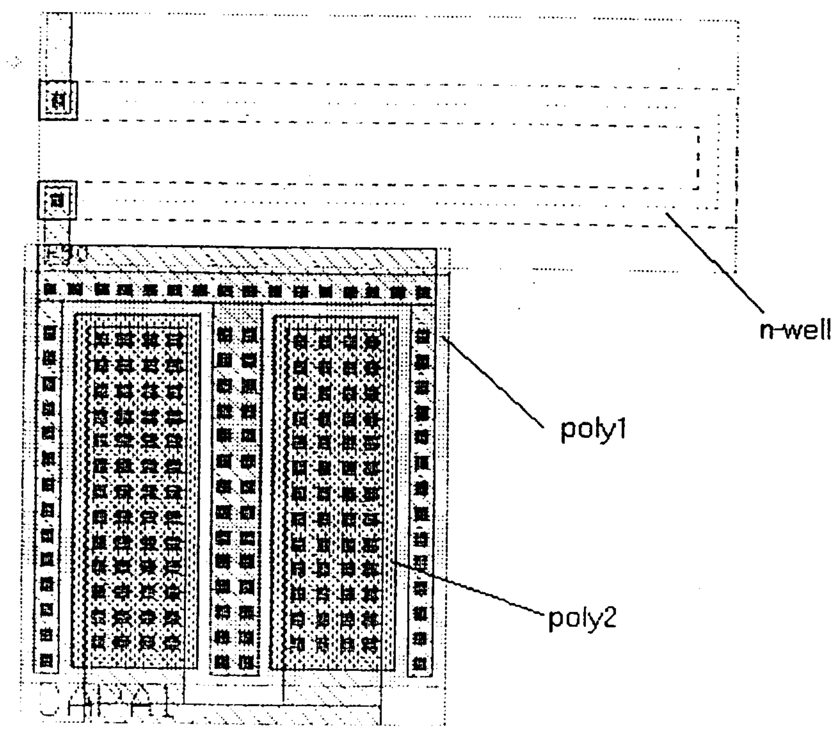
Chapter 7

Problem 7.1:
The layout of the RC circuit is shown in the following Fig.



The capacitor is composed of poly2 and poly1, and the capacitance $C \cong 1.10432pF$(which measured by "Cap" command of the LASI, $C'_{nom}=493aF/\mu m^2$ in CN20 process).

The resistor is composed of n-well, and the resistance $R \cong 90250\Omega$(which measured by "Res" command of the LASI, $R_{sheet(nom)}=2500\Omega$ in CN20 process).

$\therefore \tau = RC \cong 100ns$.

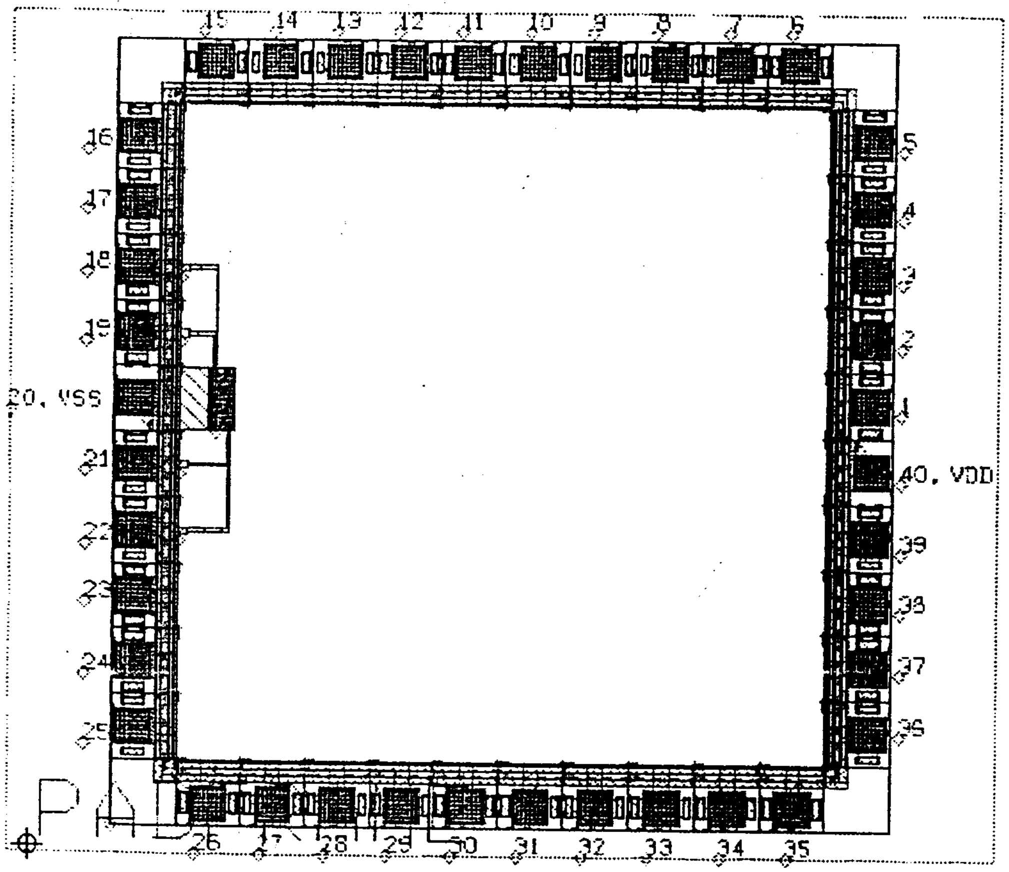
Because C' can vary from 443 to $557aF/\mu m^2$, and R_{sheet} can vary from 2000 to 3000 per square,

