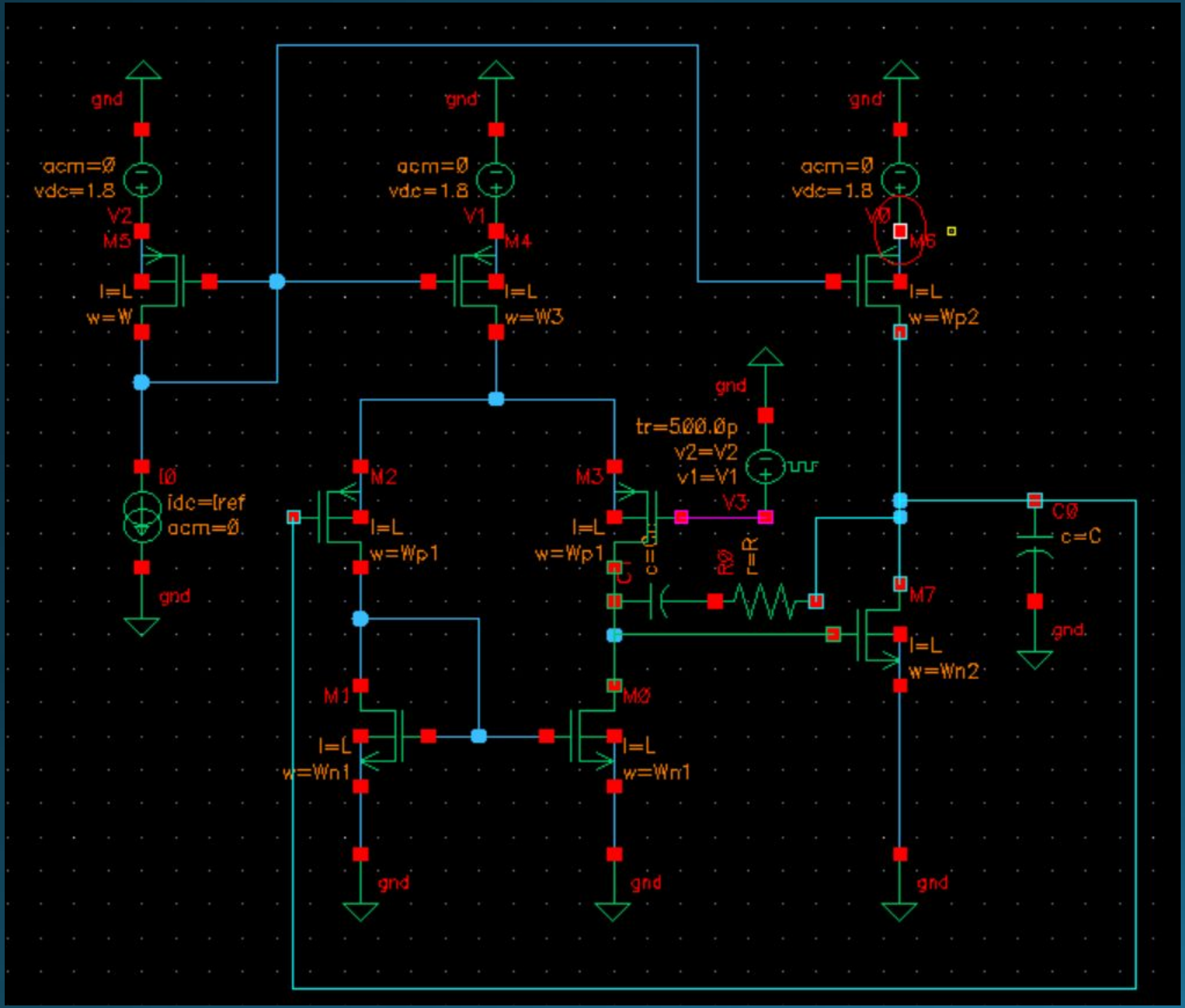
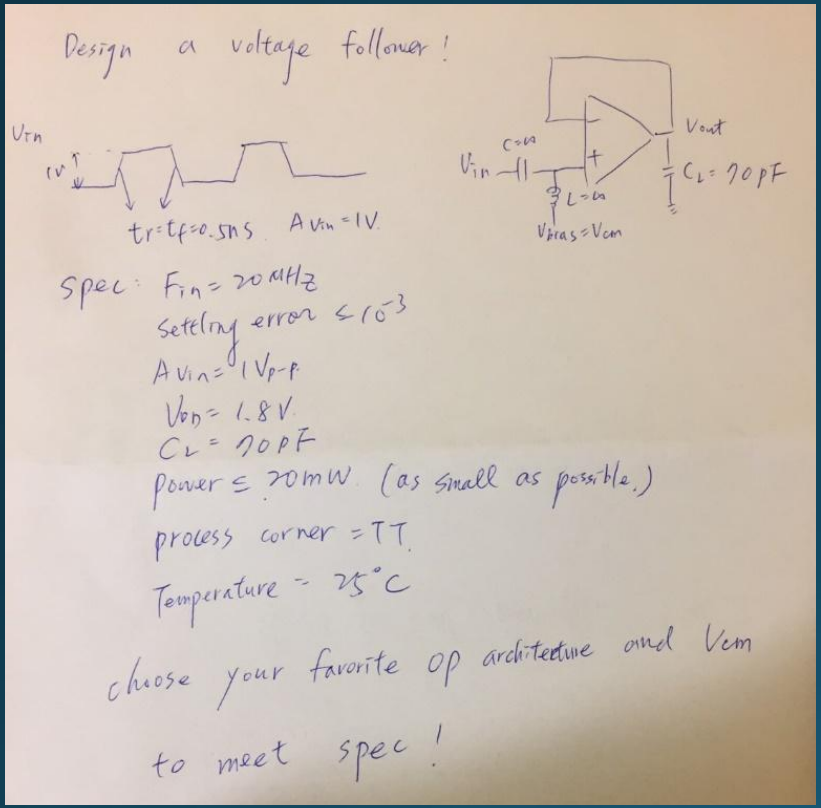


