EE577 Lab3 Report
Spring 2017

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1)The spice file screenshot

```
************************
*  lab3 sample hspice
************************

.include './lp32nm.pm'

*define parameters
.param vdd=1
.param vss=0
*.param fin_height=18n
*.param fin_width=7n
.param lg=32n
.param wg=64n
.param multiplier = 16
.param LoadCap = 5.0a

VSS Gnd 0 'vss'


*add transistors
*pfet is for the finfet nfet
mp1 Z Y X vdd pmos W=wg L=lg m=multiplier

*add cap
Cz Z Gnd 'LoadCap'

*add voltage sourse
VX X 0 'vdd/2'
VY Y 0 'vdd'

*define the initial condition of V(Z)
.IC V(Z)='vdd'

*do transient analysis
.tran 0.1u 400u

*print the V(Z) to waveform file *.tr0
.print V(Z)

*simulation options (you can modify this. Post is needed for .tran analysis)
.OPTION Post Brief NoMod probe measout

*measurement
.measure tran RTL TRIG AT=0 TARG v(Z) VAL=0.8 FALL=1
.measure tran avg_current AVG I(Cz) from 0 to 'RTL'
.measure tran avg_power AVG p(Cz)

.end
```

2)Script screenshot

```
from subprocess import call
def replace_line(file_name, line_num, text):
    lines = open(file_name, 'r').readlines()
    lines[line_num] = text
    out = open(file_name, 'w')
    out.writelines(lines)
    out.close()
f = open("dram.txt", 'w')
f.write("W\tS\trtl\tavg_current\tavg_power\n")
for i in range(1,17):
    replace_line("dram.sp",13,".param multiplier = "+str(i)+"\n")
    f.write(str(i)+"\t"+str(0.01)+"\t")
    replace_line("dram.sp",14,".param LoadCap = "+str(0.01)+"a\n")
    #call(["hspice","dram.sp"])
    lines = open("dram.mt0", 'r').readlines()
    n=lines[4].split()
    f.write(n[0]+"\t"+n[1]+"\t"+n[2]+"\n")
    for j in range(1,11):
        f.write(str(i)+"\t"+str(pow(5,j*0.1))+"\t")
        replace_line("dram.sp",14,".param LoadCap = "+str(pow(5,j*0.1))+"a\n")
        #call(["hspice","dram.sp"])
        lines = open("dram.mt0", 'r').readlines()
        n=lines[4].split()
        f.write(n[0]+"\t"+n[1]+"\t"+n[2]+"\n")
f.close()
```

