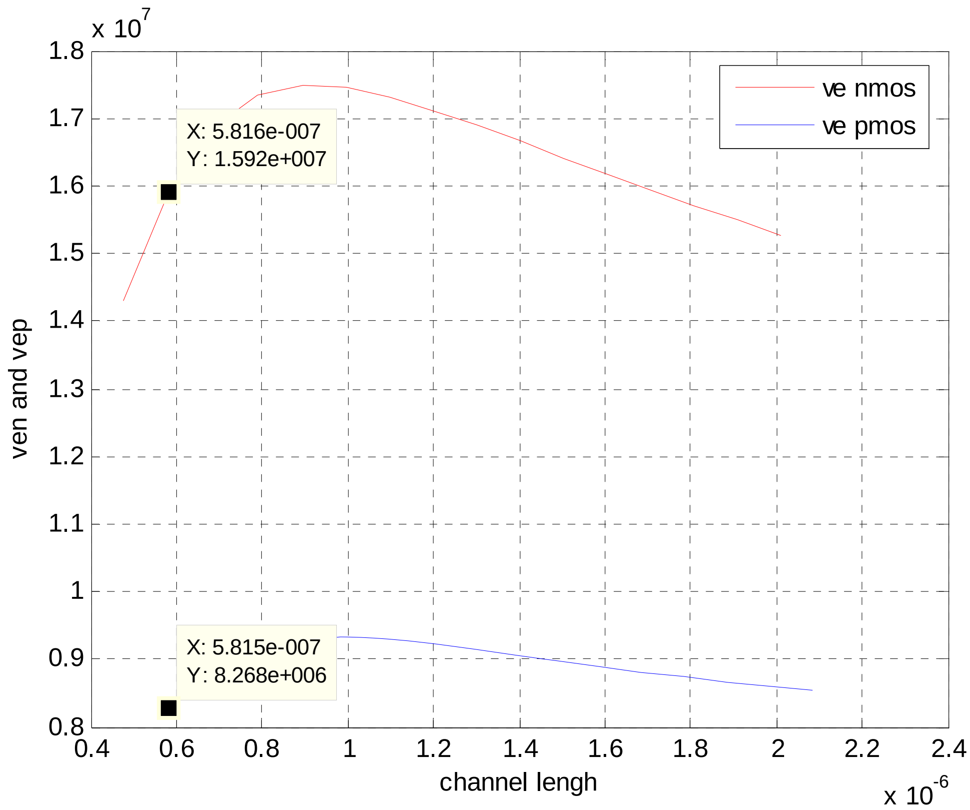
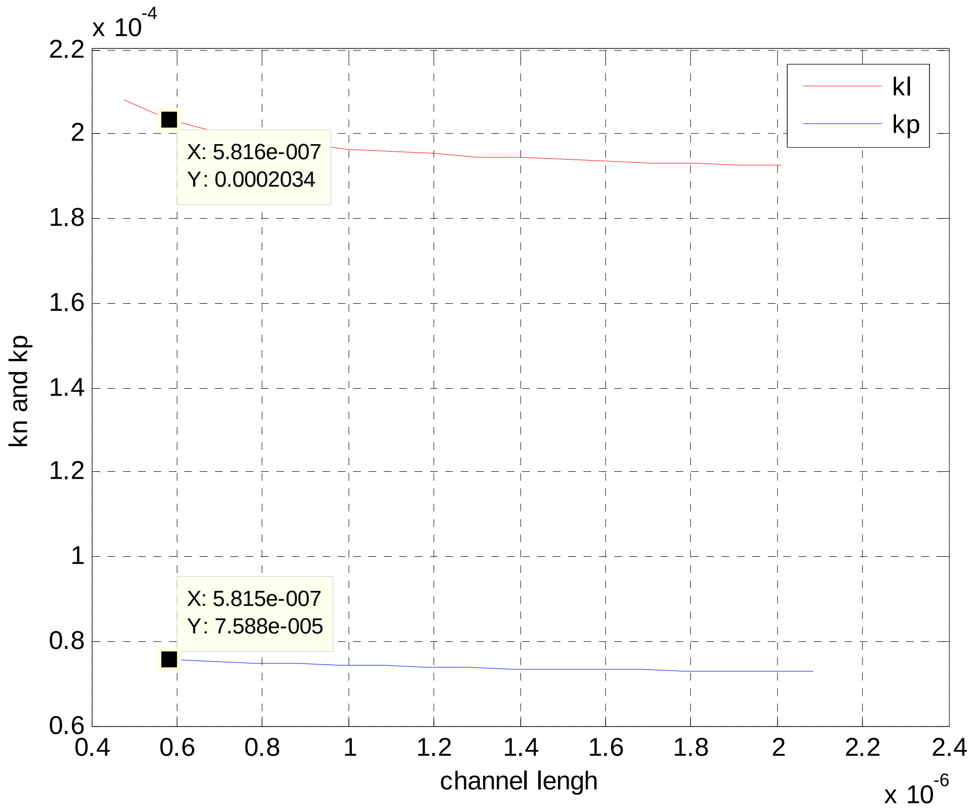
1，测试 MOS 基本参数

```
.lib    'D:\project\hspicelib\cmos035\CMOS_035_Spice_Model33v.lib'    TT
.inc    'D:\project\hspicelib\switchmodel\myswitch.cir'
.op
.option    node list post
.option    node list post
MN1          outn NMOSIN 0 0    N_33 L=kl W='2*kl' M=1
MP1          OUTP PMOSIN VDD VDD    P_33 L=kl W='2*kl' M=1
IDCN         VDD outn    kidn
IDCP         OUTP 0      kidp
VDD          VDD 0    3.3
LN           NMOSIN outn    10G
CINN         IN    NMOSIN    10G
VIN          IN    0       AC=1
CINP         IN    PMOSIN    10G
LP           OUTP PMOSIN    10G
* DICTIONARY 1
* GND = 0
.GLOBAL VDD
.ac    dec 100    1    1g * sweep    kl    0.5u     2u     0.1u
**.print       vdb(outn)    vdb(oup)
.param     kidn=7.5U       kidp=2.7u     kl=1u

****meas    ve_n of    nmos
.meas      ac    dc_gain_n      max    vm(outn)
.meas      ac     w_n            find w(mn1)       at 5
.meas      ac     l_n            find l(mn1)       at 5
.meas      ac     s_n            param='w_n/l_n'
.meas      ac     vth_n          find lv9(mn1)    at    5       *vth alias
.meas      ac     vgs_n          find lx2(mn1)    at    5
.meas      ac     vod_n          param='vgs_n-vth_n'
.meas      ac     ve_n           param='dc_gain_n*vod_n*0.5/l_n'
.meas      ac     kn             param='2*kidn/vod_n/vod_n/s_n'
***mesure    ve_p of pmos
.meas      ac    dc_gain_p      max    vm(outp)
.meas      ac     vth_p          find lv9(mp1)    at    5
.meas      ac     vgs_p          find lx2(mp1)    at    5
.meas      ac     w_p            find w(mp1)       at 5
.meas      ac     l_p            find l(mp1)       at 5
.meas      ac     s_p            param='w_p/l_p'
.meas      ac     vod_p          param='vgs_p-vth_p'
.meas      ac     ve_p           param='dc_gain_p*vod_p*0.5/l_p'
.meas      ac     kp             param='2*kidp/vod_p/vod_p/s_p'
```