B04901144 陳博仁

follower

spec



- $\omega_p > 2\pi \times Fin = 125.66M$
- $SR > {}^{1}/_{25n} = 40M$

$$\Rightarrow SR = \frac{I_{out}}{C_L} \Rightarrow I_{out} > 2.8(mA)$$

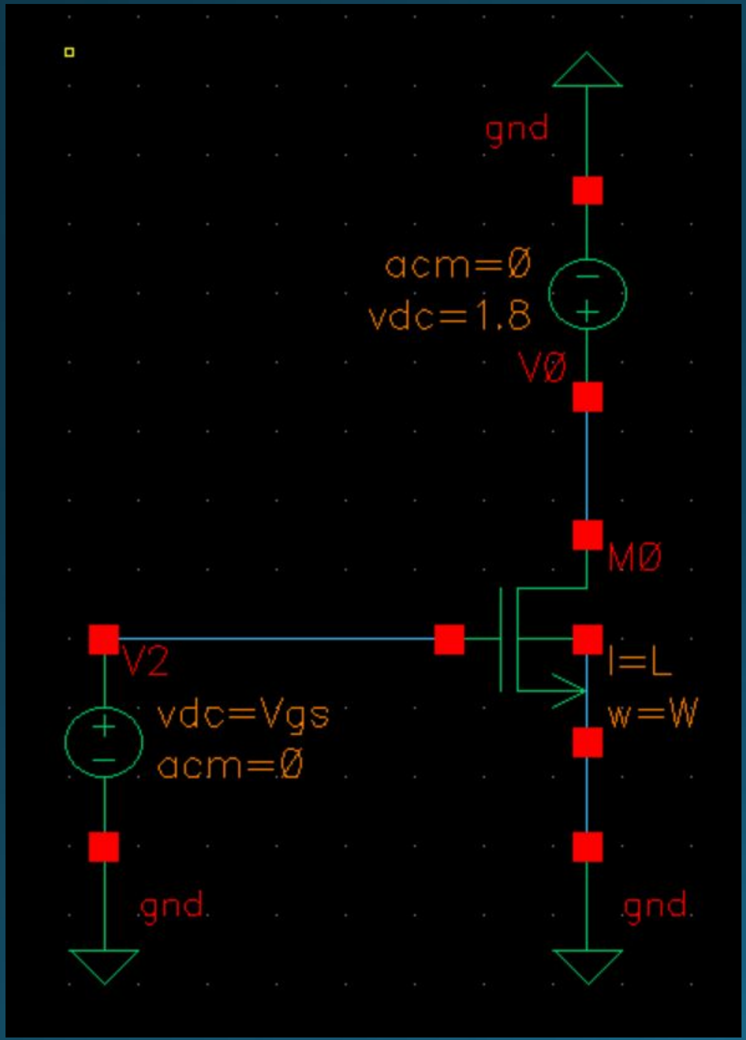
- $1.001 > {}^{A}/_{A+1} > 0.999$

$$\Rightarrow A > 999(V/V)$$

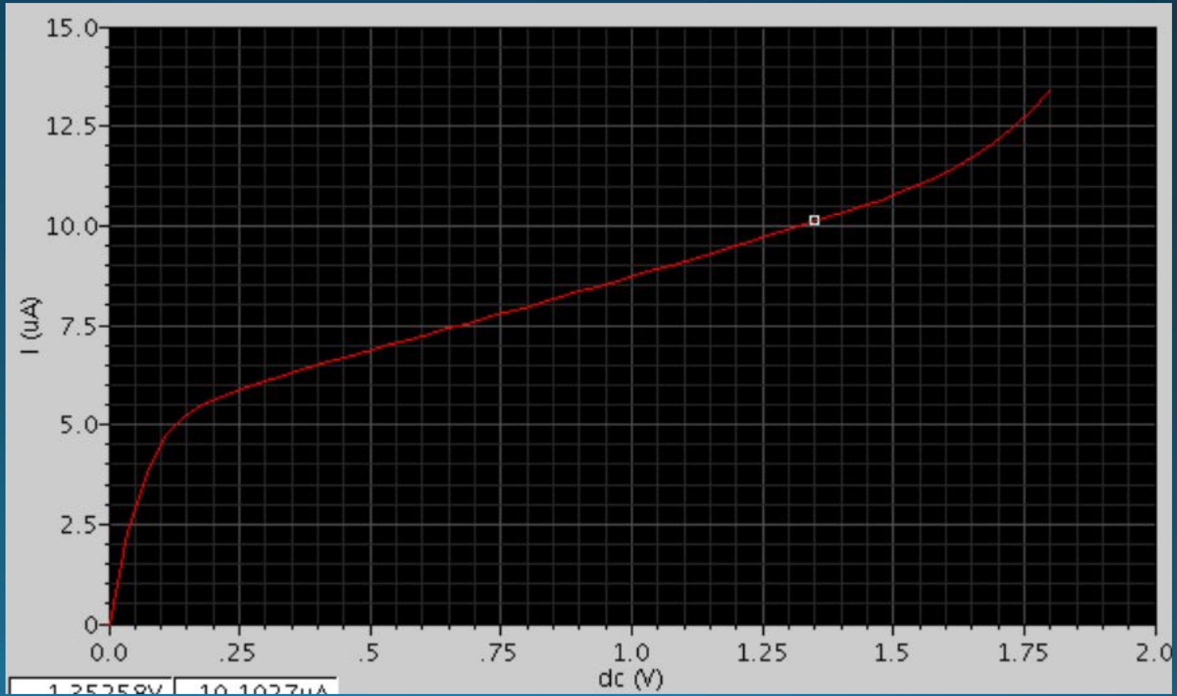
Choose circuit

- Differential input, single output
- 1 stage <-> 2 stage?
- Gain > 999 => telescopic opamp?

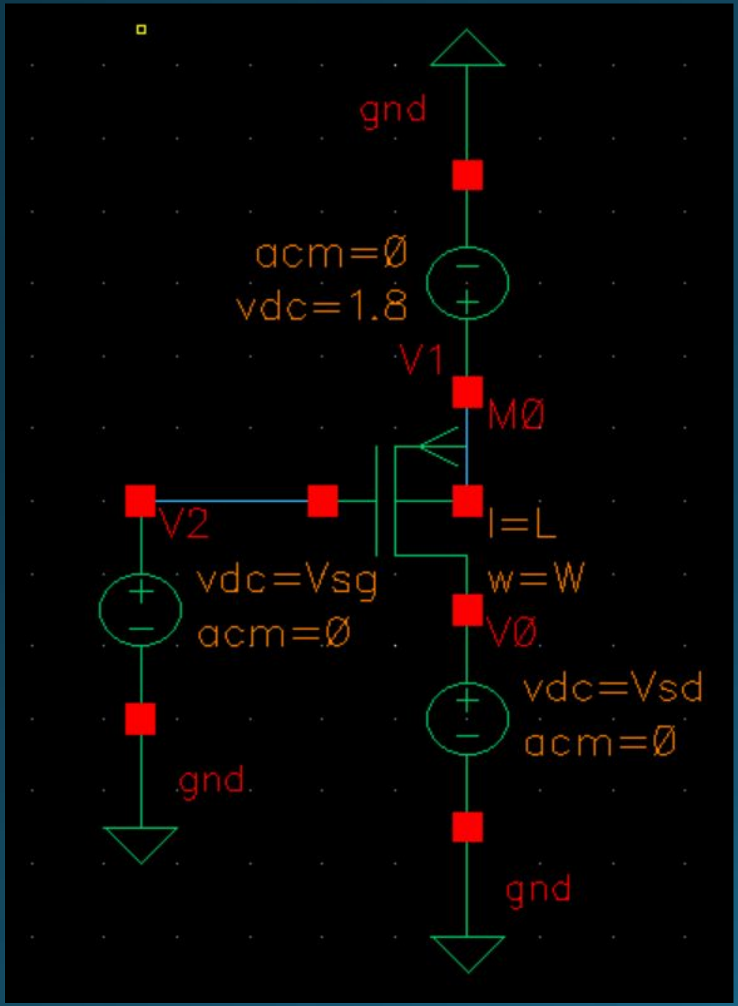
NMOS characteristics



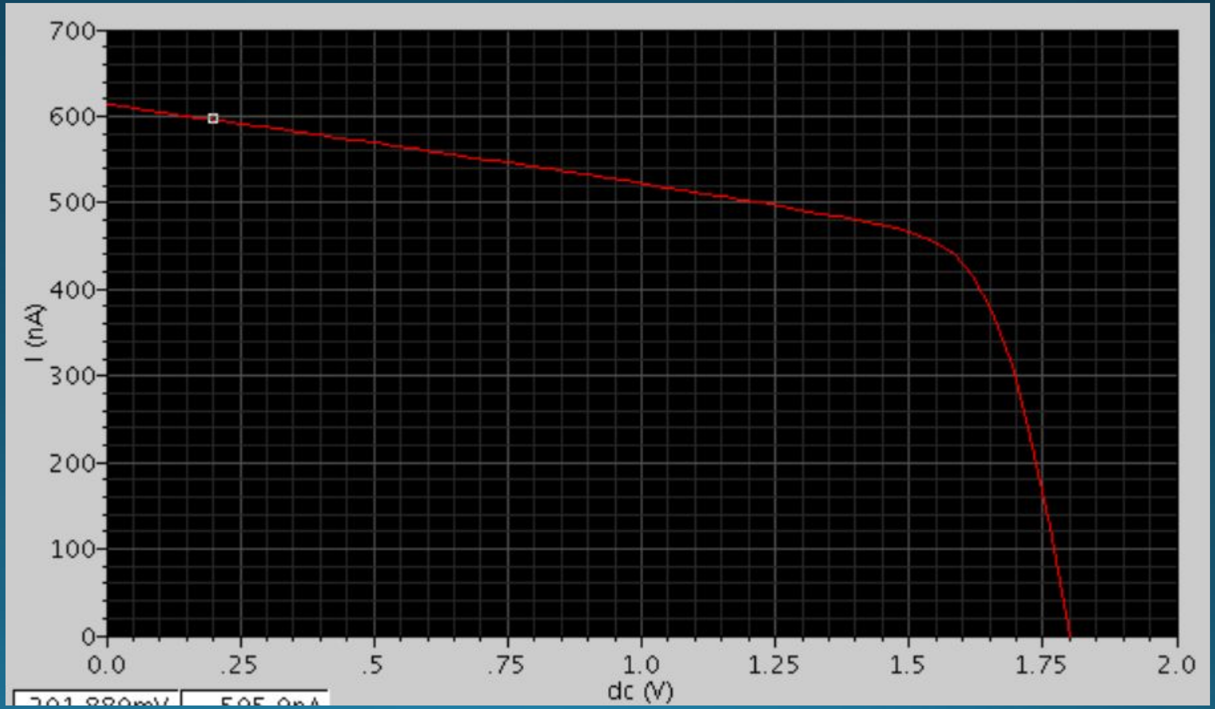
- W/L = 1
- Vgs = 0.6V; Vds: 0~1.8V
- Vds-id