3) dram.txt screenshot

W	S	rtl	avg_current	avg_power
1	0.01	3.325e-05	-6.069e-17	-9.329e-18
1	1.17461894309	3.405e-05	-6.959e-15	-1.095e-15
1	1.37972966146	3.419e-05	-8.139e-15	-1.286e-15
1	1.62065659669	3.435e-05	-9.514e-15	-1.511e-15
1	1.90365393872	3.454e-05	-1.111e-14	-1.774e-15
1	2.2360679775	3.477e-05	-1.297e-14	-2.084e-15
1	2.6265278044	3.503e-05	-1.511e-14	-2.447e-15
1	3.0851693136	3.533e-05	-1.759e-14	-2.874e-15
1	3.62389831839	3.570e-05	-2.045e-14	-3.375e-15
1	4.2566996126	3.612e-05	-2.373e-14	-3.963e-15
1	5.0	3.661e-05	-2.750e-14	-4.654e-15
2	0.01	3.325e-05	-6.069e-17	-9.329e-18
2	1.17461894309	3.365e-05	-7.043e-15	-1.096e-15
2	1.37972966146	3.372e-05	-8.255e-15	-1.287e-15
2	1.62065659669	3.380e-05	-9.672e-15	-1.511e-15
2	1.90365393872	3.390e-05	-1.133e-14	-1.775e-15
2	2.2360679775	3.401e-05	-1.326e-14	-2.085e-15
2	2.6265278044	3.415e-05	-1.551e-14	-2.449e-15
2	3.0851693136	3.430e-05	-1.814e-14	-2.876e-15
2	3.62389831839	3.448e-05	-2.119e-14	-3.378e-15
2	4.2566996126	3.470e-05	-2.473e-14	-3.967e-15
2	5.0	3.495e-05	-2.884e-14	-4.659e-15
3	0.01	3.325e-05	-6.070e-17	-9.329e-18
3	1.17461894309	3.352e-05	-7.071e-15	-1.096e-15
3	1.37972966146	3.357e-05	-8.293e-15	-1.287e-15
3	1.62065659669	3.362e-05	-9.725e-15	-1.512e-15
3	1.90365393872	3.368e-05	-1.140e-14	-1.775e-15
3	2.2360679775	3.375e-05	-1.336e-14	-2.085e-15
3	2.6265278044	3.385e-05	-1.566e-14	-2.449e-15
3	3.0851693136	3.395e-05	-1.833e-14	-2.877e-15
3	3.62389831839	3.407e-05	-2.145e-14	-3.379e-15
3	4.2566996126	3.422e-05	-2.509e-14	-3.969e-15
3	5.0	3.439e-05	-2.932e-14	-4.661e-15
4	0.01	3.325e-05	-6.069e-17	-9.329e-18
4	1.17461894309	3.345e-05	-7.087e-15	-1.096e-15
4	1.37972966146	3.348e-05	-8.315e-15	-1.287e-15
4	1.62065659669	3.352e-05	-9.756e-15	-1.512e-15
4	1.90365393872	3.357e-05	-1.144e-14	-1.776e-15
4	2.2360679775	3.363e-05	-1.342e-14	-2.085e-15
4	2.6265278044	3.369e-05	-1.573e-14	-2.450e-15
4	3.0851693136	3.378e-05	-1.843e-14	-2.877e-15
4	3.62389831839	3.386e-05	-2.159e-14	-3.379e-15
4	4.2566996126	3.398e-05	-2.527e-14	-3.969e-15