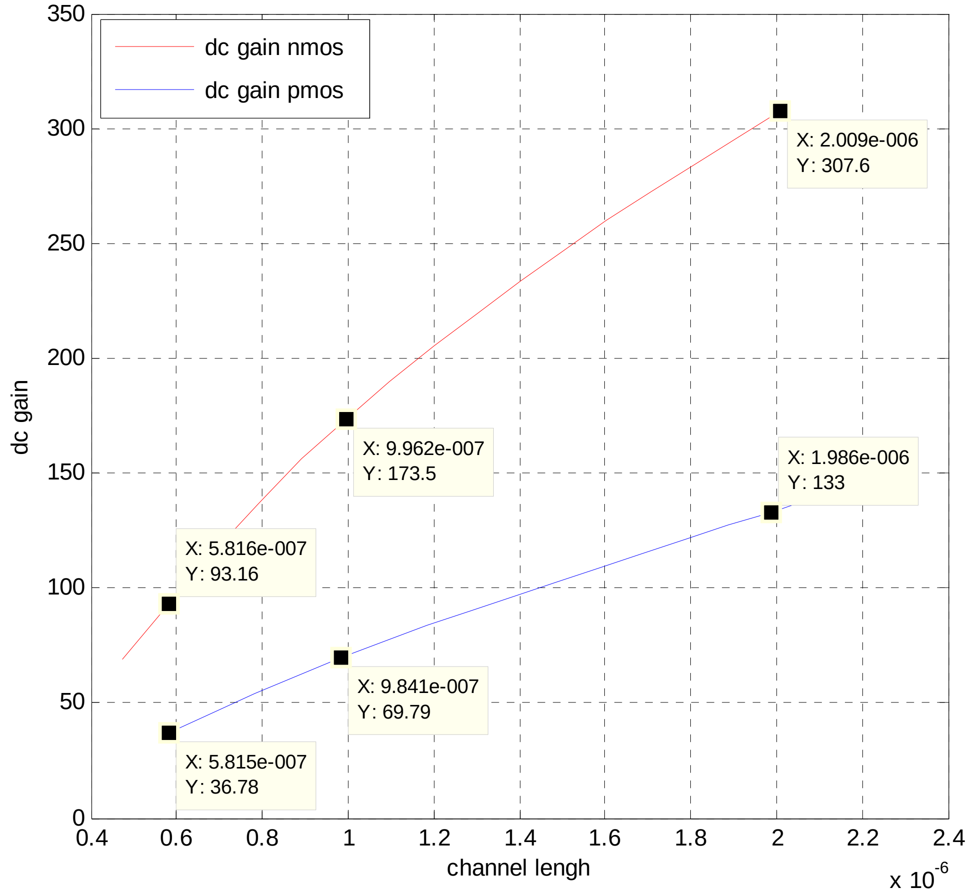
```
//其它
.meas    ac    dc_gain_n    find    vm(outn)    at 5
.meas    ac    rds_n        find    rds(mn1)    at 5
.meas    ac    gds_n        find    gdso(mn1)   at 5
.meas    ac    gm_n         find    gmo(mn1)    at 5
.meas    ac    a0_rds_n     param   'gm_n*rds_n'
.meas    ac    a0_gds_n     param   'gm_n/gds_n'
.meas    ac    rout_ac_n    param   '1/gds_n'
.meas    ac    c_gsub_n     find    cggbo(mn1)
.meas    ac    c_gs_n       find    cgsbo(mn1)
.meas    ac    w_n          find    w(mn1)
.meas    ac    l_n          find    l(mn1)
.meas    ac    cox_n        param   'c_gsub_n/w_n/l_n'

****meas    ve_n of    nmos
.meas    ac    dc_gain_p    find    vm(outp)    at 5
.meas    ac    rds_p        find    rds(mp1)    at 5
.meas    ac    gds_p        find    gdso(mp1)   at 5
.meas    ac    gm_p         find    gmo(mp1)    at 5
.meas    ac    a0_rds_p     param   'gm_p*rds_p'
.meas    ac    a0_gds_p     param   'gm_p/gds_p'
.meas    ac    rout_ac_p    param   '1/gds_p'
.meas    ac    c_gsub_p     find    cggbo(mp1)
.meas    ac    c_gs_p       find    cgsbo(mp1)
.meas    ac    w_p          find    w(mp1)
.meas    ac    l_p          find    l(mp1)
.meas    ac    cox_p        param   'c_gsub_n/w_n/l_n'
```