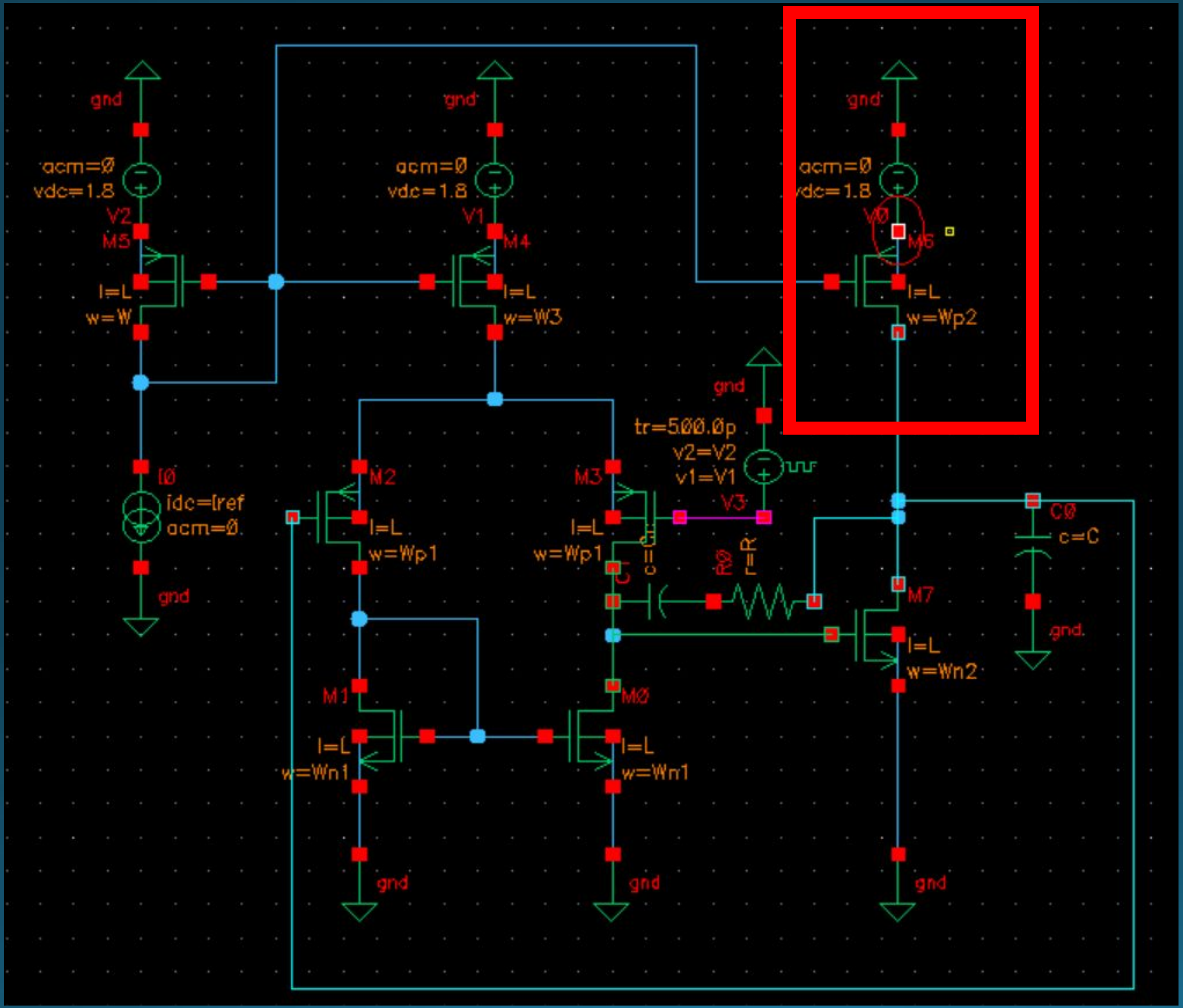


PMOS characteristics



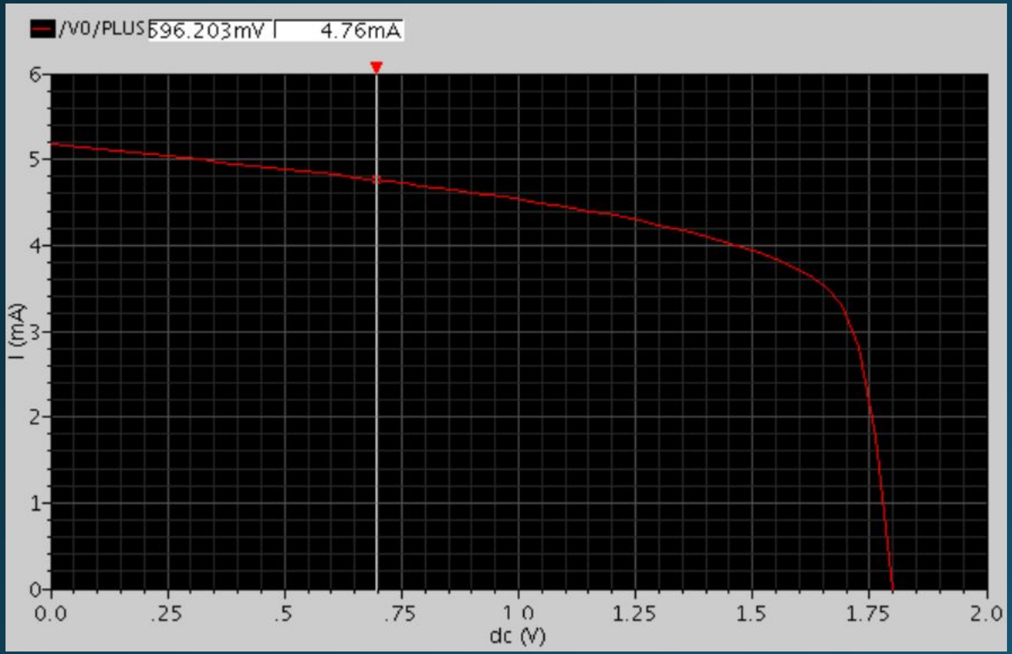
- W/L = 1
- Vsg = 0.6V; Vsd: 0~1.8V
- Id-Vsd



