

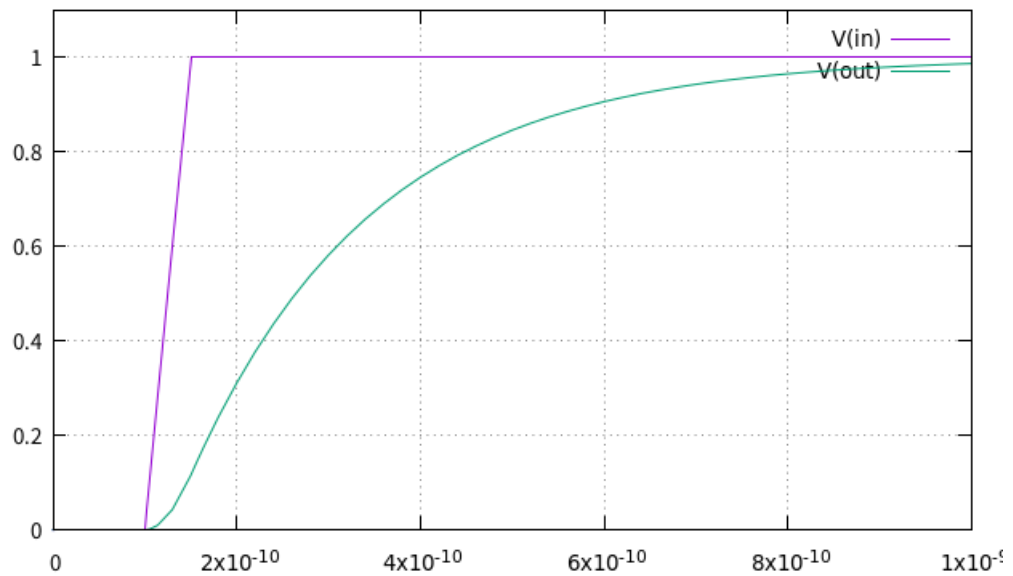
HW #2

1. RC circuit

```
ubuntu@ubuntu-virtual-machine: ~/test
File Edit View Search Terminal Help
* rc.sp for SPICE3F5

Vin in 0 pwl 0ps 0 100ps 0 150ps 1.0 1ns 1.0
R1 in out 2k
C1 out 0 100f

.tran 20ps 1ns
.print tran v(in) v(out)
.end
```



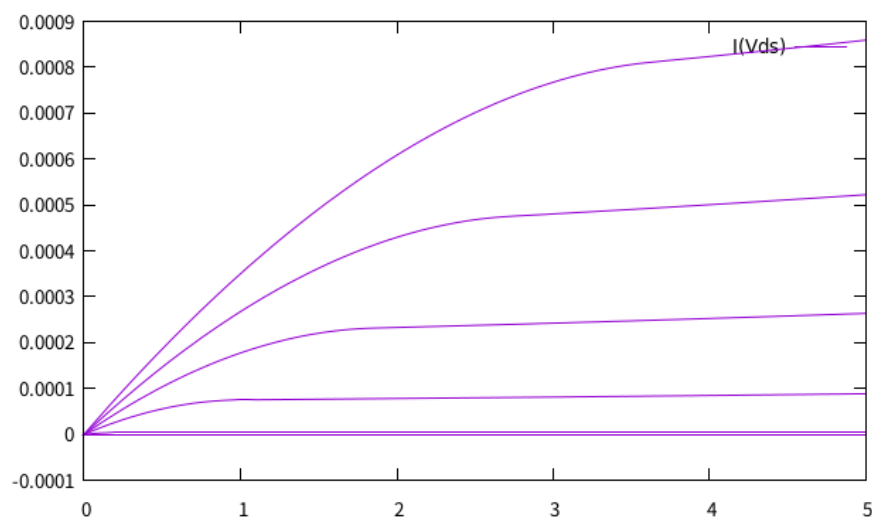
- RC 회로에 piece wise linear signal을 input으로 주었을 때, capacitor에 걸리는 전압을 시간에 대한 함수로 나타낸 그래프이다. capacitor 충전에 의한 시간 지연이 생김을 알 수 있다.

2. NMOSFET

```

ubuntu@ubuntu-virtual-machine: ~/test
File Edit View Search Terminal Help
* mosiv.sp for SPICE3F5
* models_1p2mu.sp
* Taken from
* http://bwrcs.eecs.berkeley.edu/Classes/IcBook/FILES/models.html
* SPICE LEVEL 2 Model for 1.2 mu Process
*
.MODEL NMOS NMOS LEVEL=2 LD=0.15U TOX=200.0E-10
+ NSUB=5.36726E+15 VTO=0.743469 KP=8.00059E-05 GAMMA=0.543
+ PHI=0.6 U0=655.881 UEXP=0.157282 UCRIT=31443.8
+ DELTA=2.39824 VMAX=55260.9 XJ=0.25U LAMBDA=0.0367072
+ NFS=1E+12 NEFF=1.001 NSS=1E+11 TPG=1.0 RSH=70.00
+ CGDO=4.3E-10 CGSO=4.3E-10 CJ=0.0003 MJ=0.6585
+ CJSW=8.0E-10 MJSW=0.2402 PB=0.58
+ Weff = WDrawn - Delta_W
* The suggested Delta_W is 1.9970E-07
*
.MODEL PMOS PMOS LEVEL=2 LD=0.15U TOX=200.0E-10
+ NSUB=4.3318E+15 VTO=-0.738861 KP=2.70E-05 GAMMA=0.58
+ PHI=0.6 U0=261.977 UEXP=0.323932 UCRIT=65719.8
+ DELTA=1.79192 VMAX=25694 XJ=0.25U LAMBDA=0.0612279
+ NFS=1E+12 NEFF=1.001 NSS=1E+11 TPG=-1.0 RSH=120.6
+ CGDO=4.3E-10 CGSO=4.3E-10 CJ=0.0005 MJ=0.5052
+ CJSW=1.349E-10 MJSW=0.2417 PB=0.64
+ Weff = WDrawn - Delta_W
* The suggested Delta_W is 3.1280E-07
*
Vgs g 0 0
Vds d 0 0
M1 d g 0 0 NMOS W=2.4 L=1.2
*
.dc Vds 0 5.0 0.05 Vgs 0 5.0 1.0
.print dc V(g) I(Vds)
.end