ve of nmos & pmos ve_n=16.4e6 ve_p=8.92e6



kn= 1.9396e-004 kp= 7.9971e-005 @mean



dc gain vs L at vod=0.2v

2，MOS 常见参数及函数调用

//for umc 0.35um 3.3v twin_well

ξ_0 =8.85 aF/um a=10^{-18}

$\xi_{r\_s_io_2}$ =3.97

k= 1.38*10^{-23}J/K

q=1.6*10^{-19}C

V_T=kT/q=16mv@300K

tox=5nm cox=6.9fF/um^2

tox=7nm 时 cox= Cgdoverlap=Cgsoverlap=1.5e-10

tox=12nm cox=2.88fF/um^2

vthn=0.63v

kn= 1.9396e-004

ve_n=16.4e6

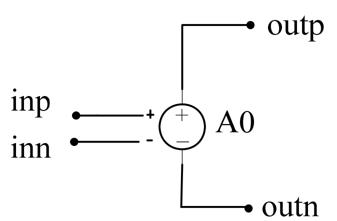
vthp= 0.86v
kp= 7.9971e-005
ve_p=8.92e6

函数
L()
W()
vth() 阈值电压，pmos 为正值
vdsat() 饱和电压即 vgs-vth
rds() 电阻，不知是怎么来的
vgs()
cdo() dc drain current
gmo() gm operational 静态时 gm
gdso() dc D-S conductance 导数为输出电阻 gmo/gdso 为直流增益
covlgs() gs overlap
covlgd() gd overlap
covlge() Gsub overlap

3, option 选项及 VCVS VCCS param

若要导入到 MATLAB 中需要 bin 进制文件时需要设置好 option 并只使用.probe 打印
.option post=1 //二进制
.probe tran V(out1) v(node1)

.option reltol
.option reltol=1e-5 abstol=1e-9
.option reli=XXX
.option methode=gear
.option post=-0,1,2 // 打印科学进制和其它形式 1,binary 2,ascii 3,减小文件空间大小。
.option post acct accurate // acct 仿真结果写入 list 文件中。default=1, accurate 仿真精度很高。
.option node list post
.option GSHUNT=1e-11 CSHUNT=1e-11 method=gear
.option fast
.option ingold=2 //list 中打印的数字为科学制度如 10e8



evcvs outp outn inp inn MAX= 5 MIN= -5 A0(如 1000)
evccs outp outn cn1 cn2 max=5 min=0 gm(如 200u)
//sybol
Prefix=G
PINODER= outp outn inp inn
gm //设置一个变量
ORDER= MAX= MIN= gm$

.subckt NAND2 vin vss x1 x2 y wn1=Wn11 //wn1 等可省去不用，
M3 X1 VSS VSS N_33 W=wn1
.ends

需导出网表为
Xaaa vin vss x1 x2 y NAND2 WN1=0.7U //或 WN11=0.7U 也可以在 symbol 中由 symb 中 ORDER 控制

.subckt
.inc '…\myswitch.cir'
Xswitch in out cont switchdai
//myswitch.cir
.subckt switchdai in out cont
子电路名 端口排序
Gswitch in out VCR pwl(1) cont 0 0, 10g 1v,0.1v //1v 时对应于 0 欧姆，0.1v
.ends

对应于 10G 欧姆
//myswitch.cir
//sybol
MODEL=switchdai
Pinorder=in out cont
Prefix=X
ORDER=MODEL$ //只显示 MODEL 值

.param Kcu=2.0
.param kv=unif(nomina_val,rel_variation,multiplier)
Aunif(…)
Gauss(nominal_val,rel_variation,sigma,multiplier)

σ^2 (sigma),

.ac dec 100 1 1g sweep monte=n_time // n_time 为取样次数。
Ex outp outn POLY(3) inp1, inn1, inp2, inn2, inp3, inn3, 0, 1, 1, 1
+IC=1.5, 2.0, 17.25
其中 0,1,1,1 为 p0,p1,p2 多项式

$$\begin{cases} V(outp,outn) = P0 + P1*V(inp1,inp1) + P2*V(inp2,inn2) + P3*V(inp3,inn3) \\ p0 = 0,\ p1 = 1,\ p2 = 1,\ p3 = 1 \end{cases}$$