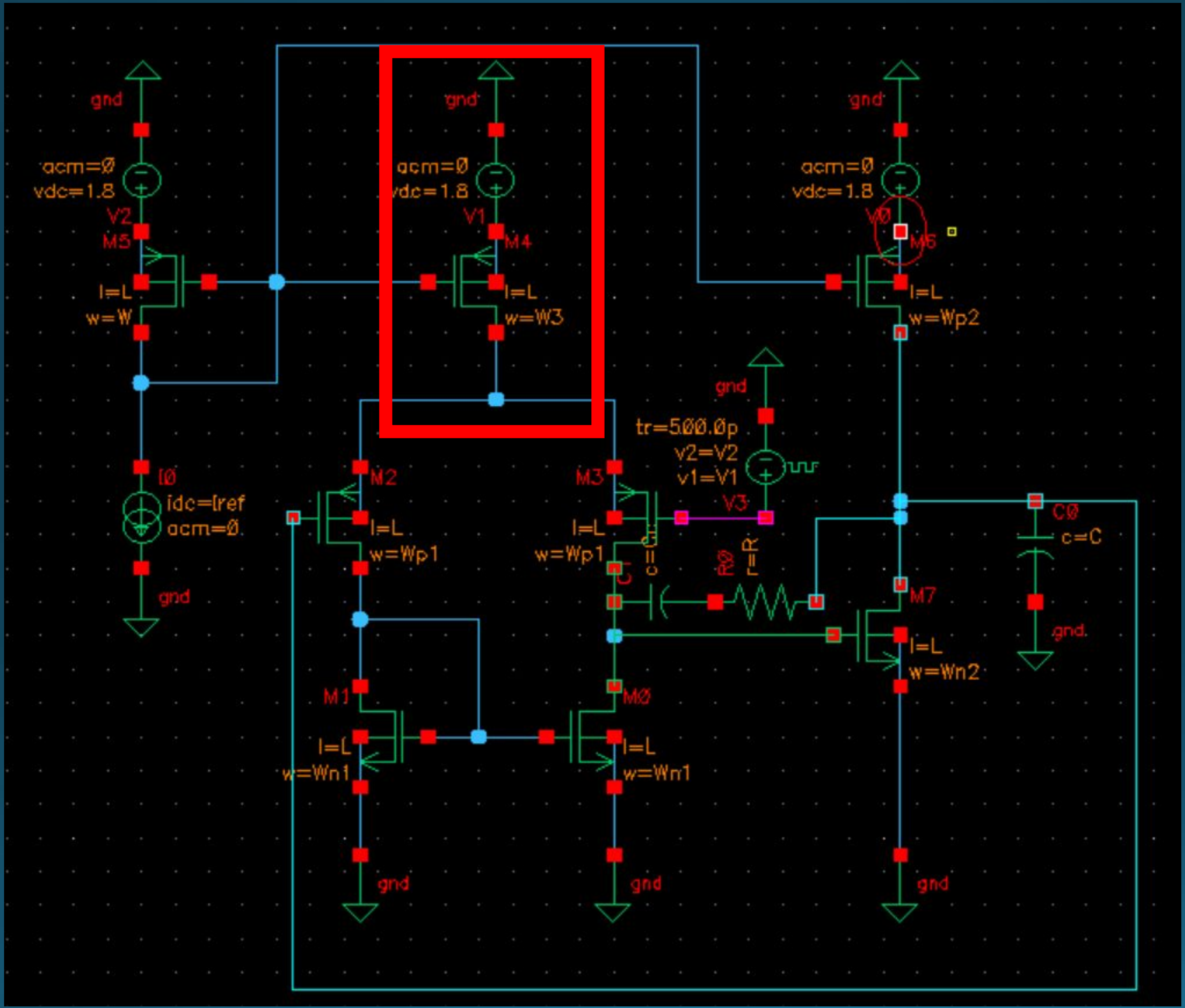


gnd
acm=Ø
vdc=1.8
V2
M5
l=L
w=W
gnd
acm=Ø
vdc=1.8
V1
M4
l=L
w=W3
gnd
acm=Ø
vdc=1.8
VØ
M6
l=L
w=Wp2
gnd
tr=500.0p
v2=V2
v1=V1
V3
I0
idc=Iref
acm=Ø
gnd
M2
l=L
w=Wp1
M3
l=L
w=Wp1
C1
c=Cc
RØ
r=R
CØ
c=C
gnd
M7
l=L
w=Wn2
M1
l=L
w=Wn1
MØ
l=L
w=Wn1
gnd
gnd
gnd

Current Source

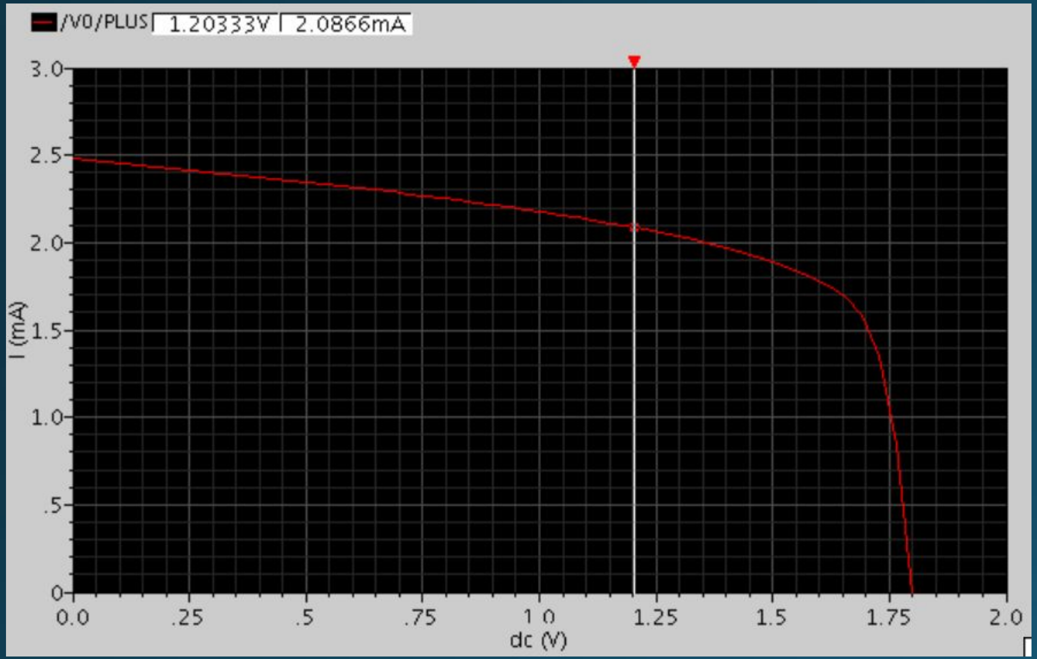


- Choose Iout = 5mA (because of satbility)
- Output swing: 0.2~1.2V
- Vsg = 0.6V; Vsd = 0.7V
- Iout = 4.76mA; W
- Power = 1.8*4.76 = 8.57mV

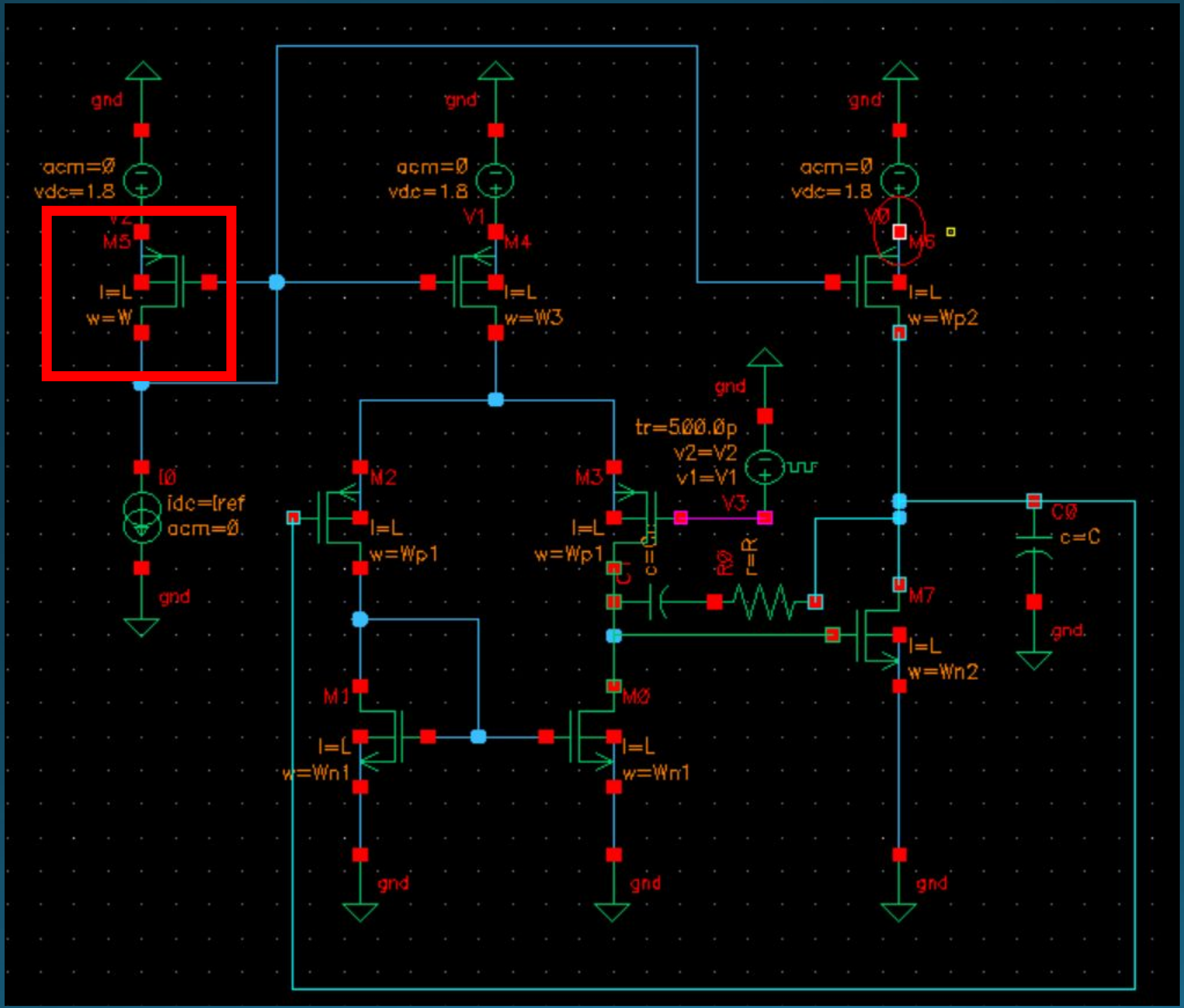


gnd
acm=Ø
vdc=1.8
V2
M5
l=L
w=W
I0
idc=Iref
acm=Ø
gnd
V1
M4
l=L
w=W3
V0
M6
l=L
w=Wp2
tr=500.0p
v2=V2
v1=V1
V3
M2
l=L
w=Wp1
M3
l=L
w=Wp1
R0
r=R
C1
c=Cc
C0
c=C
M7
l=L
w=Wn2
M1
l=L
w=Wn1
M0
l=L
w=Wn1