```



- NMOSFET의 gate에 0~5V의 dc 전압을 인가했을 때, drain의 전압에 따른 drain의 전류 값을 시뮬레이션 한 결과이다. V_{ds} 값이 일정 값을 넘기면, saturation region에서 작동됨을 알 수 있다.

3. CMOS Inverter

```
*inv.sp for SPICE3F5
* models_1p2mu.sp
* Taken from
* http://bwrce.eecs.berkeley.edu/Courses/IcBook/FILES/models.html
* SPICE LEVEL 2 Model for 1.2 mu Process

.MODEL NMOS NMOS LEVEL=2 LD=0.15U TOX=200.0E-10
+ NSUB=5.36726E+15 VTO=0.743469 KP=8.00059E-05 GAMMA=0.543
+ PHI=0.6 U0=655.881 UEXP=0.157282 UCRIT=31443.8
+ DELTA=2.39824 VMAX=55260.9 XJ=0.25U LAMBDA=0.0367072
+ NFS=1E+12 NEFF=1.001 NSS=1E+11 TPG=1.0 RSH=70.00
+ CGDO=4.3E-10 CGSO=4.3E-10 CJ=0.0003 MJ=0.6585
+ CJSW=8.0E-10 MJSW=0.2402 PB=0.58
* Weff = WDrawn - Delta_W
* The suggested Delta_W is 1.9970E-07

.MODEL PMOS PMOS LEVEL=2 LD=0.15U TOX=200.0E-10
+ NSUB=4.3318E+15 VTO=-0.738861 KP=2.70E-05 GAMMA=0.58
+ PHI=0.6 U0=261.977 UEXP=0.323932 UCRIT=65719.8
+ DELTA=1.79192 VMAX=25694 XJ=0.25U LAMBDA=0.0612279
+ NFS=1E+12 NEFF=1.001 NSS=1E+11 TPG=-1.0 RSH=120.6
+ CGDO=4.3E-10 CGSO=4.3E-10 CJ=0.0005 MJ=0.5052
+ CJSW=1.349E-10 MJSW=0.2417 PB=0.64
* Weff = WDrawn - Delta_W
```

1,1

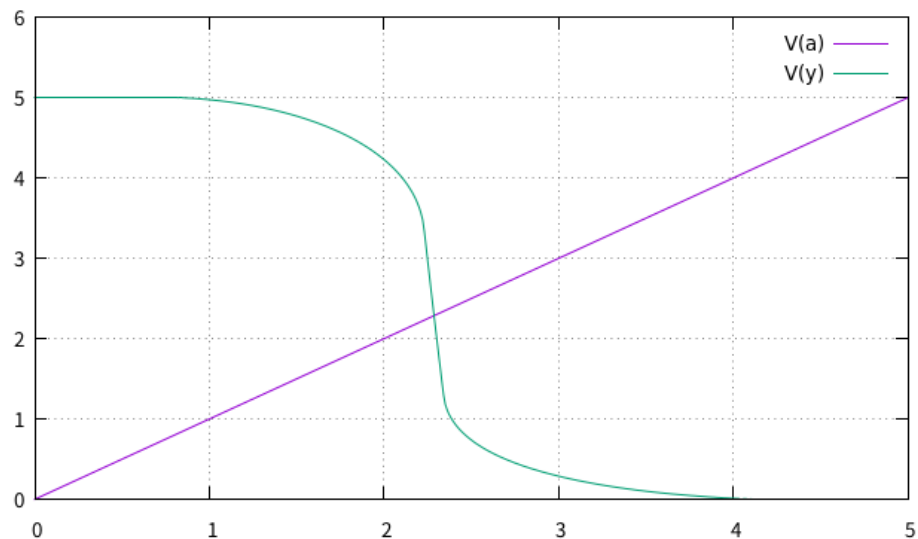
꼭대기

```
Vdd vdd 0 5.0
Vin a 0 0.0
M1 y a 0 0 NMOS W=2.4 L=1.2
M2 y a vdd vdd PMOS W=4.8 L=1.2

.dc Vin 0 5 0.01
.print dc V(a) V(y)
.end
```

38,0-1

바닥



- CMOS inverter 회로에서 gate의 전압과 drain의 전압을 시간에 대한 함수로 나타낸 결과이다. Ideal 하진 않지만, gate의 전압과 drain의 전압 사이에 inverting이 일어남을 알 수 있다.