

# Memory Circuit Design Homework #3

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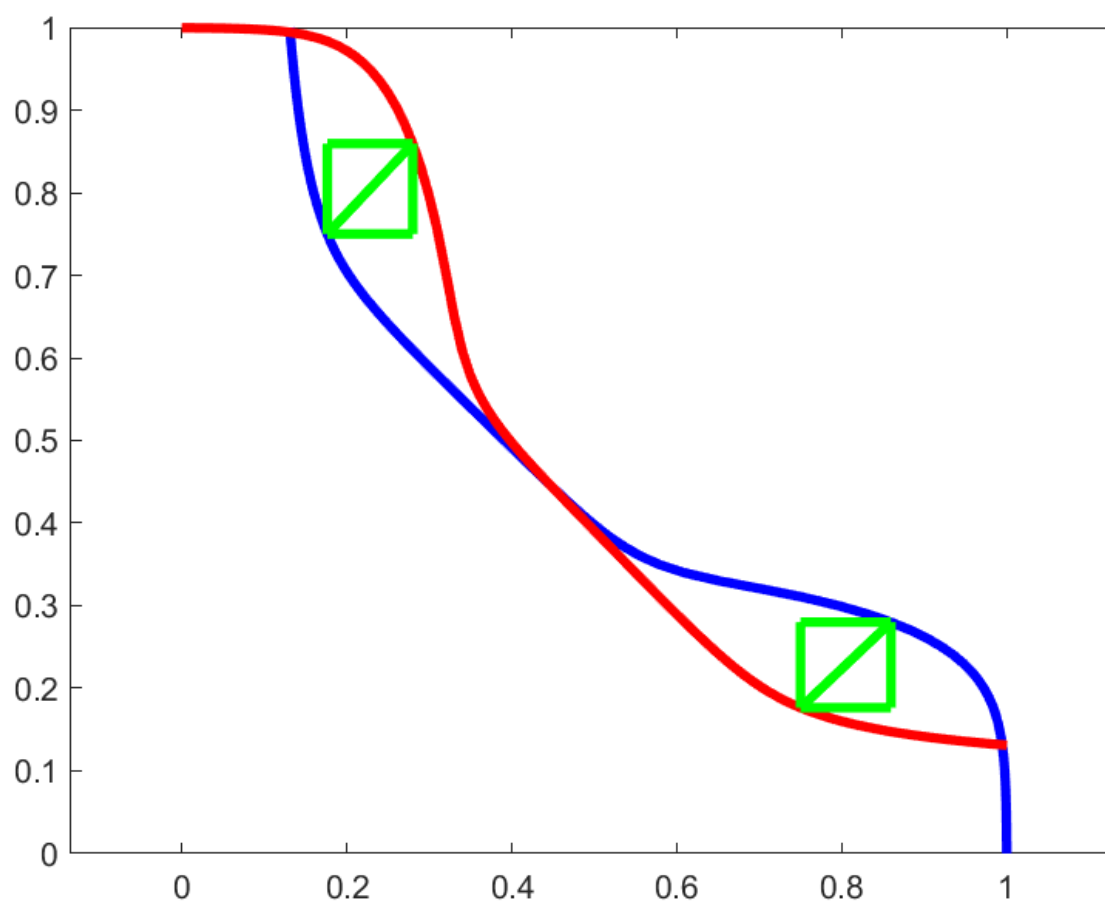
1. DC Analysis: Please compare the curves of RSNM and WNM for 6T, 8T SRAM cell with different VDD= 1V, 0.8V, 0.6V, and 0.4V. Also, with different VDD= 1V, 0.8V, 0.6V, and 0.4V, please extract the values of the RSNM and WNM, which are defined as the diagonal line of the maximal square between two curves of RSNM or WNM plots.

## 6T SRAM

```
1  **SRAM 6T AC**
2
3  .inc "C:\synopsys\65nm_bulk.pm"
4
5  .global gnd vdd
6
7  MP1 QB Q vdd vdd pmos w= 2u l=0.065u
8  MN2 QB Q gnd gnd nmos w=10u l=0.065u
9  MP3 Q QB vdd vdd pmos w= 2u l=0.065u
10 MN4 Q QB gnd gnd nmos w=10u l=0.065u
11
12 MN5 QB WL BLB gnd nmos w=6u l=0.065u
13 MN6 Q WL BL gnd nmos w=6u l=0.065u
14
15
16 vdd vdd gnd DC 0.8V
17 Vw1 WL gnd pulse(0 0.8 2n 0.1n 0.1n 2n 4n)
18
19 $ 給予初始值
20 .ic v(BL)=0.8v
21 .ic v(BLB)=0.8v
22 .ic v(q) = 0.8v
23 .ic v(qb) = 0v
24
25 $ read section
26 VQ Q gnd dc 0 //read
27 VQb Qb gnd dc 0.8 //read
28
29 $ write section
30 $Vbl BL gnd pwl 4ns 0v 5.99ns 0v 6ns 0.8v 8ns 0.8v 8.01ns 0v 9.99ns 0v 10ns 0.8v
31 $Vblb blb gnd pwl 4ns 0.8v 5.99ns 0.8v 6ns 0v 8ns 0v 8.01ns 0.8v 9.99ns 0.8v 10ns 0v
32
33
34 $ other section
35 $Vw1 WL gnd pwl 0ns 0v 1.99ns 0v 2ns 0.8v 8ns 0.8v 8.01ns 0v
36
37 **"PAR" is use to declare parameter or expression
38 .probe bl_POWER = PAR('abs(V(bl)*I(vdd))')
39 .probe blb_POWER = PAR('abs(V(blb)*I(vdd))')
40
41 .tran 0.1ns 8ns
42 .option post
43 .temp 25
44 .probe v(BLB)
45 $.measure tran BL_Power avg power
46
```

RSNM:

1v:

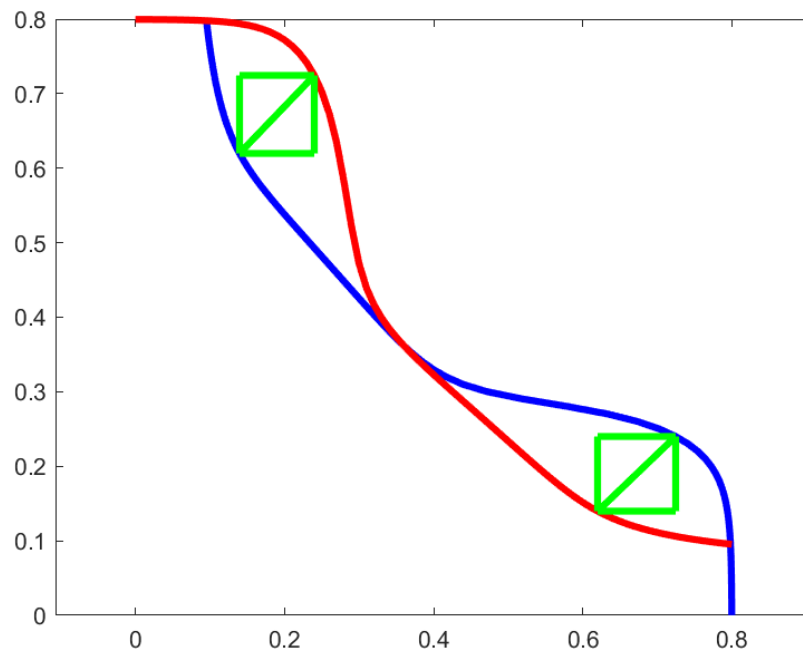


square diagonal length :  $1.507041e-01v$

lagrest square area:  $1.135586e-02(v*v)$

$SNM = 4.262555e-01v$

0.8v:

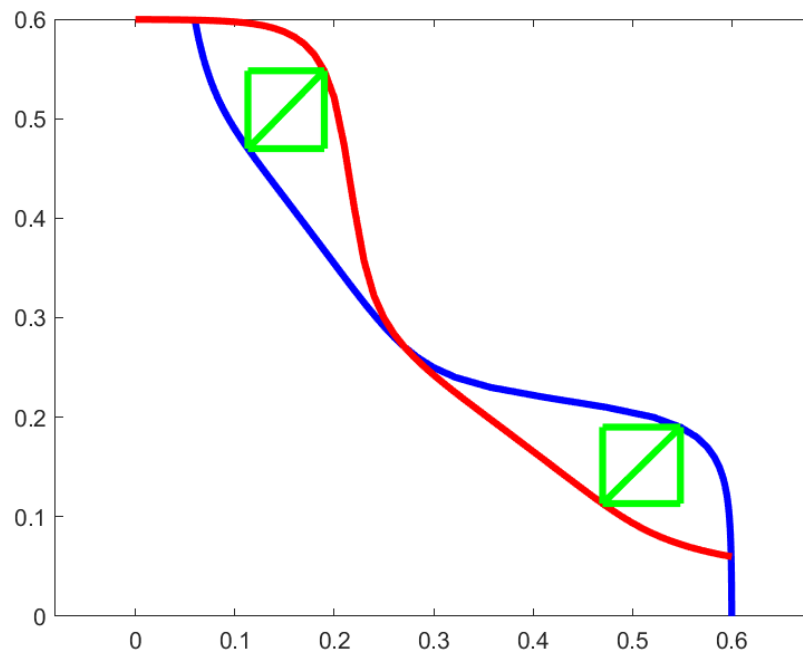


square diagonal length :  $1.449913e-01v$

lagrest square area:  $1.051123e-02(v*v)$

SNM =  $4.100972e-01v$

0.6v:

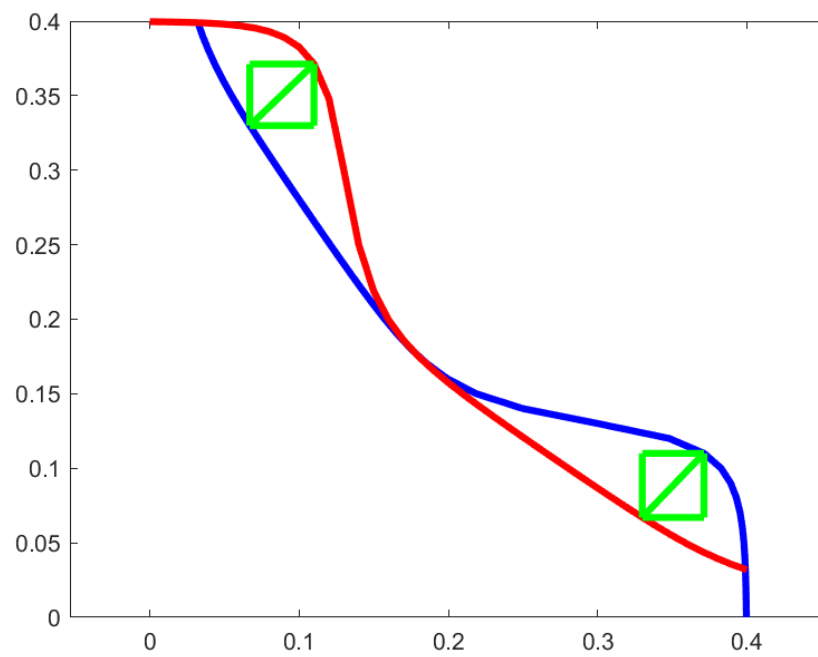


square diagonal length :  $1.096480e-01v$

lagrest square area:  $6.011339e-03(v*v)$

SNM =  $3.101313e-01v$

0.4v:



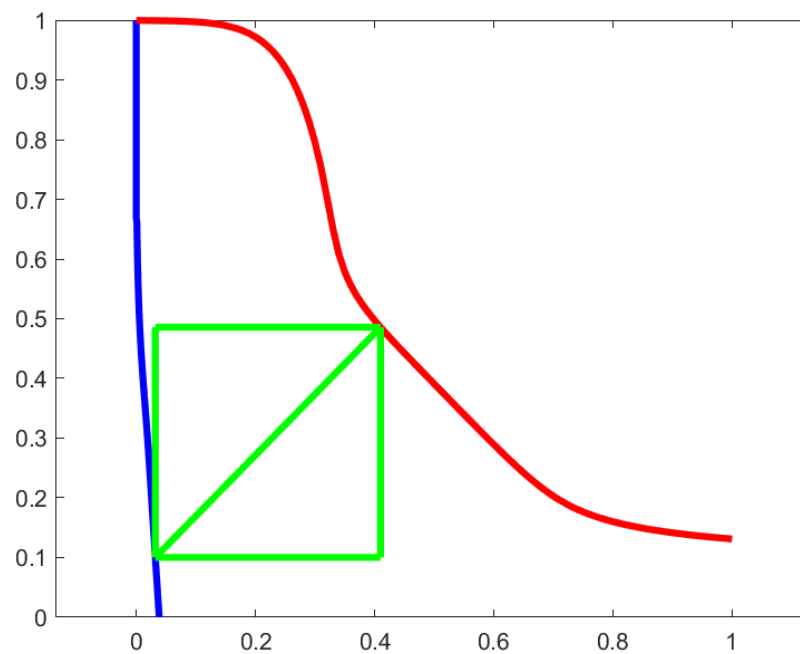
square diagonal length :  $5.963761e-02v$

lagrest square area:  $1.778322e-03(v*v)$

SNM =  $1.686806e-01v$

WNM

1v:

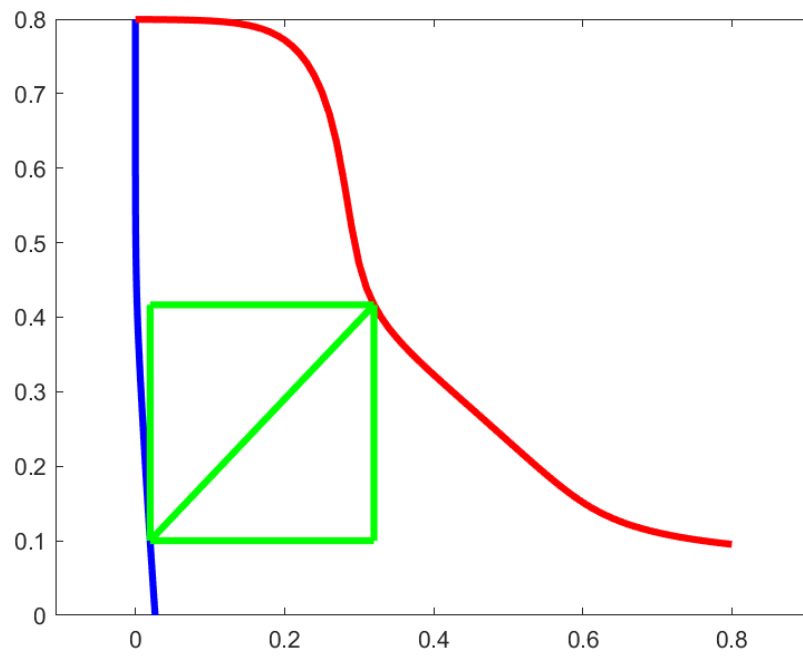


square diagonal length :  $5.400224e-01v$

lagrest square area:  $1.458121e-01(v*v)$

WNM =  $1.527414e+00v$

0.8v

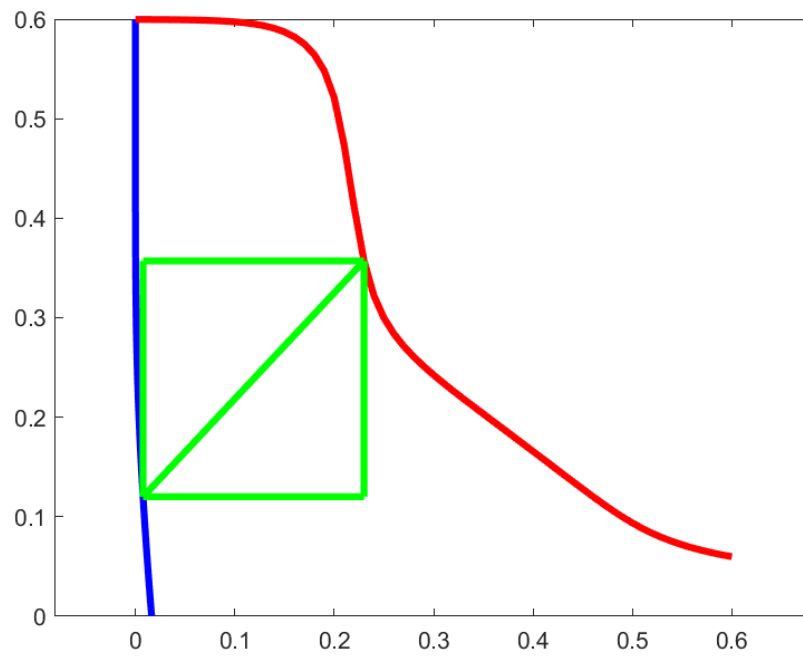


square diagonal length :  $4.363950e-01v$

lagrest square area:  $9.522031e-02(v*v)$

WNM =  $1.234312e+00v$

0.6v

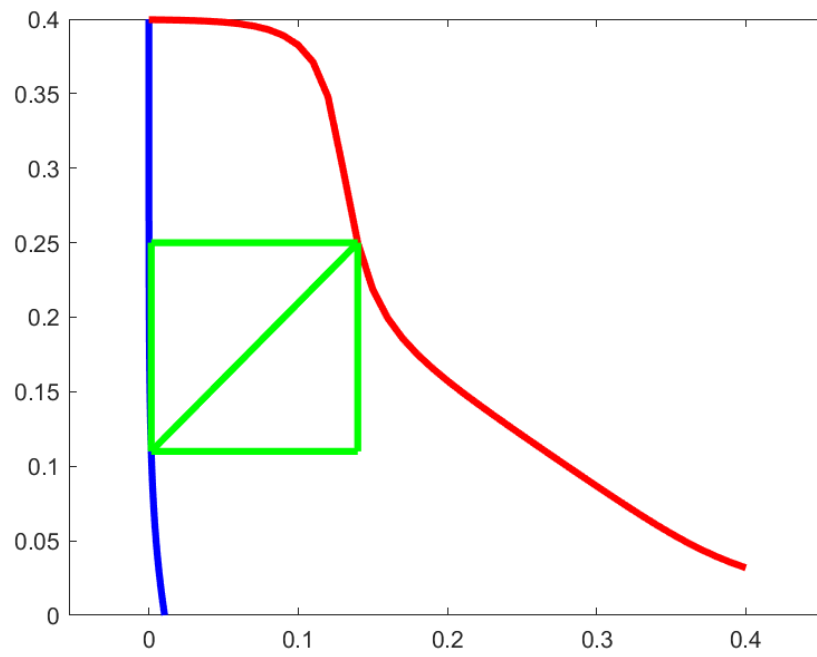


square diagonal length :  $3.249793e-01v$

lagrest square area:  $5.280577e-02(v*v)$

WNM =  $9.191802e-01v$

0.4v



square diagonal length :  $1.968859e-01v$

largest square area:  $1.938202e-02(v*v)$

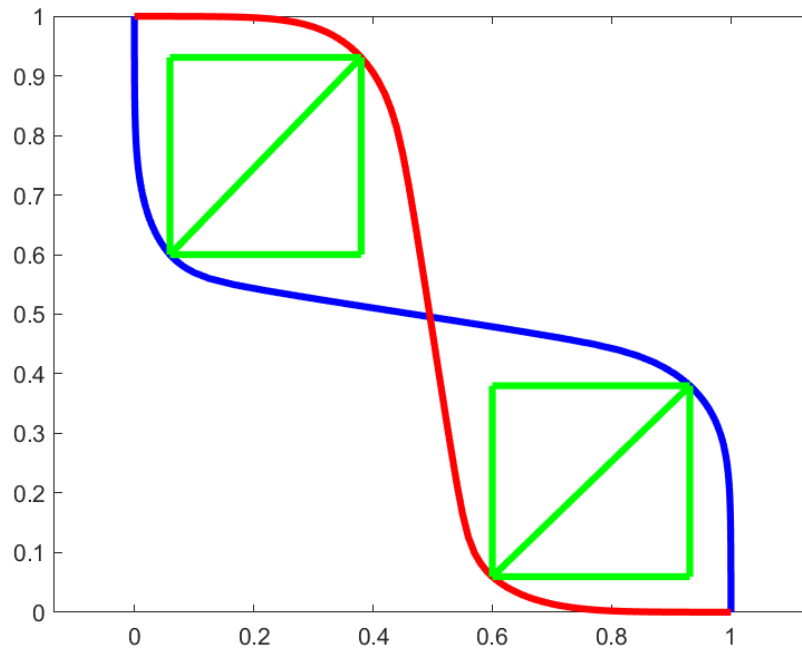
WNM =  $5.568773e-01v$

## 8T SRAM

```
1  **SRAM 8T DC 1v**
2
3  .inc "C:\synopsys\65nm_bulk.pm"
4
5  .global gnd vdd
6
7  MP1 QB Q vdd vdd pmos w=3u l=0.065u
8  MN2 QB Q gnd gnd nmos w= 1u l=0.065u
9  MP3 Q QB vdd vdd pmos w=3u l=0.065u
10 MN4 Q QB gnd gnd nmos w= 1u l=0.065u
11
12 MN5 QB WL BLB gnd nmos w=1u l=0.065u
13 MN6 Q WL BL gnd nmos w=1u l=0.065u
14
15 MN9 node Qb gnd gnd nmos w=1u l=0.065u
16 MN8 node RDWL RDBL gnd nmos w=10u l=0.065u
17
18 vdd vdd gnd DC 0.8V
19
20
21 $ 給予初始値
22
23 .ic v(q) = 0.8v
24 .ic v(qb) = 0v
25 $.ic v(rdbl) = 0.8v
26
27 $ read section
28 $Vwl WL gnd dc 0
29 $vrdwl RDWL gnd pulse(0 0.8 2n 0.1n 0.1n 2n 4n)
30 $VQ Q gnd dc 0.8
31 $VQb Qb gnd dc 0
32
33 $ write section
34 Vwl WL gnd pulse(0 0.8 2n 0.1n 0.1n 2n 4n)
35 Vbl BL gnd pwl 4ns 0v 5.99ns 0v 6ns 0.8v 8ns 0.8v 8.01ns 0v 9.99ns 0v 10ns 0.8v
36 Vblb blb gnd pwl 4ns 0.8v 5.99ns 0.8v 6ns 0v 8ns 0v 8.01ns 0.8v 9.99ns 0.8v 10ns 0v
37
38
39 $ other section
40 $Vwl WL gnd pwl 0ns 0v 1.99ns 0v 2ns 0.8v 8ns 0.8v 8.01ns 0v
41
42 **"PAR" is use to declare parameter or expression
43 $.print bl_POWER = PAR('abs(V(RDBL)*I(vdd))')
44 |.probe blb_POWER = PAR('abs(V(bl)*I(vdd))')
45
46 .tran 0.1ns 8ns
47 .option post
48 .temp 25
49 .probe v(BLB)
50 $.measure tran BL_Power avg power
51
52 .end
53
54 **end**
```

RSNM:

1v:

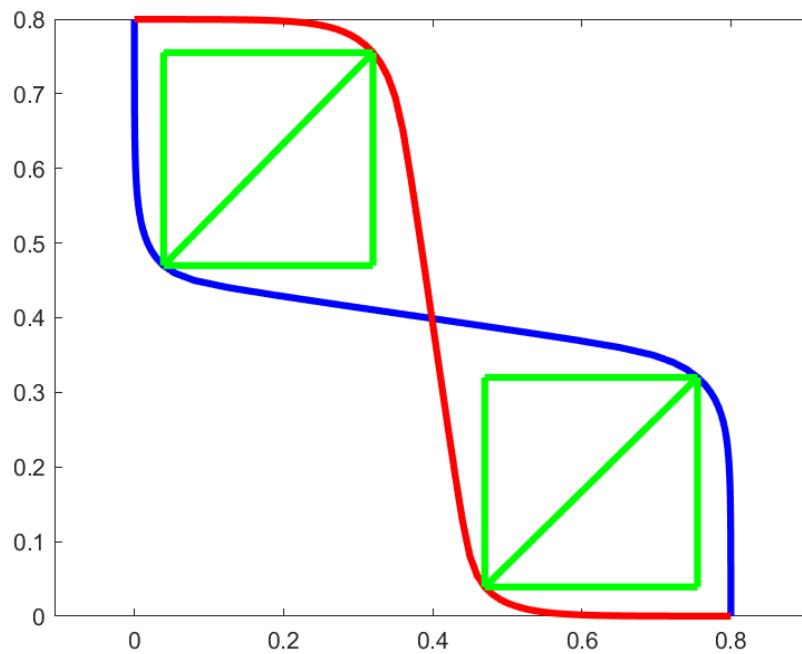


square diagonal length :  $4.607226e-01v$

largest square area:  $1.061327e-01(v*v)$

SNM =  $1.303120e+00v$

0.8v:



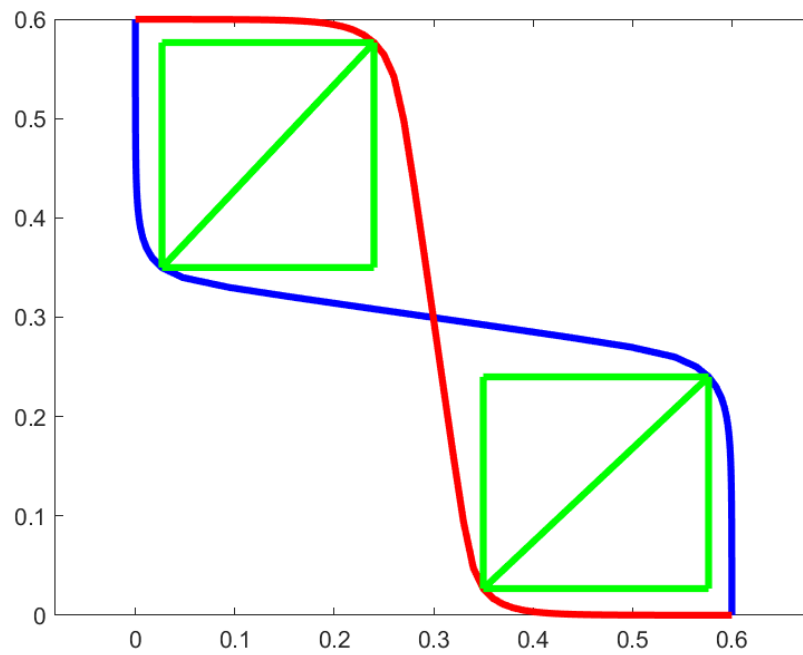
square diagonal length :  $4.004623e-01v$

largest square area:  $8.018503e-02(v*v)$

SNM =  $1.132678e+00v$



0.6v:

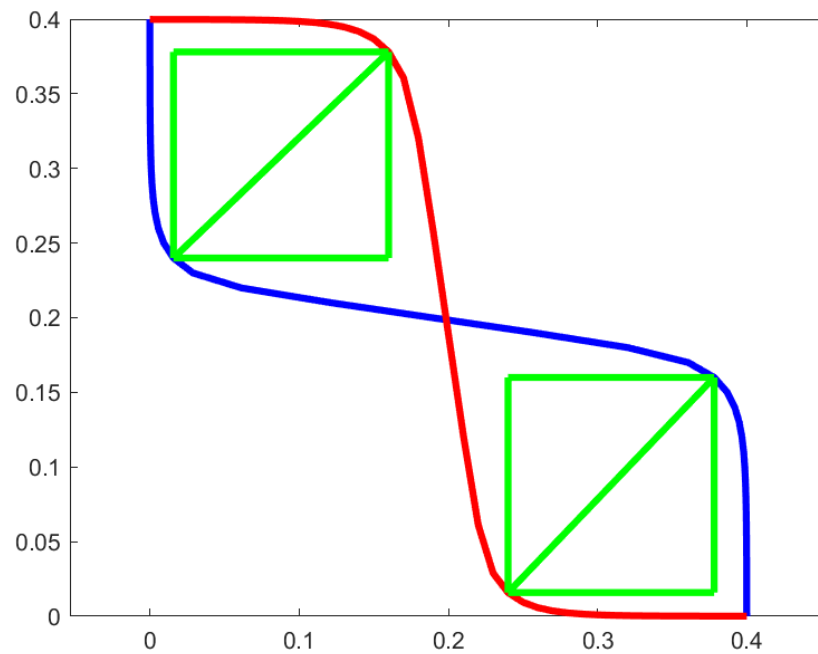


square diagonal length :  $3.111642e-01v$

lagrest square area:  $4.841159e-02(v*v)$

SNM =  $8.801053e-01v$

0.4v:



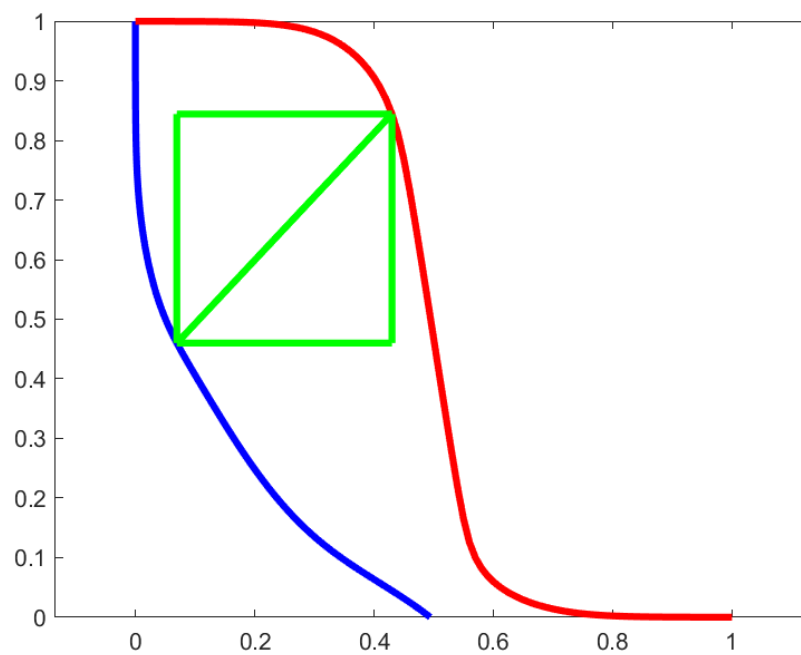
square diagonal length :  $1.996891e-01v$

lagrest square area:  $1.993787e-02(v*v)$

SNM =  $5.648061e-01v$

WNM:

1v

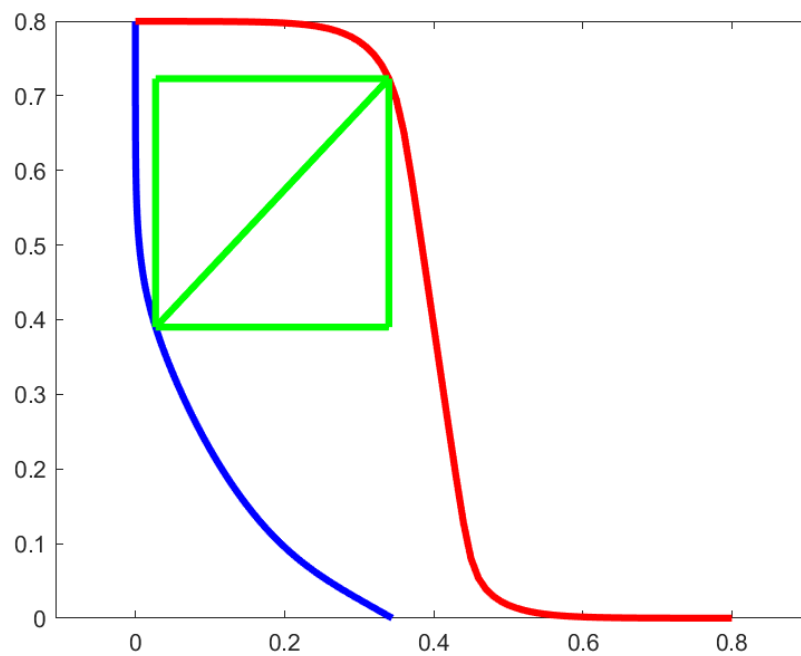


square diagonal length :  $5.269827\text{e-}01v$

lagrest square area:  $1.388554\text{e-}01(v*v)$

WNM =  $1.490532\text{e+}00v$

0.8v

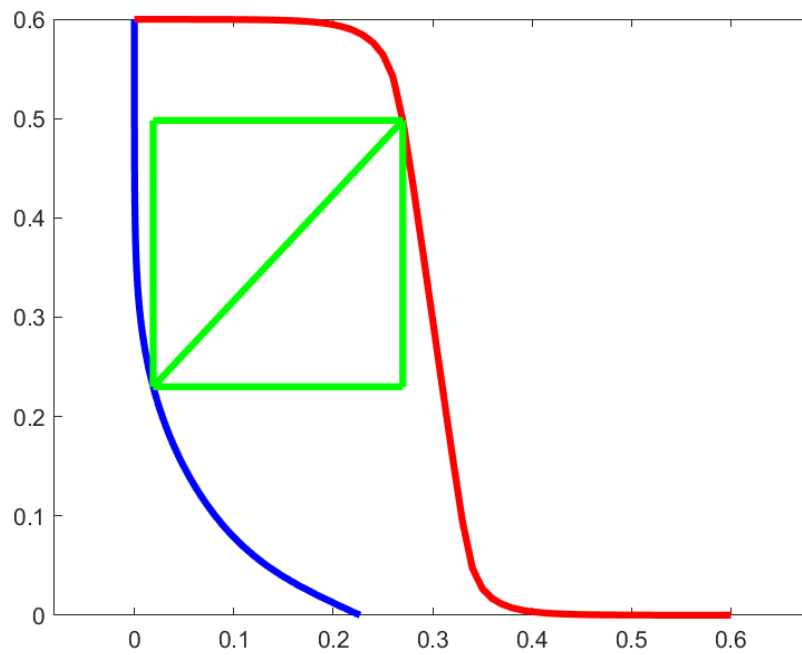


square diagonal length :  $4.570721\text{e-}01v$

lagrest square area:  $1.044574\text{e-}01(v*v)$

WNM =  $1.292795\text{e+}00v$

0.6v

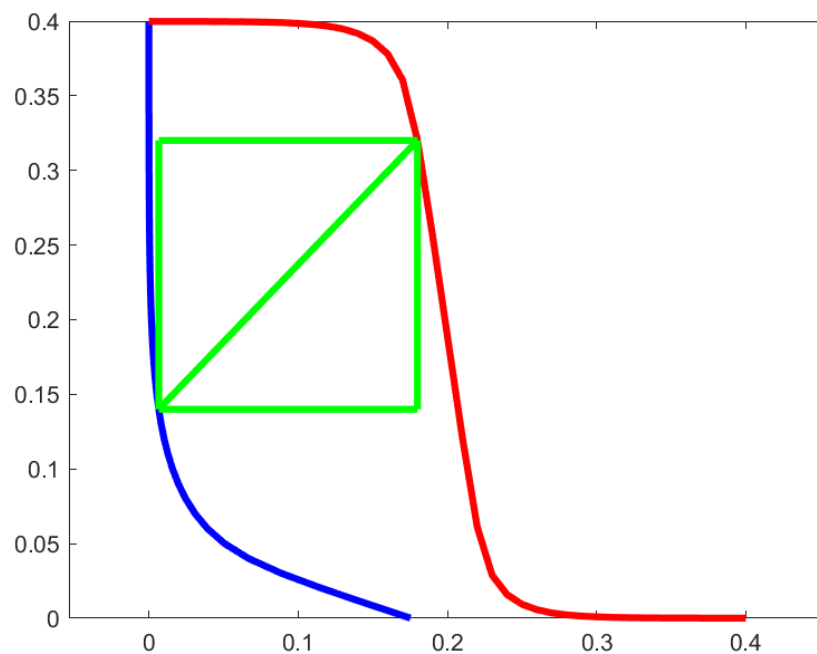


square diagonal length :  $3.673589 \times 10^{-1} \text{v}$

lagrest square area:  $6.747627 \times 10^{-2} (\text{v} * \text{v})$

WNM =  $1.039048 \times 10^0 \text{v}$

0.4v



square diagonal length :  $2.500330 \times 10^{-1} \text{v}$

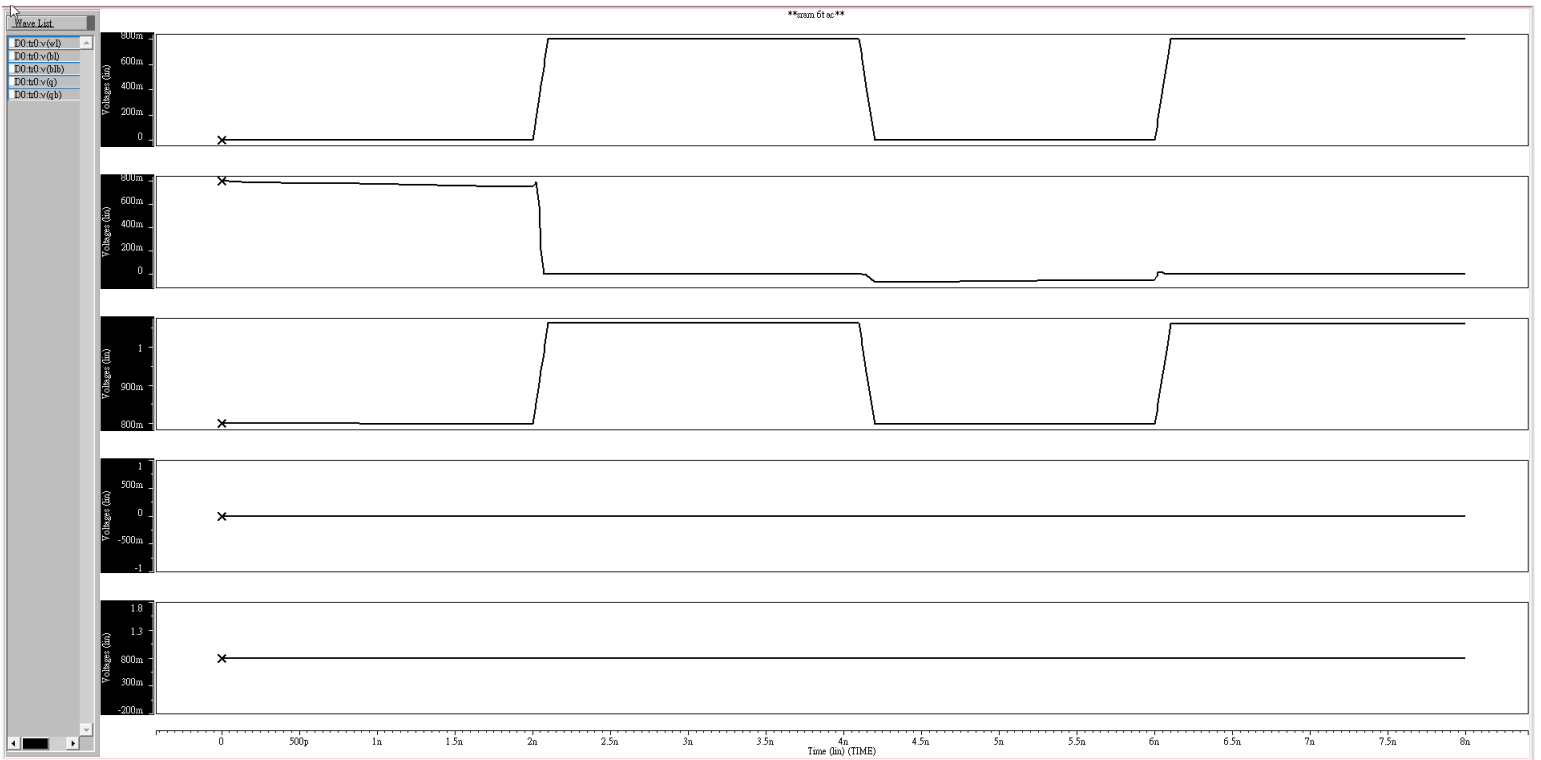
lagrest square area:  $3.125824 \times 10^{-2} (\text{v} * \text{v})$

WNM =  $7.072001 \times 10^{-1} \text{v}$

2. AC Analysis: Please show the BL (BLB) voltage transient curves of

6T, 8T SRAM during READ and WRITE. You may need to apply appropriate pulses on the WL or BL to READ or to WRITE the cells with  $V_{DD}=0.8V$  and the pulse width equivalent to 2ns.

6T(read)