Current Source

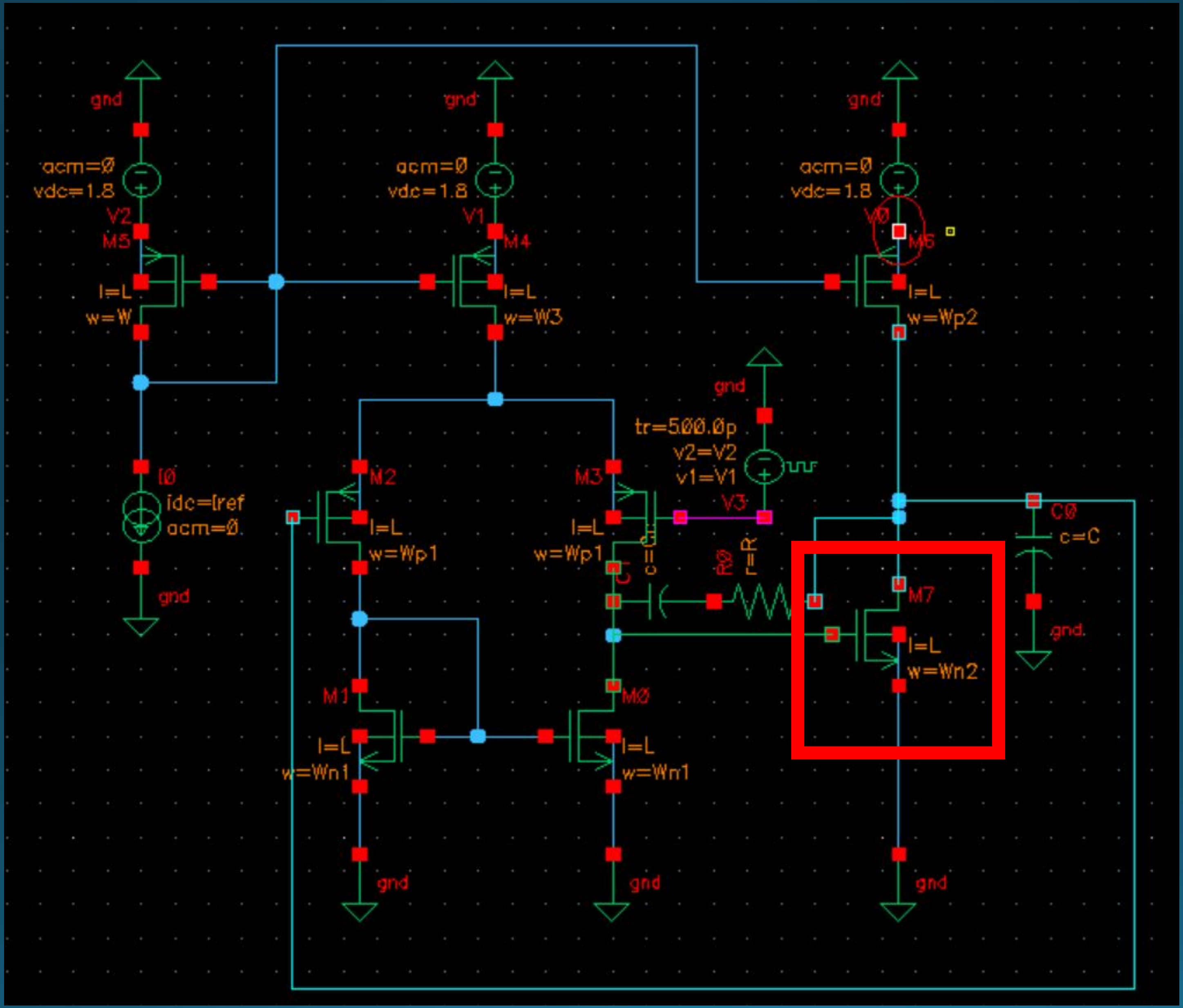


- Choose I = 2mA
- Vsg = 0.6V, Vsd = 0.6V
- I = 2.08mA; W
- Power = 3.74mV

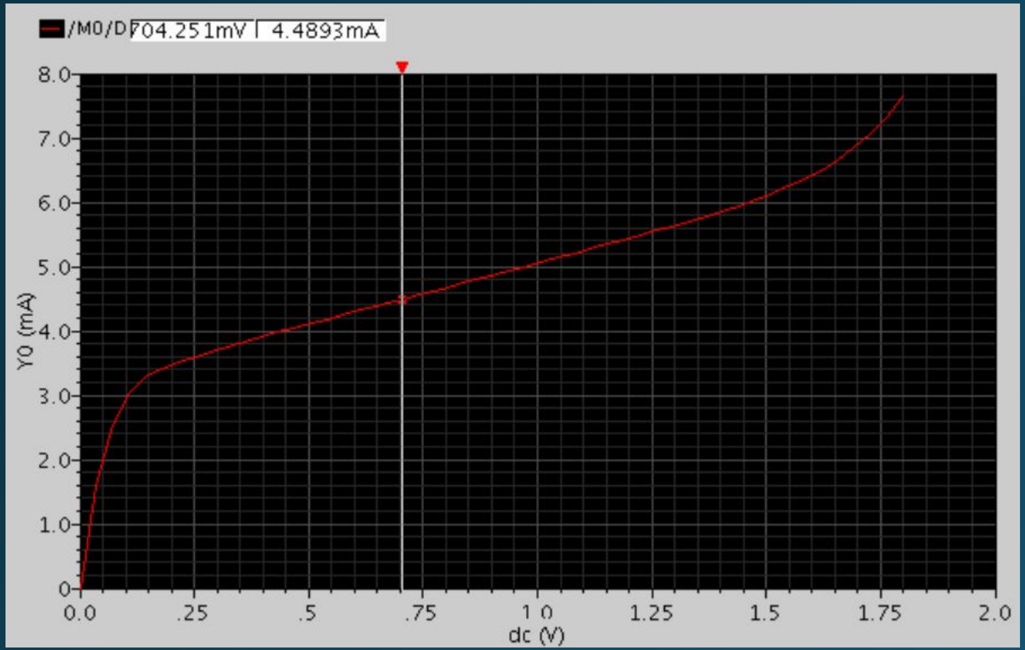

gnd
acm=0
vdc=1.8
V2
M5
l=L
w=W
I0
idc=Iref
acm=0
gnd
V1
M4
l=L
w=W3
V0
M6
l=L
w=Wp2
M2
l=L
w=Wp1
M3
l=L
w=Wp1
tr=500.0p
v2=V2
v1=V1
V3
C1
c=Cc
R0
r=R
M7
l=L
w=Wn2
C0
c=C
M1
l=L
w=Wn1
M0
l=L
w=Wn1