零延时反相器

Einv   outp outn   pwl(1)   inp, inn,   0.7v,   5v,   1v , 0 v

输出电压 0.7v 对应输入电压 1v，输出 5v 对输入 0v

4,激励源和 print prob

sin (vo va f   t_d θ φ)

sin (偏置电压 振幅 频率 延时 衰减因子   初始相位)

$$V0 + Va * \exp[-(t - td)\theta] \cdot \sin\left\{2\pi[f \cdot (t - td) + \frac{\varphi}{360}]\right\}$$

pulse (v1 v2 td   tr tf pw per   R   t)

pulse (初始值 高值 延时 上升时间   下降时间 高占比例   周期 repeat   重复时间)

pwl(t1 v1   t2 v2   R Trepeat)

```
.print ac(*)
.print   ac   vdb(node1,node2)
.print   ac   par('(v(node1)-v(node2))/v(node3)')
.print   ac   par('DB(V(dop)-V(don))')
.print   noise   inoise   onoise

.print   ac   v(node1,node2)
.print   dc      par ('sqrt(I1(m1))')

.probe   tran   V(in1)   v(nod1)   v(nod2)
```

5, ac   dc 仿真及 meas   sweep

ac

.ac dec 100   1   1g

.ac 每十倍频程 100   频率 1 至 1g Hz

.ac dec 100   1   1G   sweep   Kcp   POI   3   1p 2p 3p   //变量 Kcp 有三个点扫描 1p,2p,3p

.ac dec 100   1   1G   sweep   Kcp   LIN   5   25   125   //从 25 度到 125 度有 5 个点扫描

.ac dec 100   1   1G   sweep   Kcp   DEC 10 1K 100K   //从 1k 到 100k 每十倍频程有 10 个点

.ac dec 100   1   1G   sweep   data=ac

```
.data   ac
Temp     K1
25          1p
26          2p
```

27 5p

……

也可将上面写在一个文件中如 sweep.txt 再在网表中添加

.inc ‘….\sweep.txt’

dc

.dc v2 0.1v 5v 0.01v

.dc vds 0 5v 0.001v seeep vgs 0 5v 1v //都是步长

从 0.1v 到 5v，0.001v 间距递增

v1 vin 0 dc 0.9 ac 1

meas

.meas tran t_cycle1 trig v(compout) val=2.5v fall=1 targ v(compout) val=2.5v fall=2

//compout 第一次下降时间到第二次下降时间间隔值存在变量 t_cycle1 中

.meas dc Rout DERIV I1(M1) from=0v to=5v //等号都可以用空格代替

.meas tran Avgdai AVG V(compout) from=10u to=400u

.meas tran Cycle_dai PARAM=’(Rout/2)’

.meas tran id1 find i1(m24) at= 4m //在 4ms 处 m24 的电流值

.meas ac dcgain_db max vdb(don)

.meas ac dcgai_m max vm(don)

.meas ac phsmagin find vp(don) when vdb(don)=0 fall=1

.meas ac gbw when vdb(dop=0) fall=1 //此时 when 是指 ac 变量频率

.meas tran Slew_Rate DERIV V(out) at=25ns

tran

.tran 1u 5m sweep vdd 1v 5v 1v 从 1v 到 5v 中每 1v 取一个点

.tran 1u 20u swee temp -15 75 10 //从-15 到 75 度，每 10 度取一个点

.tran 0.1n 10u 1ns 40us start=10ns //10u 40us 10ns 都是时刻

0~10us 的时间内精度为 0.1n 10u~40u 的时间内精度为 1ns，开始打印时刻为 10ns。

.tran 10n 1us UIC sweep temp -55 75 10 //温度从-55 到 75，每 10 度一个点。

.op at=10u or at 10u 10u 时的静态工作状态

.tf V(outp) VINP

.noise V(outp) Vinp 10 //10 为每十倍频程打印十个点结果。

输出电压 输入 AC 激励源

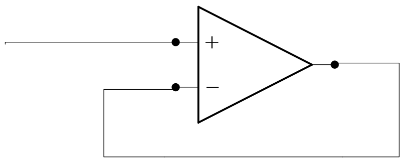
.fft V(1) np=1024 start=0.3m stop=2m freq=5.0k window=kaiswe alfa=0.5

.temp -20 25 50 //分别取三个温度点都仿真

.pz v(node_out) vin
.IC v(node1)=5v
.alter
.del .lib '.....' tt
.protect
.lib '.....' ss
.unprotect

.prot
.lib
.unprot
.alter
.del .lib ‘…’ //原句复制下来
.prot
.lib ‘….’ tt
.unprot

6，常见仿真电路图
Input common range



一看尾电流二看输出是否跟随输入变化而变化
Input common reject ration