WL = 0 0.8v 0 0.8v

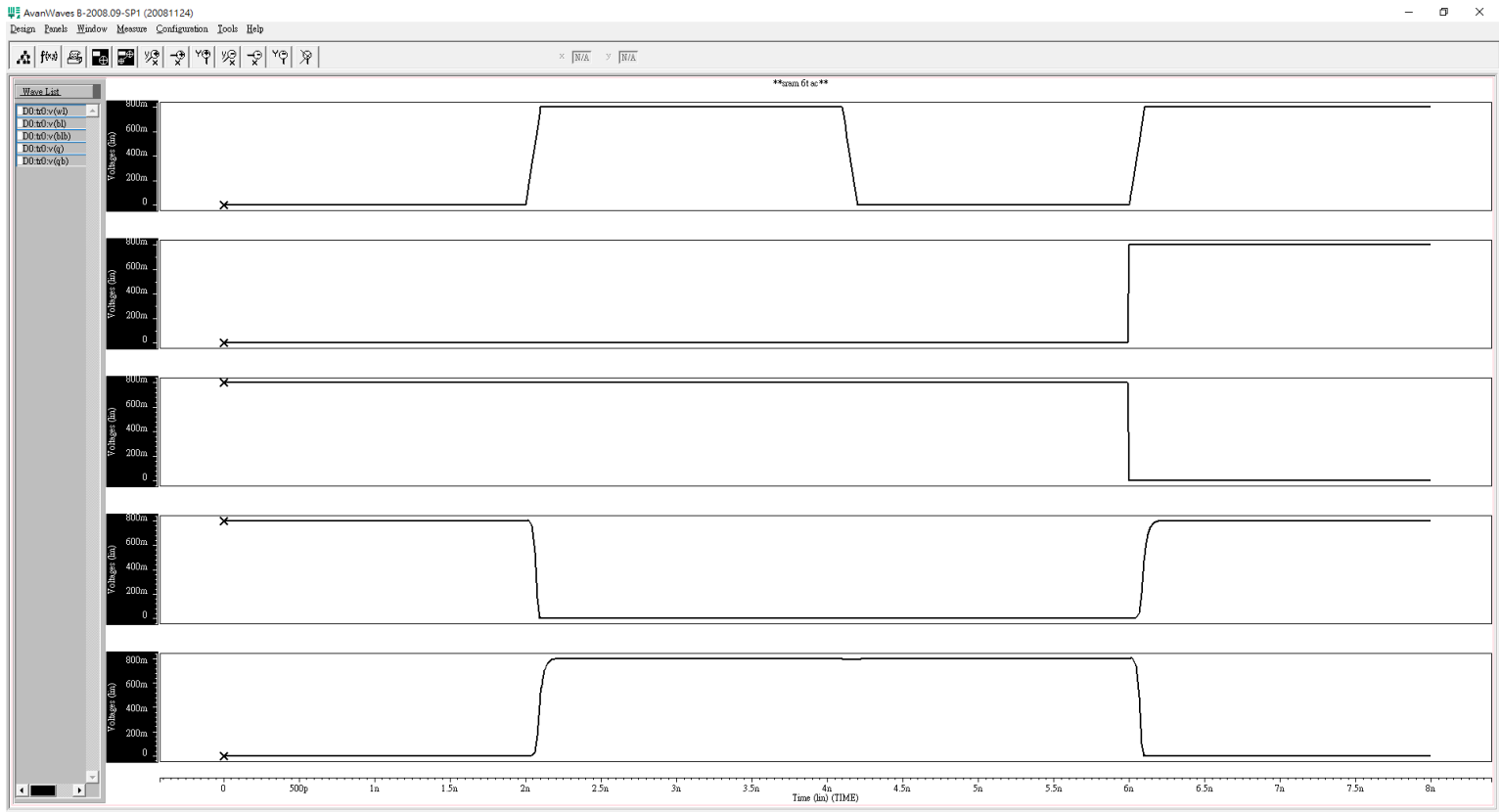
BL = 0.8v 0 0 0

BLB = 0.8v 0 0.8v 0

QB = 0v

Q = 0.8v

# 6T(read)



WL = 0 0.8v 0 0.8v

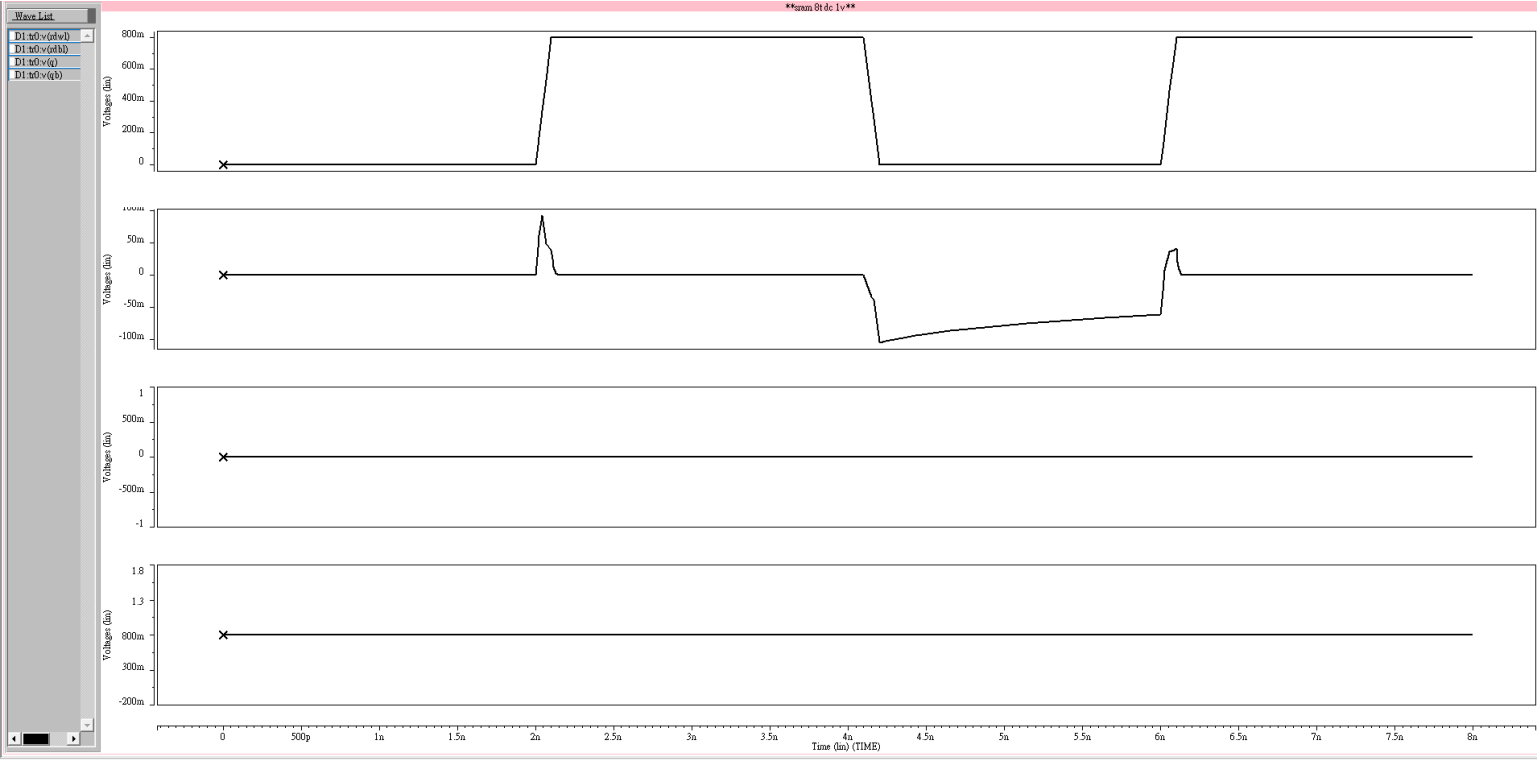
BL = 0 0 0 0.8v

BLB = 0.8v 0.8v 0.8v 0

Q = 0.8v 0 0 0.8v

QB = 0 0.8v 0.8v 0

8T\_SRAM  
READ 0:



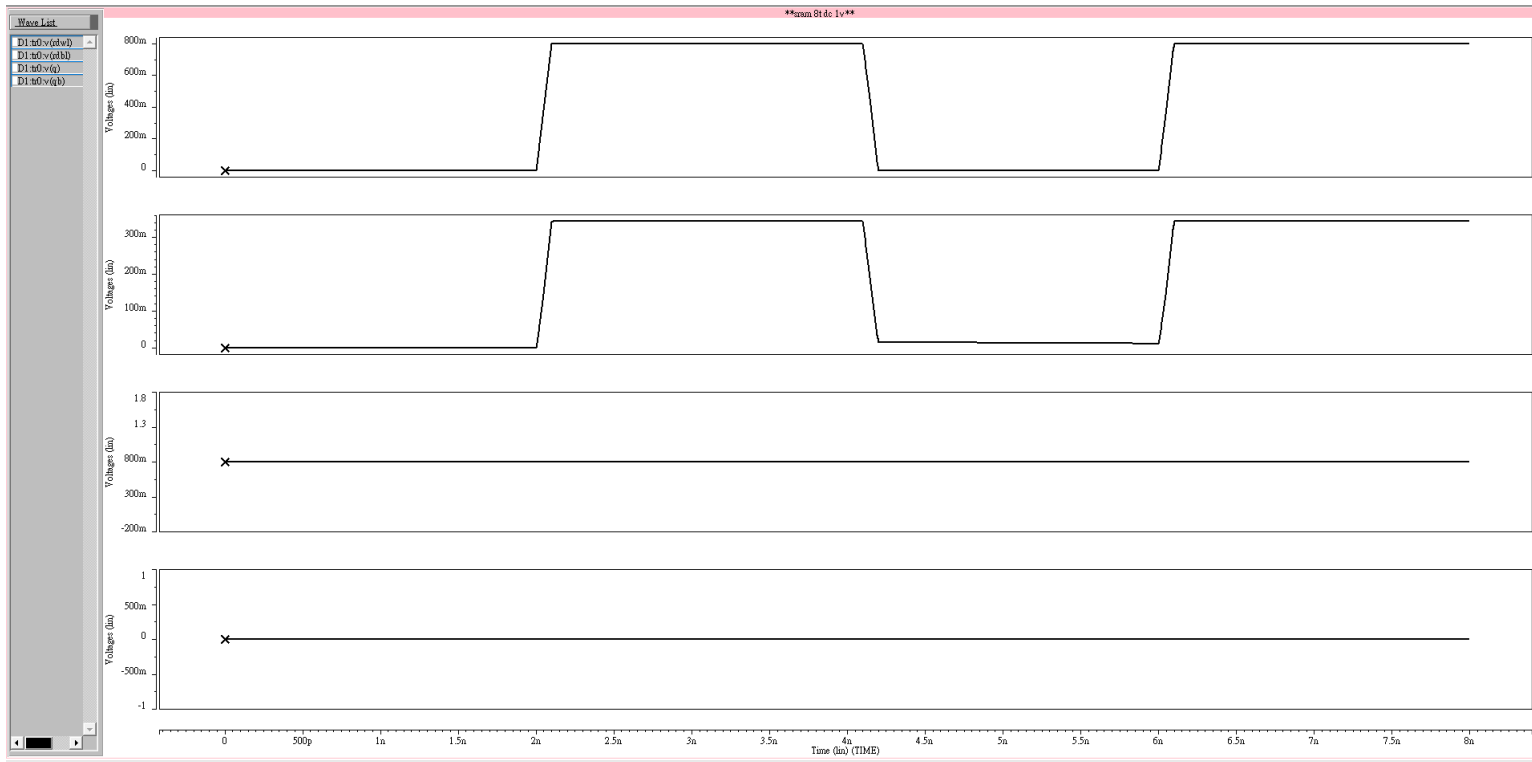
$$\text{RDWL} = [0 \ 0.8 \ 0 \ 0.8]$$

$$\text{RDBL} = [0 \ 0 \ 0 \ 0]$$

$$Q = 0$$

$$QB = 0.8$$

READ 1:



$$RDWL = [0 \ 0.8 \ 0 \ 0.8]$$

$$RDBL = [0 \ 0.4 \ 0 \ 0.4]$$

$$Q = 0.8$$

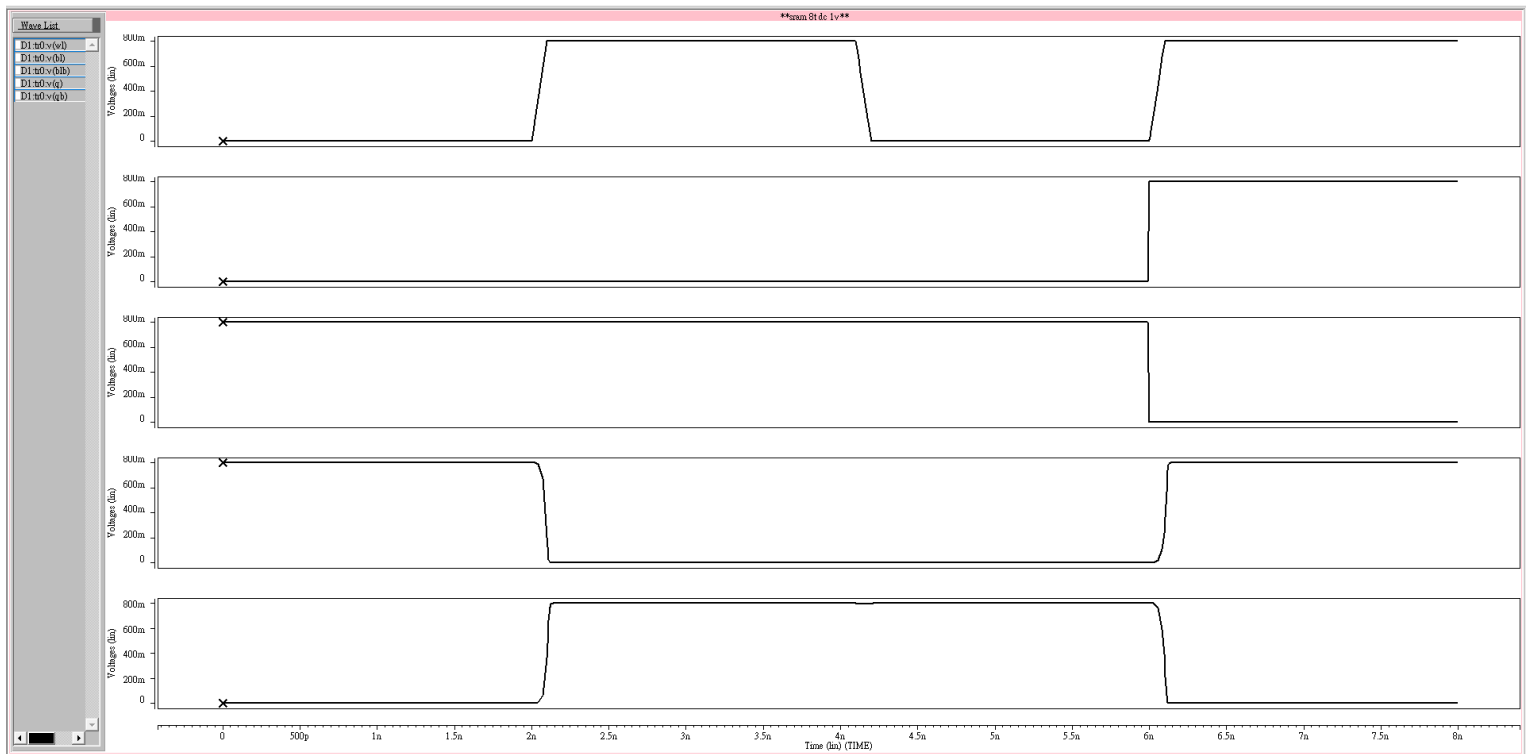
$$QB = 0$$

由於 M8 與 M9 所得的電壓為 RDBL 的浮接值因此漏電與分壓問題

非常嚴重，可以看到圖中雖然 RDWL 打開但是由於上述問題 RDBL

的電壓嚴重降壓。

Write:



$WL = [0 \ 0.8 \ 0 \ 0.8]$

$BL = [0 \ 0 \ 0 \ 0.8]$

$BLB = [0.8 \ 0.8 \ 0.8 \ 0]$

$Q = [0.8 \ 0 \ 0 \ 0.8]$

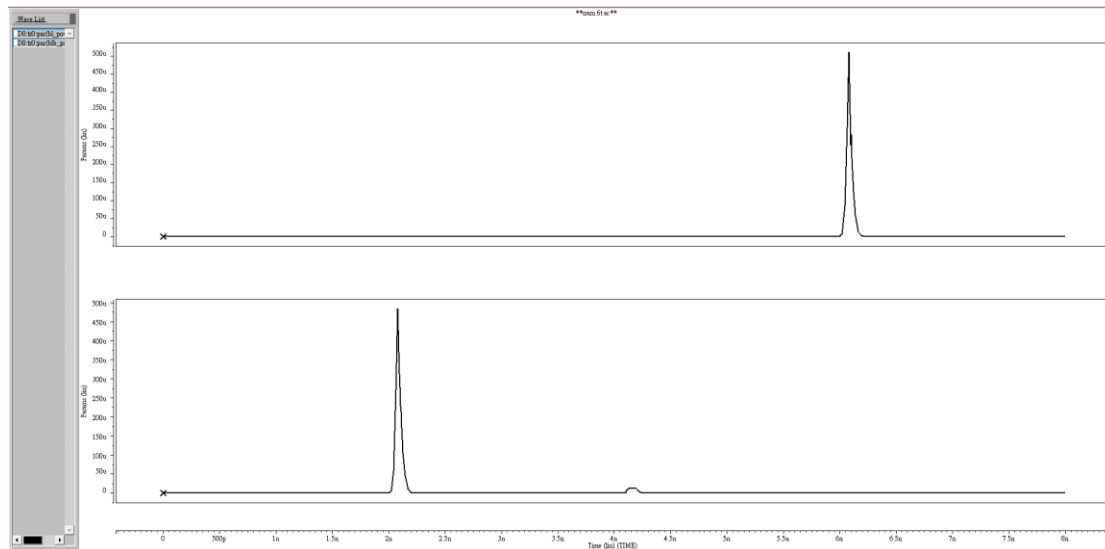
$QB = [0 \ 0.8 \ 0.8 \ 0]$



3. Power Analysis: Please show the BL (BLB) power transient curves of 6T, 8T SRAM during READ and WRITE. The power transient curves can be calculated by multiplication of voltage and current transient curves. ( $P=I \times V$ ) You may need to apply appropriate pulses on the WL or BL to READ or to WRITE the cells with  $VDD=0.8V$  and the pulse width equivalent to 2ns.