Current source

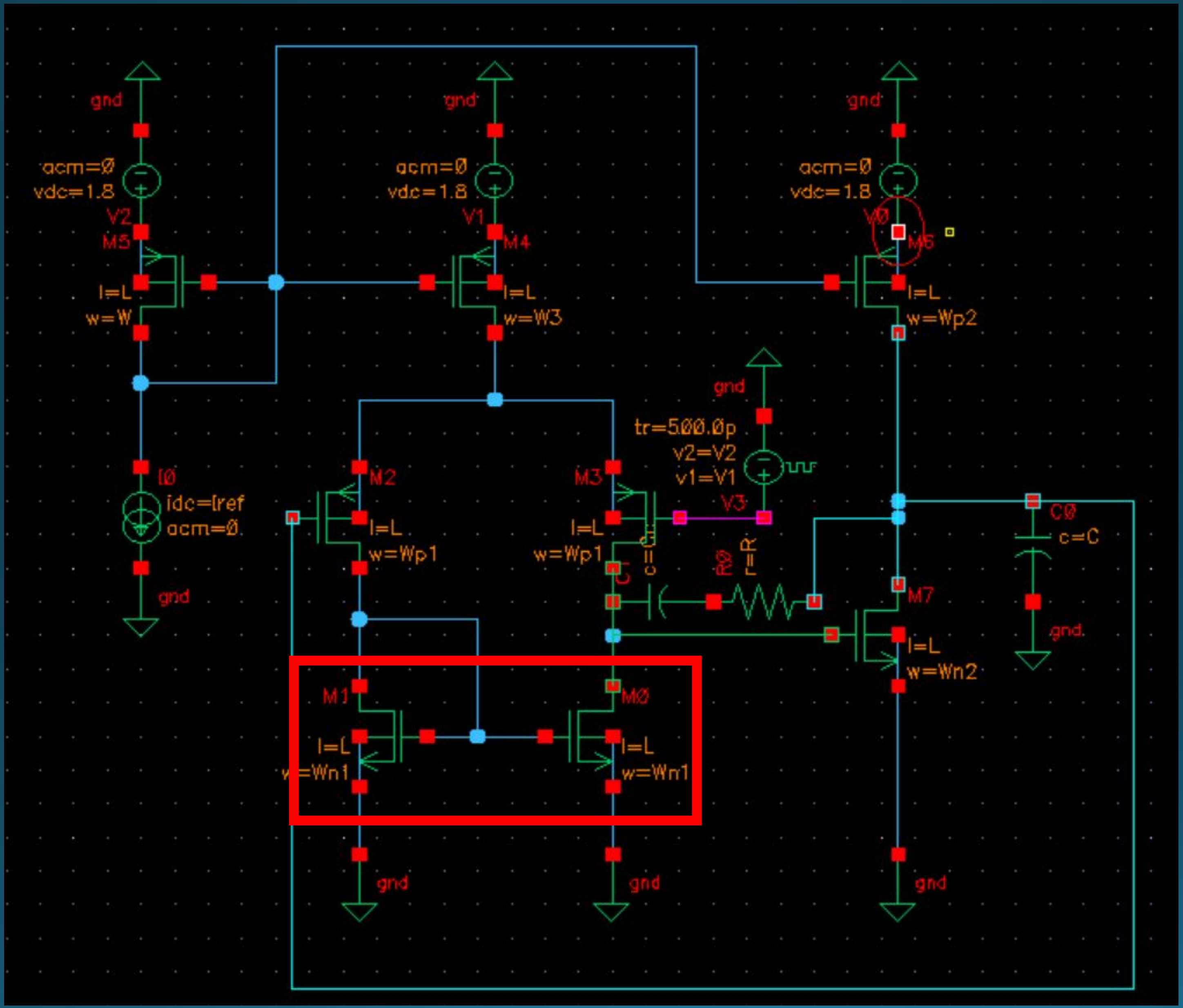
- Save power => small as possible
- Vsg = 0.6V; Vsd = 0.6V
- $\frac{W}{W_{stage1\_CS}} = \frac{I}{I_{satge1\_CS}}$
- W; I


gnd
acm=Ø
vdc=1.8
V2
M5
l=L
w=W
gnd
acm=Ø
vdc=1.8
V1
M4
l=L
w=W3
gnd
acm=Ø
vdc=1.8
VØ
M6
l=L
w=Wp2
gnd
tr=5ØØ.Øp
v2=V2
v1=V1
V3
IØ
idc=Iref
acm=Ø
gnd
M2
l=L
w=Wp1
M3
l=L
w=Wp1
C1
c=Cc
RØ
r=R
M7
l=L
w=Wn2
CØ
c=C
gnd
M1
l=L
w=Wn1
MØ
l=L
w=Wn1
gnd
gnd
gnd

