacitance-----
+ cj=0.0002424   cjsw=2.73e-10    mj=0.3551        mjsw=0.3873
+ cgso=9e-13     cgdo=9e-13       cgbo=7e-10
+ pb=0.5614      pbsw=0.8         xpart=0
+ dlc=5e-08      dwc=1.5e-07
*-----BulkChargeEffect-----
* a0=0.7         a1=0              a2=1              ags=0.05583
* b0=6.305e-08  b1=6.579e-08    keta=-1.531E-02
*-----ShortChannel-----
+ dvt0=2.2       dvt1=0.53        dvt2=-1.521E-01  drout=0.76
+ pdiblc1=.4     pdiblc1=0.00886  pdiblc2=0.00029
*-----NarrowChannel-----
+ w0=2.6e-04     wint=0.16e-06
+ ww=-9.525E-14 wwn=1.0
+ dvt0w=0        dvt1w=5.3e6     dvt2w=-1.E-01    dwb=0
+ k3=2.53        k3b=-5           dwg=0
*-----Noise-----
* af=1           kf=1e-28         ef=0.95
*-----Temperature-----
* pvsat=0        ute=-1.258E+00   kt1=-3.85E-01    ua1=5.705e-09
* kt11=0         kt2=-3.098E-02
* ub1=-1.147E-17 uc1=-1.302E-01   at=20380
* prt=-3.287E+02 lk1=0             lk2=0
* lvsat=0        la0=0            lags=0            lute=0
+ luc=0
)

```

```

.model          PMOSC          PMOS(
+ Level= 8      Tnom=27.0
*-----Process-----
+ tox=1.725e-08  xj=2e-07         nch=1e+17
*-----V threshold-----
+ vth0=-0.90     nlx=1.84e-08
*-----Bulk-----
+ k1=0.3969      k2=0.03536
*-----mobility-----
+ u0=268         ua=4.124e-09
+ ub=-3.8E-19   uc=-1.512E-02    vsat=140000
*-----Subthresshold-----
+ nfactor=.5016
* cit=0.0001     voff=-0.08       nfactor=1.0016   vth0=-0.94
* eta0=0.038     etab=-1.057E-02  dsub=0.3501
*-----Hot electrons-----
+ alpha0=2.5e-08 beta0=28.92
*-----VAF-----
+ lint=.1e-06    pclm=3.2          pscbe1=5e+08     pscbe2=1e-05
+ delta=0.009    pvag=4
*-----Bulk_diode-----
+ js=3.95e-08
*-----Resistance-----
+ rsh=135        rdsw=2500
+ prwg=-7.2E-02 prwb=0.06        wr=0.8625
*-----Capacitance-----
+ cj=0.0002424   cjsw=2.73e-10    mj=0.3551        mjsw=0.3873
+ cgso=9e-13     cgdo=9e-13       cgbo=7e-10
+ cdsc=-2.4E-4   cdsd=-1.506E-01  cdsb=-2.219E-04
* pb=0.85        pbsw=0.88        xpart=0
* dlc=5e-08      dwc=1.5e-07
*-----BulkChargeEffect-----
* a0=1           a1=0              a2=2              ags=0.268

```

```

* b0=5e-07      b1=1e-07      keta=-1.0E-02
* -----ShortChannel-----
* dvt0=2.9      dvt1=0.2      dvt2=-1.521E-01      drout=0.175
* pdiblc0=0     pdiblc1-     pdiblc2=0.001
* -----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06
+ ww=-3.1E-19   wwn=1.9
* dvt0w=0.68    dvt1w=5.3e6    dvt2w=0.051
* k3=56         k3b=-3         dwg=0             dwb=1e-08
* -----Noise-----
+ af=0.8        kf=1.50e-30    ef=0.95
* -----Temperature-----
* ldelta=0.02282  lpdiblc1=0.01877  ute=-1.500E+00
* cgsl=1.5e-10    cgd1=1.5e-10     ckappa=0.2463      cf=0
* kt1=-4.684E-01  kt11=-2.0E-08    kt2=-2.818E-02
* ual=-2.E-10     ub1=-4.5E-18     uc1=-2.000E-02
+ at=-1.5E+05     prt=1400
)

```

.end

4.11.10_4.54PM
dsauersanjose@aol.com
Don Sauer
<http://www.idea2ic.com/>