$\therefore$The minimum time constant $\tau_{min}=100\times(2000/2500)\times(443/493)\cong 71.9ns$.

The maximum time constant $\tau_{max}=100\times(3000/2500)\times(557/493)\cong 135.6ns$.

Problem 7.2:

$R(T)=R_{T0}\cdot(1+TCR\cdot(T-T_0))=20000\cdot(1+0.0002(T-27))$, and T vary from -50 to 100°C. The result is shown below:


15
14
13
12
11
10
9
8
7
6
16
17
18
19
20, VSS
21
22
23
24
25
5
4
3
2
1
40, VDD
39
38
37
36
26
27
28
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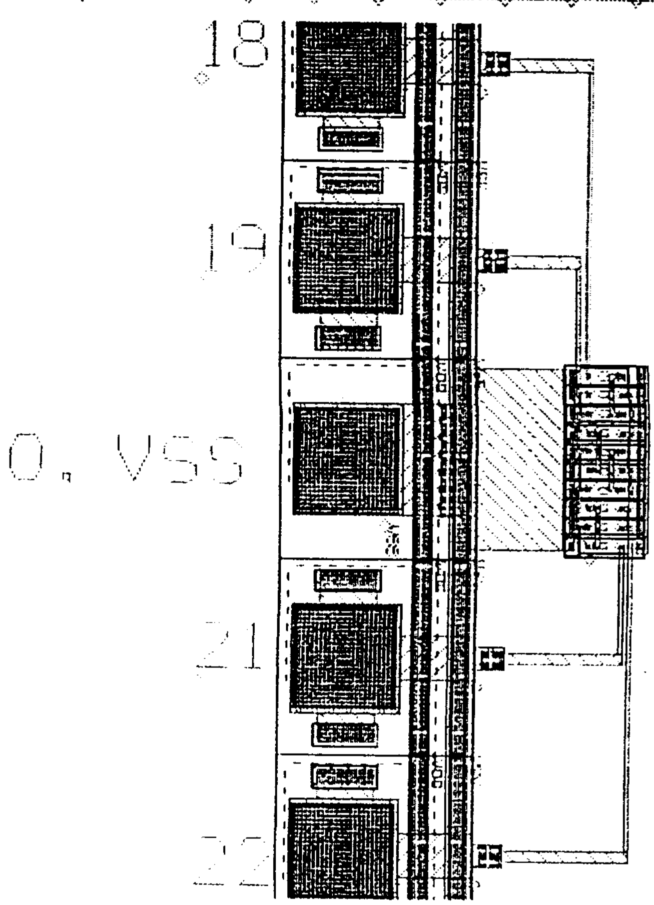
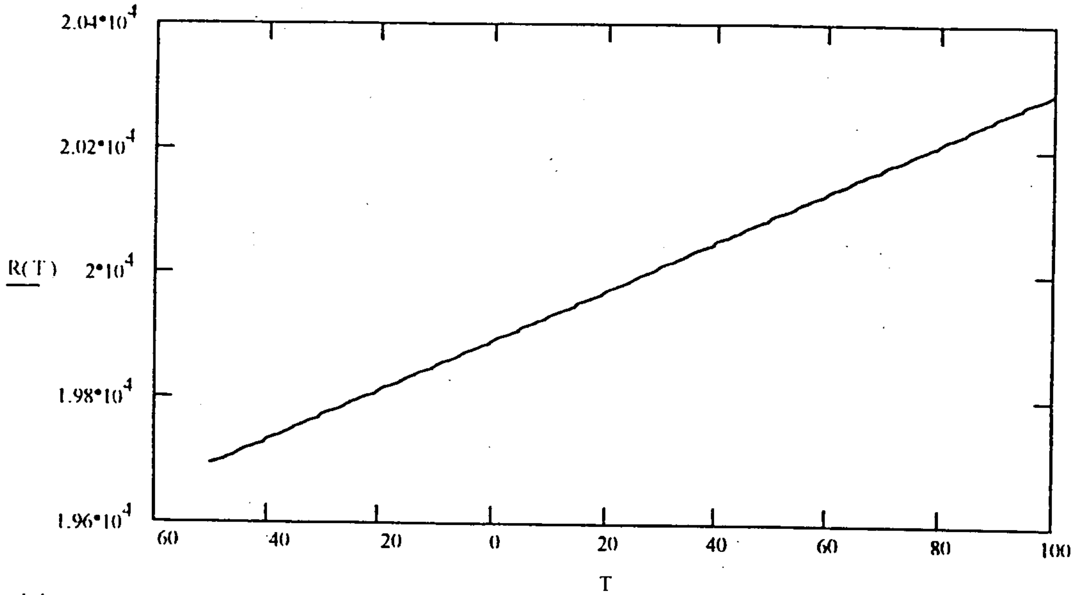
35