4	5.0	3.410e-05	-2.958e-14	-4.662e-15
5	0.01	3.325e-05	-6.070e-17	-9.365e-18
5	1.17461894309	3.341e-05	-7.095e-15	-1.100e-15
5	1.37972966146	3.343e-05	-8.328e-15	-1.292e-15
5	1.62065659669	3.347e-05	-9.772e-15	-1.518e-15
5	1.90365393872	3.350e-05	-1.146e-14	-1.782e-15
5	2.2360679775	3.355e-05	-1.345e-14	-2.093e-15
5	2.6265278044	3.361e-05	-1.577e-14	-2.459e-15
5	3.0851693136	3.367e-05	-1.849e-14	-2.890e-15
5	3.62389831839	3.375e-05	-2.167e-14	-3.392e-15
5	4.2566996126	3.383e-05	-2.538e-14	-3.988e-15
5	5.0	3.393e-05	-2.972e-14	-4.662e-15
6	0.01	3.325e-05	-6.070e-17	-9.365e-18
6	1.17461894309	3.338e-05	-7.102e-15	-1.100e-15
6	1.37972966146	3.341e-05	-8.334e-15	-1.292e-15
6	1.62065659669	3.343e-05	-9.783e-15	-1.517e-15
6	1.90365393872	3.346e-05	-1.148e-14	-1.782e-15
6	2.2360679775	3.350e-05	-1.347e-14	-2.094e-15
6	2.6265278044	3.355e-05	-1.580e-14	-2.459e-15
6	3.0851693136	3.360e-05	-1.853e-14	-2.888e-15
6	3.62389831839	3.366e-05	-2.172e-14	-3.395e-15
6	4.2566996126	3.373e-05	-2.546e-14	-3.988e-15
6	5.0	3.382e-05	-2.983e-14	-4.684e-15
7	0.01	3.325e-05	-6.069e-17	-9.365e-18
7	1.17461894309	3.336e-05	-7.105e-15	-1.100e-15
7	1.37972966146	3.338e-05	-8.340e-15	-1.292e-15
7	1.62065659669	3.341e-05	-9.788e-15	-1.518e-15
7	1.90365393872	3.344e-05	-1.149e-14	-1.782e-15
7	2.2360679775	3.347e-05	-1.348e-14	-2.094e-15
7	2.6265278044	3.350e-05	-1.582e-14	-2.459e-15
7	3.0851693136	3.355e-05	-1.855e-14	-2.888e-15
7	3.62389831839	3.360e-05	-2.176e-14	-3.393e-15
7	4.2566996126	3.367e-05	-2.551e-14	-3.988e-15
7	5.0	3.374e-05	-2.990e-14	-4.680e-15
8	0.01	3.324e-05	-6.070e-17	-9.365e-18
8	1.17461894309	3.334e-05	-7.109e-15	-1.100e-15
8	1.37972966146	3.336e-05	-8.346e-15	-1.292e-15
8	1.62065659669	3.338e-05	-9.797e-15	-1.518e-15
8	1.90365393872	3.341e-05	-1.150e-14	-1.783e-15
8	2.2360679775	3.344e-05	-1.349e-14	-2.094e-15
8	2.6265278044	3.347e-05	-1.583e-14	-2.459e-15
8	3.0851693136	3.351e-05	-1.858e-14	-2.889e-15
8	3.62389831839	3.356e-05	-2.179e-14	-3.393e-15
8	4.2566996126	3.361e-05	-2.555e-14	-3.985e-15
8	5.0	3.367e-05	-2.996e-14	-4.684e-15