6T\_SRAM

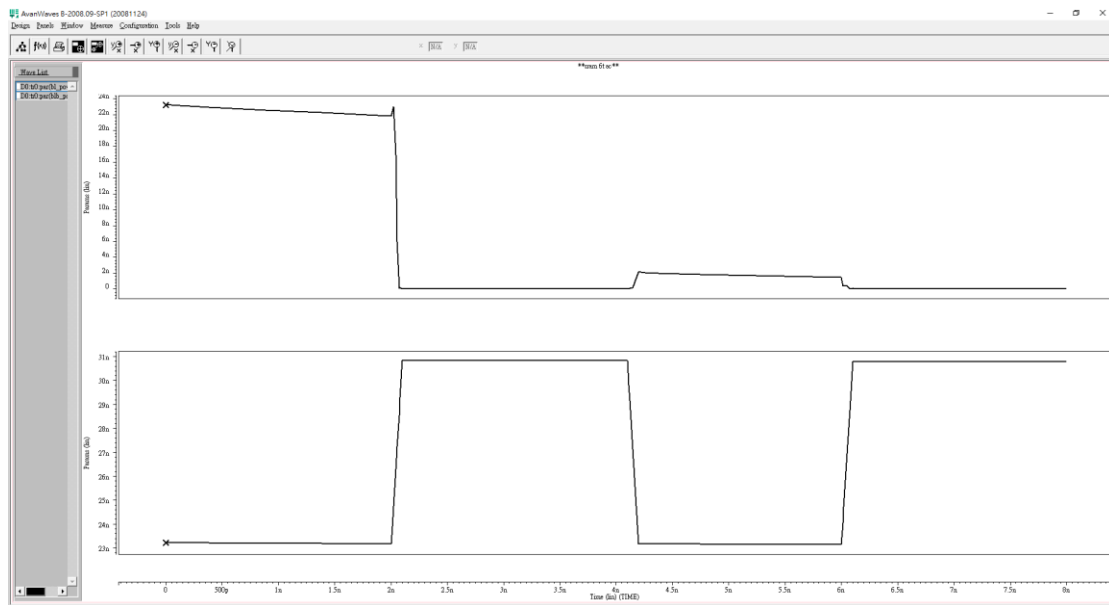
write power transient curves



Up: BL power

Down : BLB power

## Read power transient curves

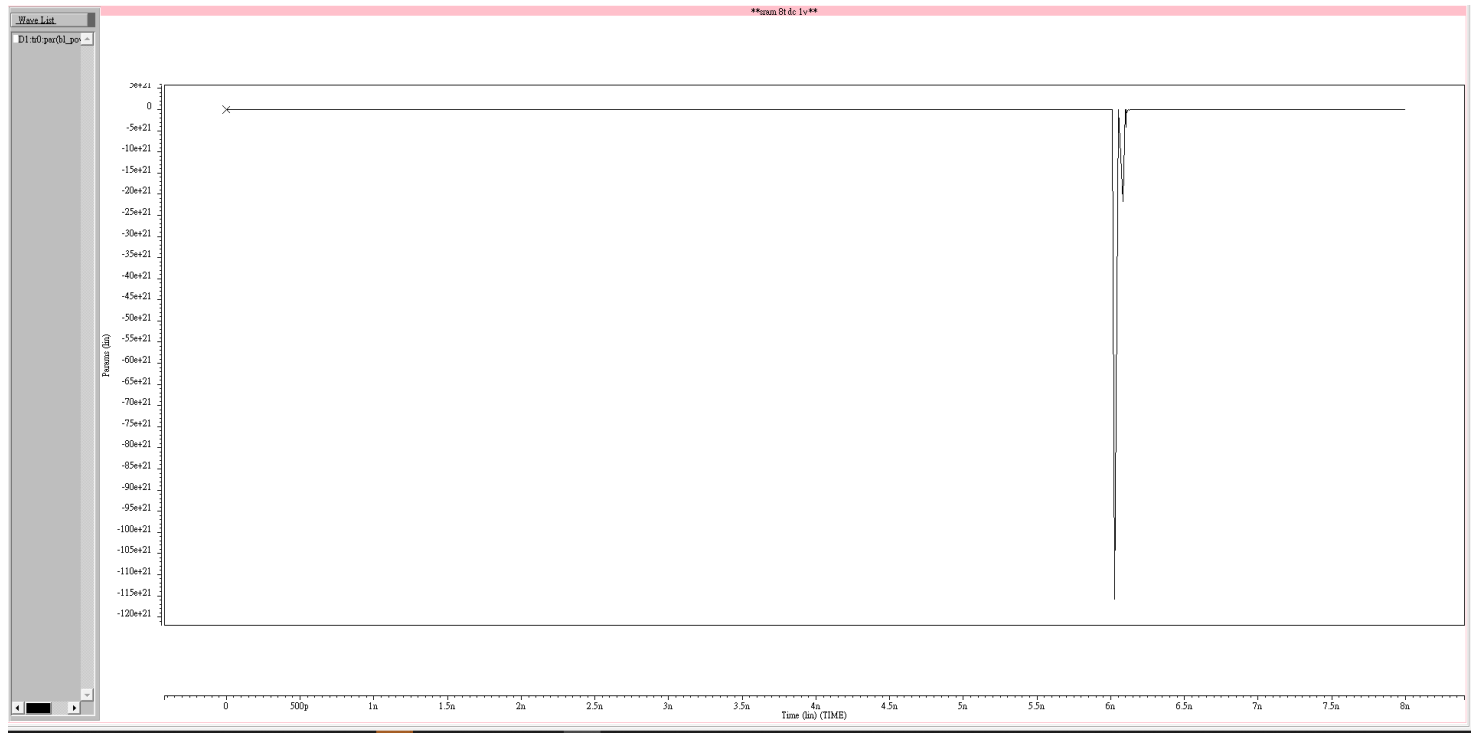


Up: BL power

Down : BLB power

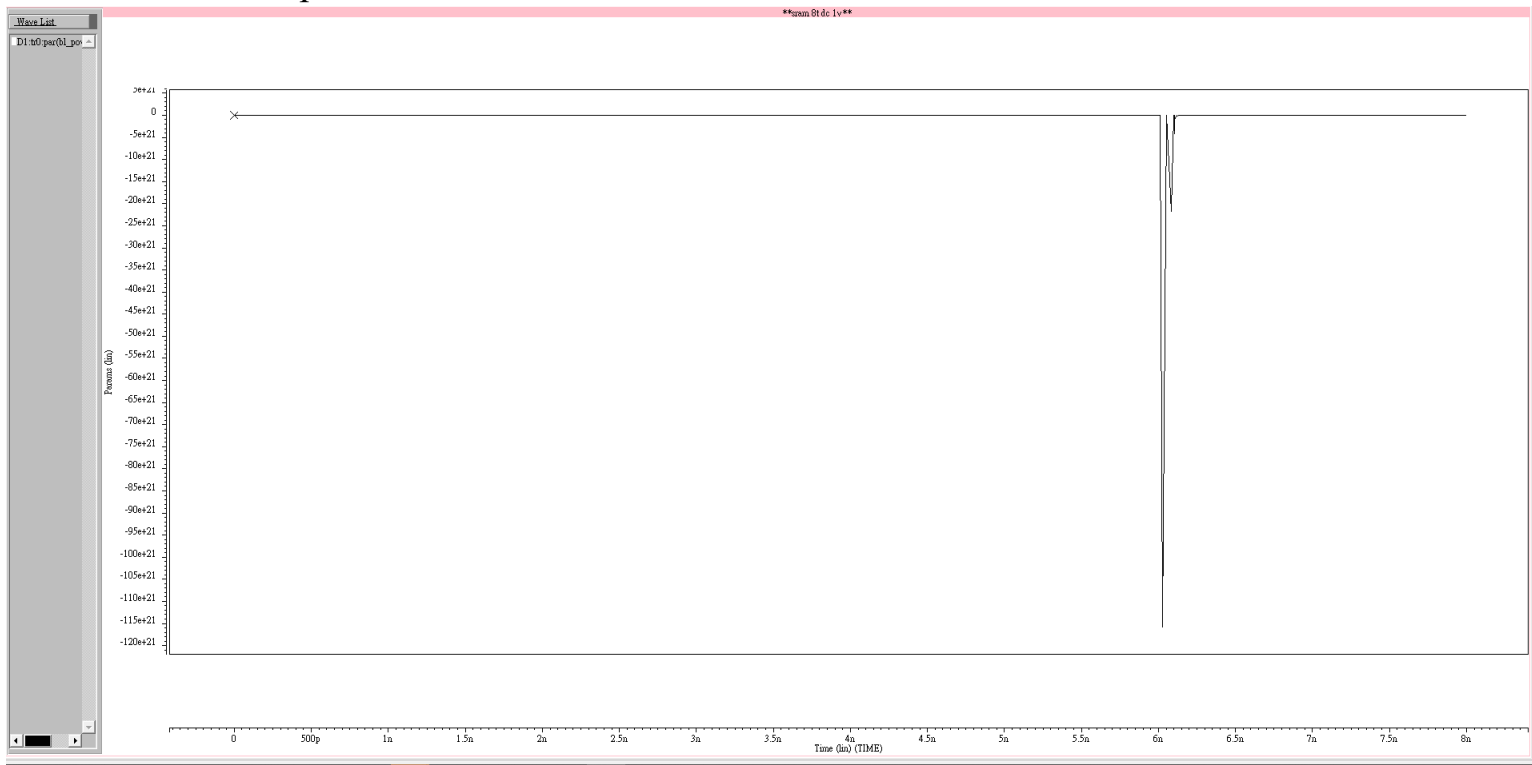
## 8T\_SRAM

### read power transient curves



RDBL power

### write power transient curves



BL power