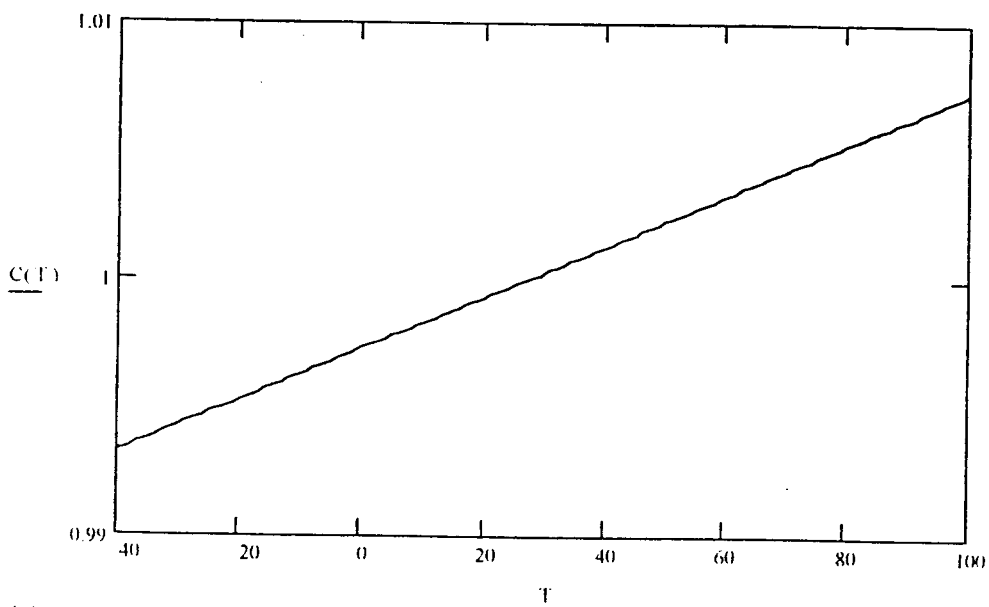

18
19
0, VSS
21
22



Problem 7.3:

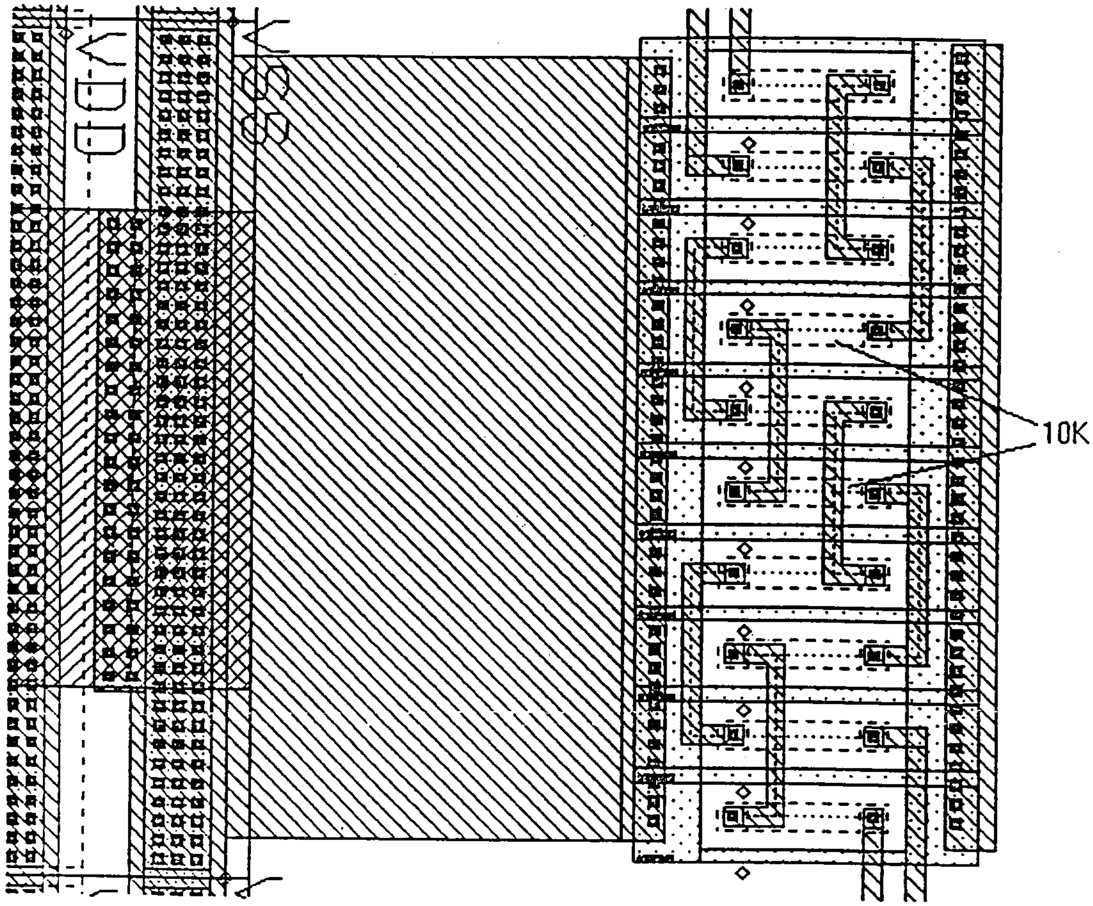
$C(T)=C_{T0}\cdot(1+TCC\cdot(T-T_0))=1\cdot(1+0.0001(T-27))(pF)$, and T vary from -40 to 100°C.

The result is shown below:



Problem 7.4:

The layout is shown below:



Problem 7.5:

The RMS noise current of each resistor:

$$\sqrt{\overline{i^2}}=\sqrt{\frac{4kT}{R}}=\sqrt{\frac{4\times 1.38\times 10^{23}\times 300}{20000}}=9.1\times 10^{-13}\left(\frac{A}{\sqrt{Hz}}\right)$$

The RMS noise voltage of each resistor:

$$\sqrt{\overline{v^2}}=\sqrt{4kTR}=\sqrt{\overline{i^2}}\cdot R=9.1\times 10^{13}\times\frac{20\times 20}{20+20}=9.1\left(\frac{nV}{\sqrt{Hz}}\right)$$

$$\overline{\left(v_{out}\right)^2}=\int_{f_L}^{f_H}\overline{\left(v_T\right)^2}\,df=\int_0^{100kHz}9.1^2+9.1^2\,df=165.6\times 10^{13}\,V^2$$

$$\overline{\left(v_{out}\right)^2}=\int_{f_L}^{f_H}\overline{\left(v_T\right)^2}\,df=\int_0^{100kHz}9.1^2+9.1^2\,df=165.6\times 10^{13}\,V^2$$

$$\sqrt{\overline{\left(v_{out}\right)^2}}=4.07\mu V$$

$$\sqrt{\overline{\left(v_{in}\right)^2}}=4.07\times\frac{20+20}{20}=8.14\mu V$$

Problem 7.6:

The RMS noise current of the resistor:

$$\sqrt{\overline{i^2}}=\sqrt{\frac{4kT}{R}}=\sqrt{\frac{4\times 1.38\times 10^{-23}\times 300}{20000}}=9.1\times 10^{-13}\left(\frac{A}{\sqrt{Hz}}\right)$$