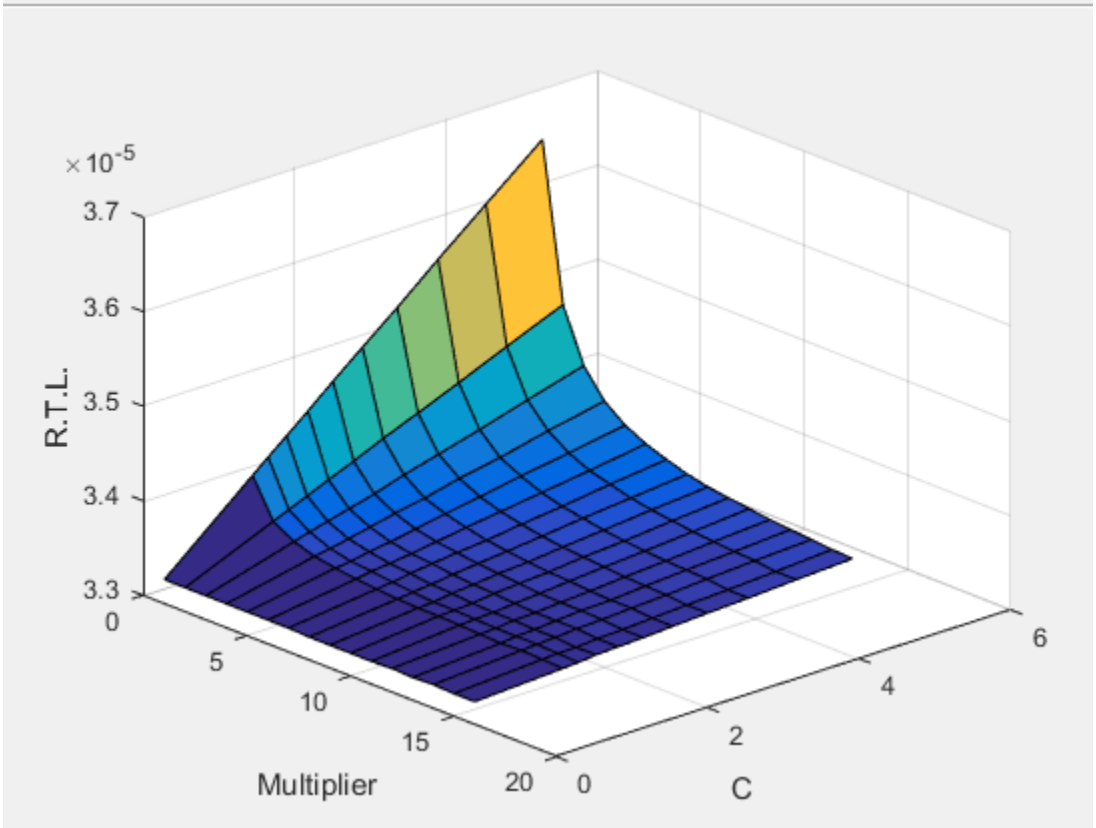
```
9       0.01    3.324e-05     -6.071e-17    -9.365e-18
9       1.17461894309 3.333e-05     -7.112e-15    -1.100e-15
9       1.37972966146 3.334e-05     -8.350e-15    -1.292e-15
9       1.62065659669 3.337e-05     -9.801e-15    -1.518e-15
9       1.90365393872 3.339e-05     -1.150e-14    -1.783e-15
9       2.2360679775  3.342e-05     -1.350e-14    -2.094e-15
9       2.6265278044  3.344e-05     -1.585e-14    -2.459e-15
9       3.0851693136  3.348e-05     -1.860e-14    -2.889e-15
9       3.62389831839 3.352e-05     -2.181e-14    -3.393e-15
9       4.2566996126  3.357e-05     -2.558e-14    -3.985e-15
9       5.0     3.362e-05     -3.000e-14    -4.681e-15
10      0.01    3.324e-05     -6.071e-17    -9.366e-18
10      1.17461894309 3.333e-05     -7.113e-15    -1.100e-15
10      1.37972966146 3.334e-05     -8.351e-15    -1.292e-15
10      1.62065659669 3.335e-05     -9.806e-15    -1.518e-15
10      1.90365393872 3.338e-05     -1.151e-14    -1.783e-15
10      2.2360679775  3.340e-05     -1.351e-14    -2.094e-15
10      2.6265278044  3.342e-05     -1.586e-14    -2.459e-15
10      3.0851693136  3.346e-05     -1.861e-14    -2.889e-15
10      3.62389831839 3.349e-05     -2.183e-14    -3.393e-15
10      4.2566996126  3.354e-05     -2.561e-14    -3.985e-15
10      5.0     3.359e-05     -3.003e-14    -4.681e-15
11      0.01    3.324e-05     -6.070e-17    -9.365e-18
11      1.17461894309 3.332e-05     -7.114e-15    -1.100e-15
11      1.37972966146 3.333e-05     -8.354e-15    -1.292e-15
11      1.62065659669 3.334e-05     -9.808e-15    -1.518e-15
11      1.90365393872 3.336e-05     -1.151e-14    -1.783e-15
11      2.2360679775  3.338e-05     -1.352e-14    -2.094e-15
11      2.6265278044  3.341e-05     -1.586e-14    -2.459e-15
11      3.0851693136  3.344e-05     -1.862e-14    -2.889e-15
11      3.62389831839 3.347e-05     -2.185e-14    -3.393e-15
11      4.2566996126  3.351e-05     -2.563e-14    -3.986e-15
11      5.0     3.356e-05     -3.006e-14    -4.681e-15
12      0.01    3.325e-05     -6.070e-17    -9.365e-18
12      1.17461894309 3.331e-05     -7.116e-15    -1.100e-15
12      1.37972966146 3.332e-05     -8.356e-15    -1.292e-15
12      1.62065659669 3.334e-05     -9.810e-15    -1.518e-15
12      1.90365393872 3.335e-05     -1.152e-14    -1.783e-15
12      2.2360679775  3.337e-05     -1.352e-14    -2.094e-15
12      2.6265278044  3.339e-05     -1.587e-14    -2.460e-15
12      3.0851693136  3.342e-05     -1.862e-14    -2.889e-15
12      3.62389831839 3.345e-05     -2.186e-14    -3.393e-15
12      4.2566996126  3.349e-05     -2.565e-14    -3.986e-15
12      5.0     3.353e-05     -3.009e-14    -4.681e-15