Stage 2

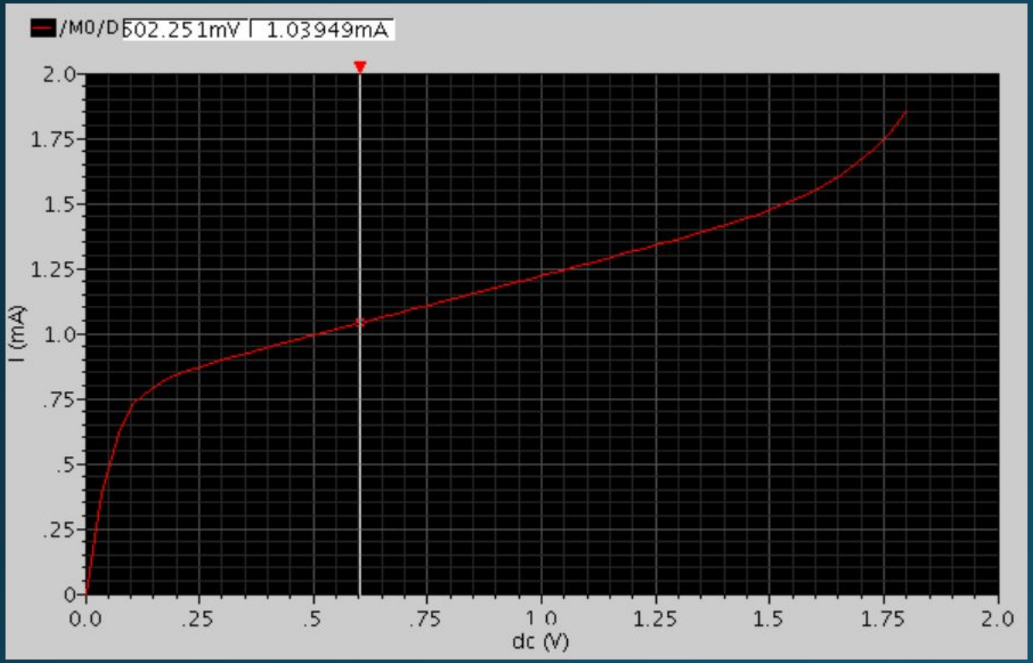


- Iout = 4.76mA
- Vsg = 0.6V; Vsd = 0.7V
- Iout = 4.76mA; W

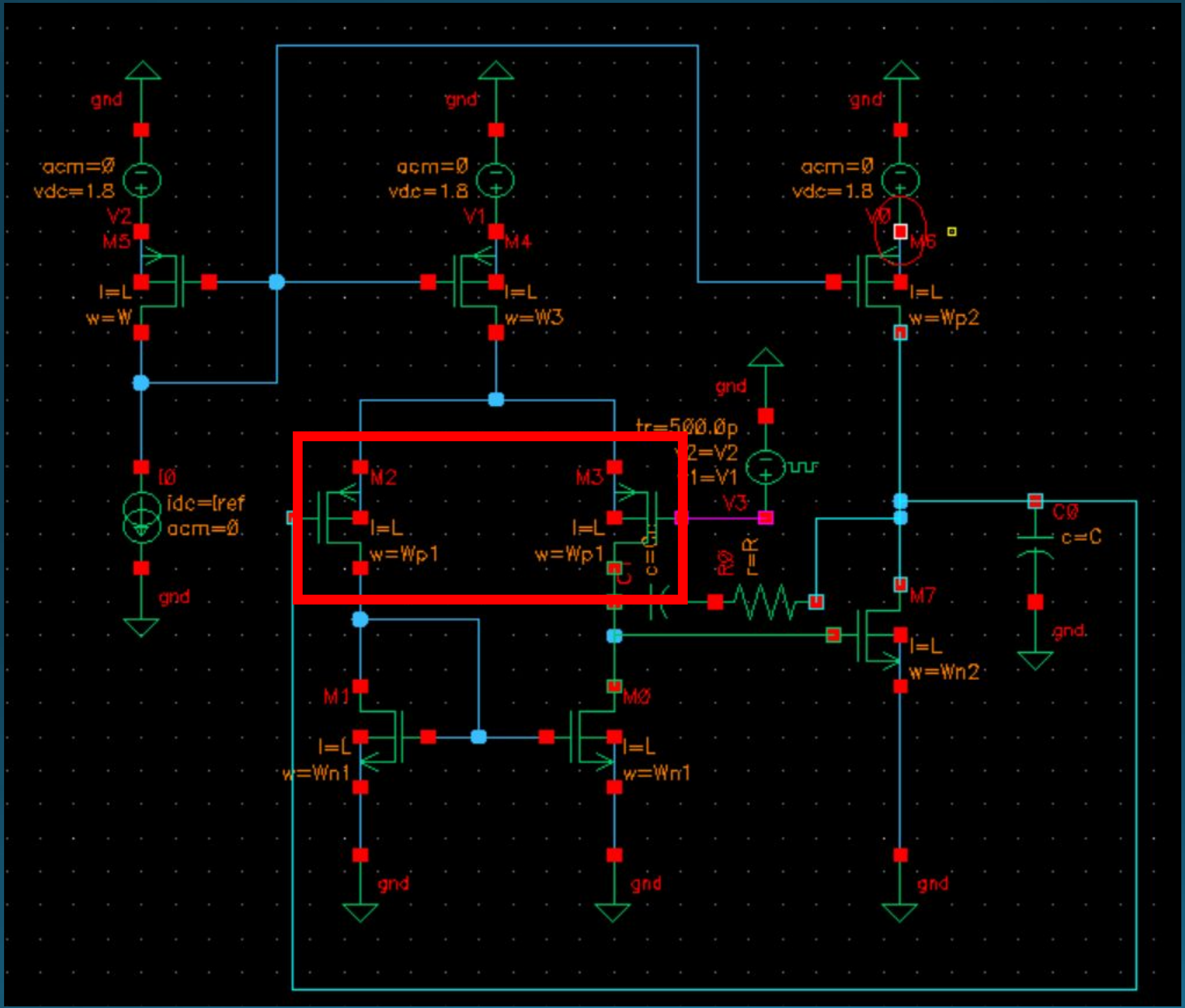


gnd
acm=0
vdc=1.8
V2
M5
l=L
w=W
V1
M4
w=W3
V0
M6
w=Wp2
I0
idc=Iref
M2
M3
w=Wp1
tr=500.0p
v2=V2
v1=V1
V3
C1
R0
r=R
C0
c=C
M7
w=Wn2
M1
M0
w=Wn1

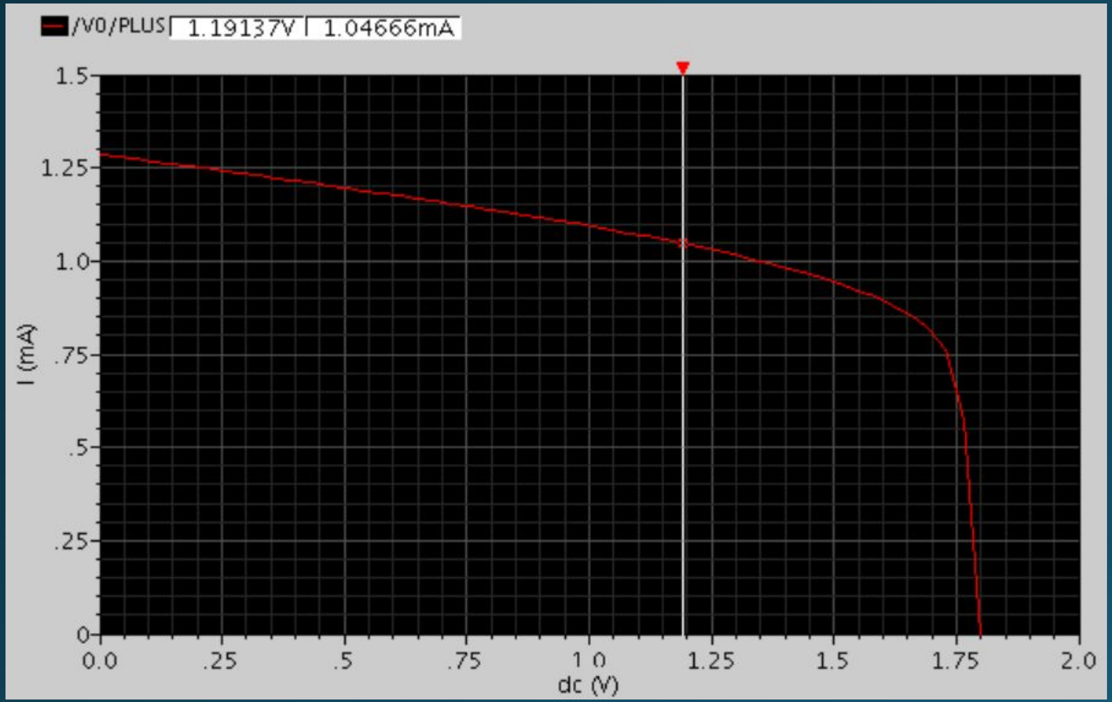
Stage 1



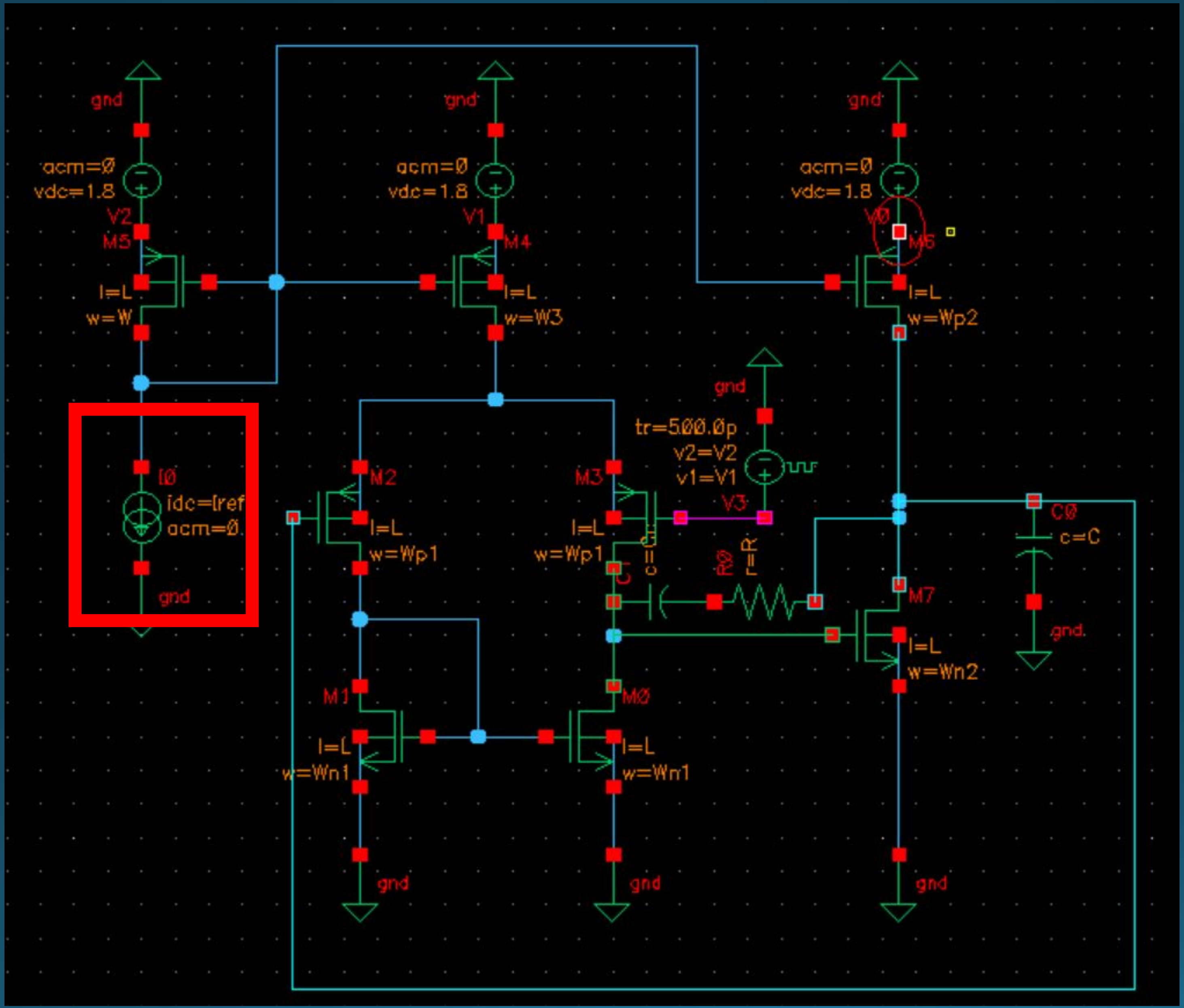
- I = 2.08/2 = 1.04mA
- Vgs = 0.6V; Vds = 0.6V
- Iout = 1.04mA; W


gnd
acm=Ø
vdc=1.8
V2
M5
l=L
w=W
gnd
acm=Ø
vdc=1.8
V1
M4
l=L
w=W3
gnd
acm=Ø
vdc=1.8
VØ
M6
l=L
w=Wp2
gnd
tr=500.0p
v2=V2
v1=V1
V3
IØ
idc=Iref
acm=Ø
gnd
M2
l=L
w=Wp1
M3
l=L
w=Wp1
C1
RØ
r=R
CØ
c=C
gnd
M7
l=L
w=Wn2
M1
l=L
w=Wn1
MØ
l=L
w=Wn1
gnd
gnd
gnd