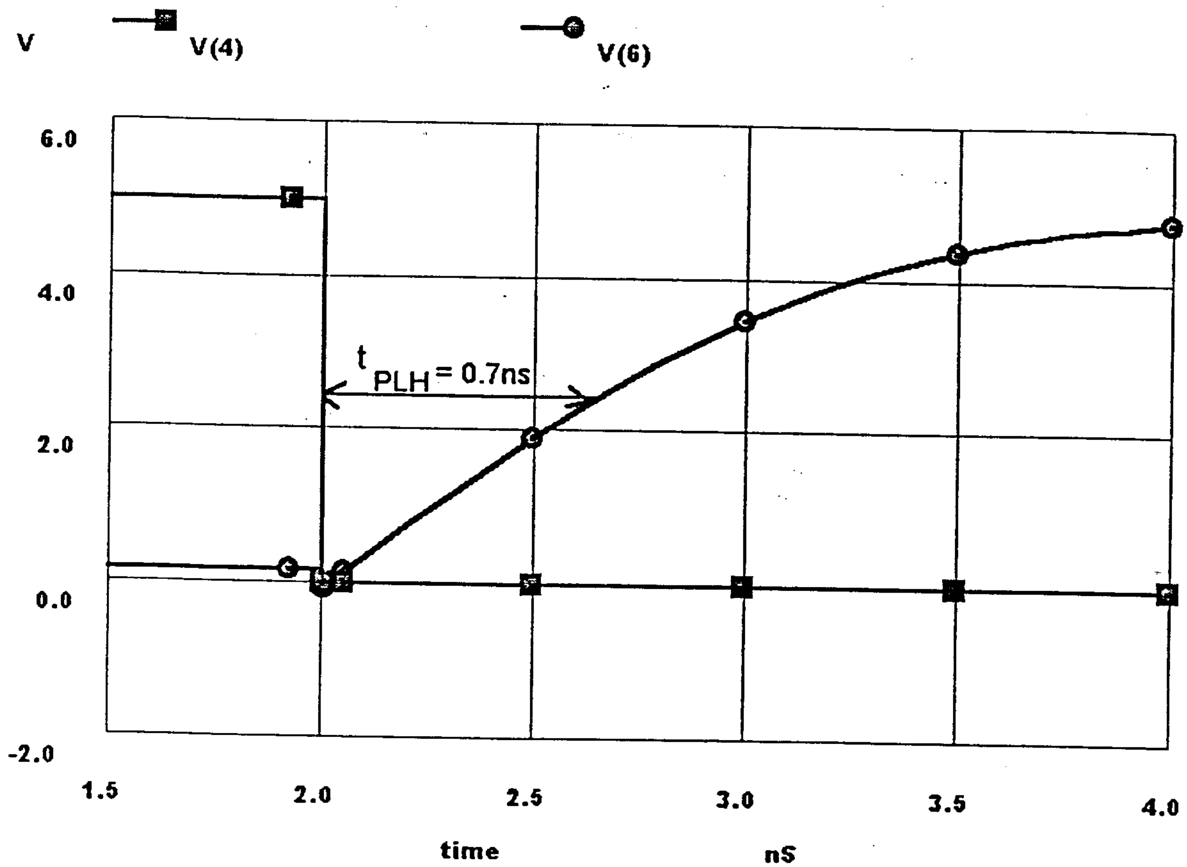
$$\overline{(v_{out})^2}=\frac{\overline{(i_{20k})^2}\cdot R^2}{2\sqrt{pRC}}\cdot\left[\tan\left(2\sqrt{pRC}\cdot f_H\right)^{(-1)}-\tan\left(2\sqrt{pRC}\cdot f_L\right)^{(-1)}\right]=0.412nv^2$$

$$\therefore\ \sqrt{\overline{(v_{out})^2}}=2.03\mu V$$

Because $\frac{v_{out}}{v_{in}}=\frac{R}{R+\frac{1}{j\omega C}}=\frac{j\omega RC}{1+j\omega RC}$

$$\overline{(v_{in})^2}=\int_{f_L}^{f_H}\frac{\overline{i^2}}{(2\pi Cf)^2}\,df=\frac{\sqrt{\overline{i^2}}}{2\pi C}\cdot\left(-\frac{1}{100MHz}+\frac{1}{0}\right)=\infty$$

2) for pmos,



3) netlist

```
C1      3 0 150f  IC=5    C2      6 0 50f  IC=0
M1      0 2 3 0 CMOSNB  L=2u W=10u
M2      5 4 6 5 CMOSPB  L=2u W=10u
V1      2 0      DC 0 AC 5 0 PULSE(0 5 2n 1p 0 5n 10n)
V2      4 0      DC 0 AC 0 0 PULSE(5 0 2n 1p 0 5n 10n)
V3      5 0      DC 5 AC 0 0
.MODEL CMOSNB NMOS LEVEL=4 ...appendix A
.MODEL CMOSPB PMOS LEVEL=4 ...appendix A
***** End of spice models and macro models *****
.OPTION ABSTOL=1u ITL4=100 RELTOL=0.01 VNTOL=0.1mv
.tran 1n 5n 0 0.01n uic
.end
```