13      0.01    3.324e-05     -6.071e-17    -9.365e-18
13      1.17461894309 3.330e-05     -7.117e-15    -1.100e-15
13      1.37972966146 3.332e-05     -8.357e-15    -1.292e-15
13      1.62065659669 3.333e-05     -9.813e-15    -1.518e-15
13      1.90365393872 3.335e-05     -1.152e-14    -1.783e-15
13      2.2360679775  3.337e-05     -1.352e-14    -2.094e-15
13      2.6265278044  3.338e-05     -1.588e-14    -2.459e-15
13      3.0851693136  3.341e-05     -1.864e-14    -2.889e-15
13      3.62389831839 3.344e-05     -2.187e-14    -3.393e-15
13      4.2566996126  3.347e-05     -2.567e-14    -3.986e-15
13      5.0     3.351e-05     -3.011e-14    -4.681e-15
14      0.01    3.325e-05     -6.068e-17    -9.365e-18
14      1.17461894309 3.331e-05     -7.116e-15    -1.100e-15
14      1.37972966146 3.332e-05     -8.357e-15    -1.292e-15
14      1.62065659669 3.333e-05     -9.811e-15    -1.518e-15
14      1.90365393872 3.335e-05     -1.152e-14    -1.783e-15
14      2.2360679775  3.336e-05     -1.353e-14    -2.094e-15
14      2.6265278044  3.338e-05     -1.588e-14    -2.459e-15
14      3.0851693136  3.340e-05     -1.864e-14    -2.889e-15
14      3.62389831839 3.343e-05     -2.187e-14    -3.393e-15
14      4.2566996126  3.346e-05     -2.567e-14    -3.985e-15
14      5.0     3.349e-05     -3.012e-14    -4.681e-15
15      0.01    3.324e-05     -6.072e-17    -9.366e-18
15      1.17461894309 3.330e-05     -7.119e-15    -1.100e-15
15      1.37972966146 3.331e-05     -8.360e-15    -1.292e-15
15      1.62065659669 3.331e-05     -9.818e-15    -1.518e-15
15      1.90365393872 3.333e-05     -1.153e-14    -1.783e-15
15      2.2360679775  3.334e-05     -1.353e-14    -2.094e-15
15      2.6265278044  3.336e-05     -1.589e-14    -2.460e-15
15      3.0851693136  3.338e-05     -1.865e-14    -2.889e-15
15      3.62389831839 3.340e-05     -2.189e-14    -3.393e-15
15      4.2566996126  3.343e-05     -2.569e-14    -3.986e-15
15      5.0     3.347e-05     -3.015e-14    -4.682e-15
16      0.01    3.324e-05     -6.071e-17    -9.365e-18
16      1.17461894309 3.329e-05     -7.120e-15    -1.100e-15
16      1.37972966146 3.330e-05     -8.361e-15    -1.292e-15
16      1.62065659669 3.332e-05     -9.816e-15    -1.518e-15
16      1.90365393872 3.333e-05     -1.153e-14    -1.783e-15
16      2.2360679775  3.334e-05     -1.353e-14    -2.094e-15
16      2.6265278044  3.336e-05     -1.589e-14    -2.460e-15
16      3.0851693136  3.338e-05     -1.865e-14    -2.889e-15
16      3.62389831839 3.340e-05     -2.189e-14    -3.393e-15
16      4.2566996126  3.343e-05     -2.570e-14    -3.986e-15
16      5.0     3.346e-05     -3.016e-14    -4.682e-15
```

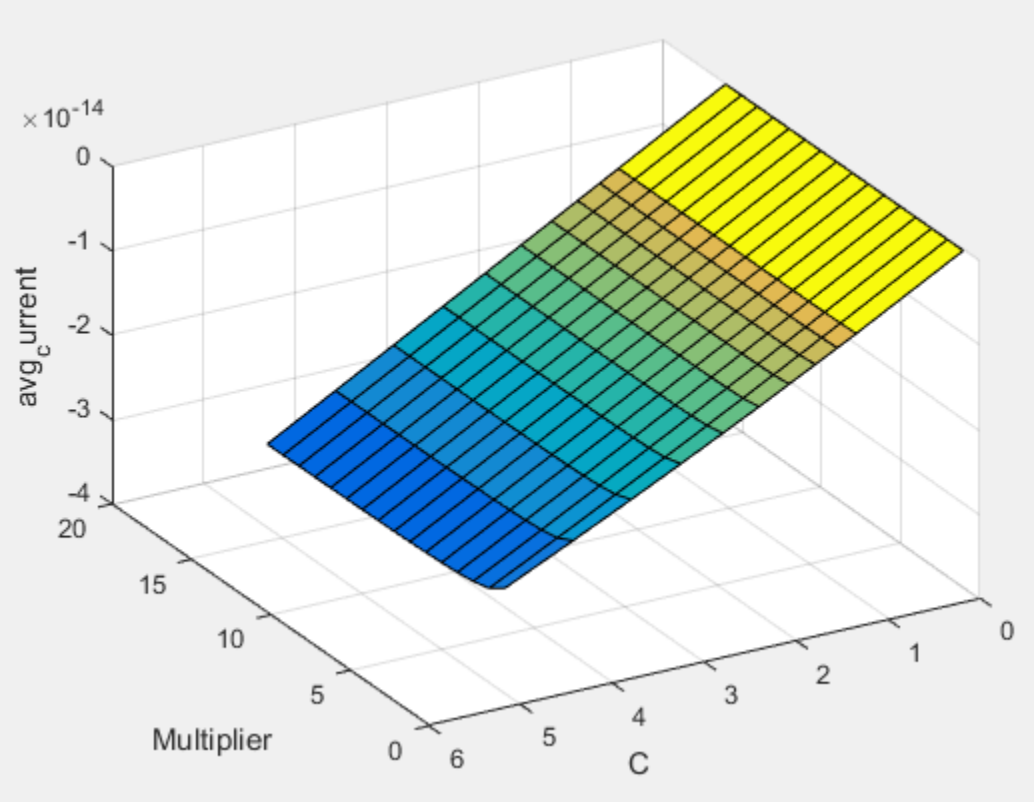
4) analysis.m screenshot

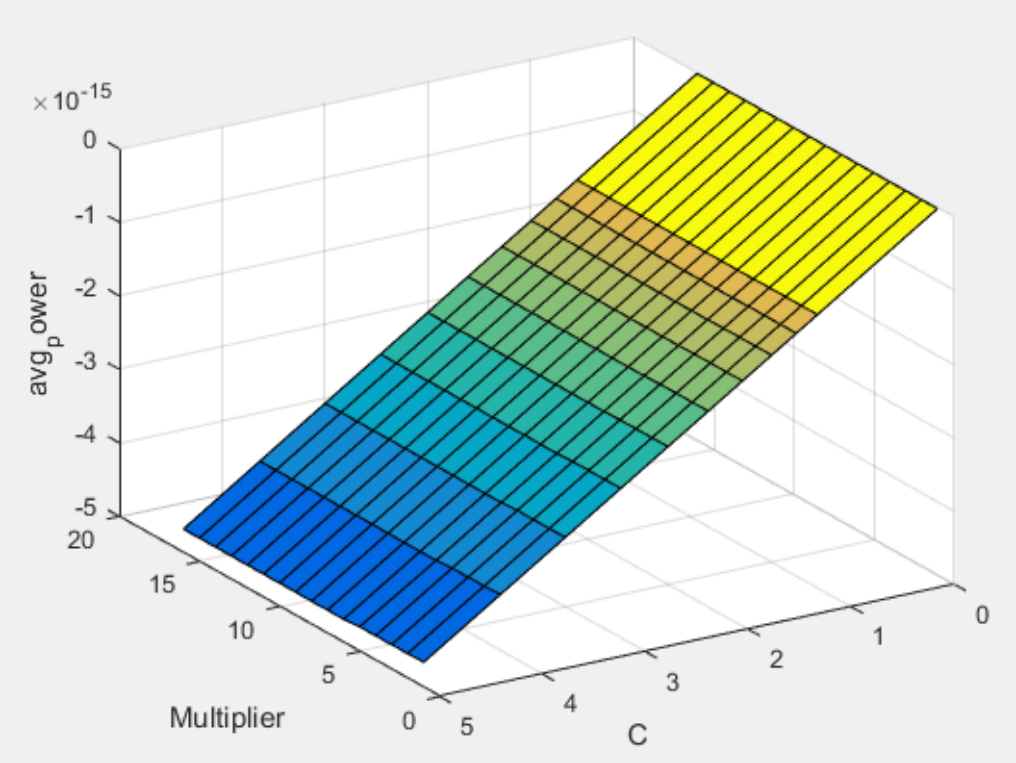
analysis.m

```
M=readtable('dram.txt');
rtl=reshape(M.rtl,[11,16]);
avg_current=reshape(M.avg_current,[11,16]);
avg_power=reshape(M.avg_power,[11,16]);
surf(1:16,M.S(1:11),rtl);
zlabel('R.T.L.');
xlabel('Multiplier');
ylabel('C');
figure;
surf(1:16,M.S(1:11),avg_current);
zlabel('avg_current');
xlabel('Multiplier');
ylabel('C');
figure;
surf(1:16,M.S(1:11),avg_power);
zlabel('avg_power');
xlabel('Multiplier');
ylabel('C');
```

5) 3D graphs of R.T.L., I_{avg} and P_{avg}







6) Calculated statistic values

i. R.T.L.

Min = 3.3240e-05

Max = 3.6610e-05

STD = 4.8914e-07

Average = -1.4648e-14

ii. avg_current

Min = -3.0160e-14

Max = -6.0680e-17

STD = 8.2980e-15

Average = -1.4648e-14

Average = -1.4648e-14

iii. avg_power

Min = -4.6840e-15

Max = -9.3290e-18

STD = 1.3060e-15

Average =-2.2887e-15