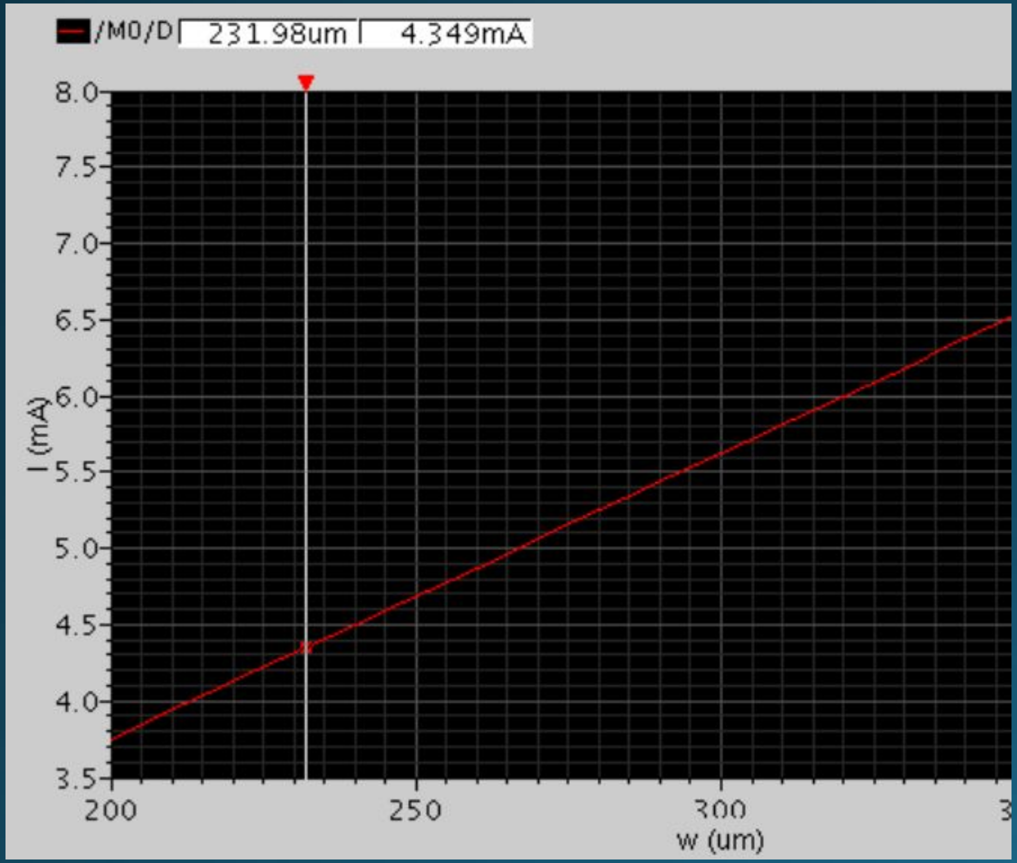
Stage 1



- I = 2.08/2 = 1.04mA
- Vsg = 0.5V; Vsd = 0.6V
- I = 1.04mA; W

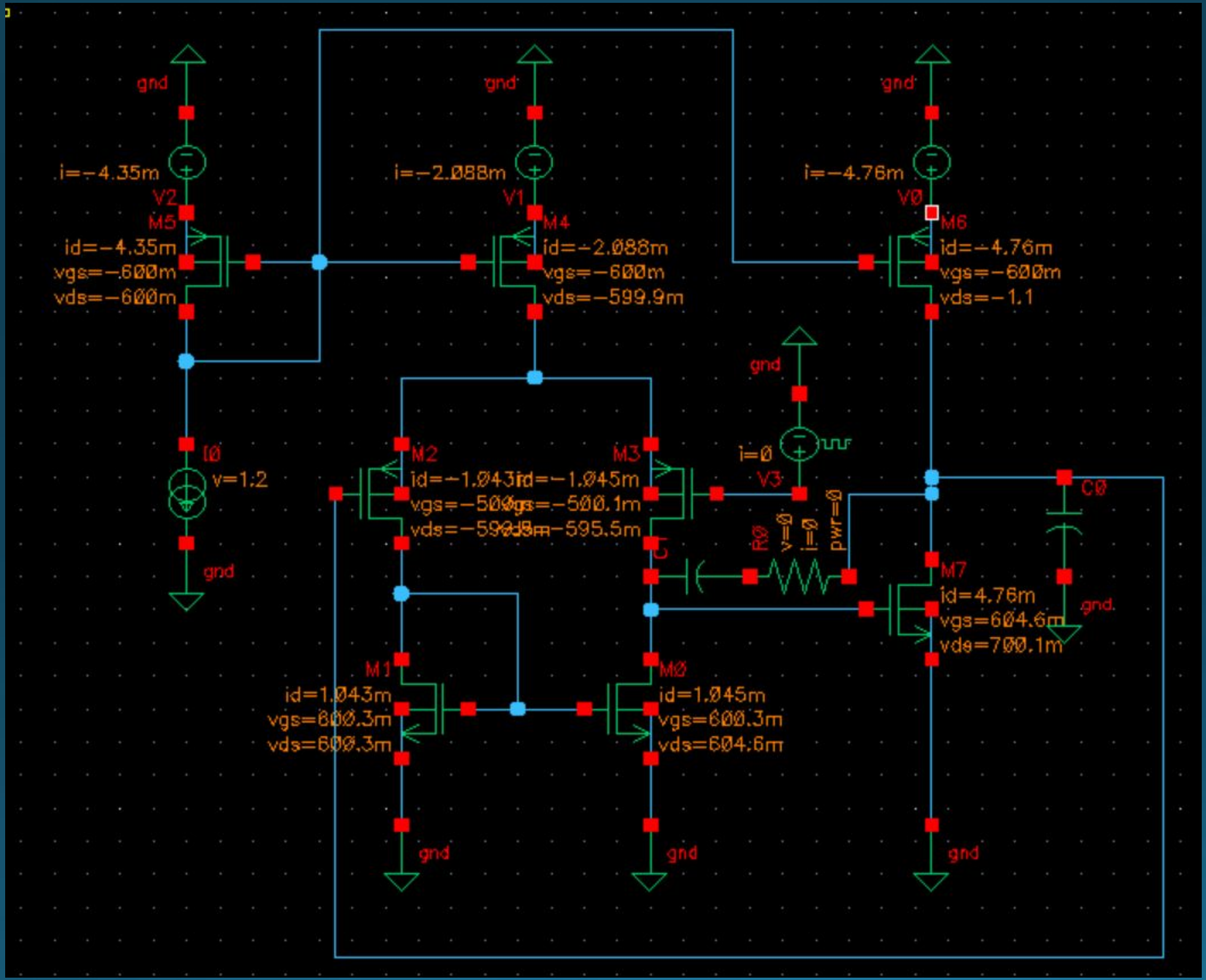

gnd
acm=0
vdc=1.8
V2
M5
l=L
w=W
gnd
acm=0
vdc=1.8
V1
M4
l=L
w=W3
gnd
acm=0
vdc=1.8
V0
M6
l=L
w=Wp2
gnd
tr=500.0p
v2=V2
v1=V1
V3
I0
idc=Iref
acm=0.
gnd
M2
l=L
w=Wp1
M3
l=L
w=Wp1
C1
c=C1
R0
r=R
C0
c=C
gnd
M7
l=L
w=Wn2
M1
l=L
w=Wn1
M0
l=L
w=Wn1
gnd
gnd
gnd

Iref



- I = 4.35mA
- Vds = 1.2V
- I = 4.35mA; W; Vgs

Vbias, I



gnd
i=-4.35m
V2
M5
id=-4.35m
vgs=-600m
vds=-600m
gnd
i=-2.088m
V1
M4
id=-2.088m
vgs=-600m
vds=-599.9m
gnd
i=-4.76m
V0
M6
id=-4.76m
vgs=-600m
vds=-1.1
I0
v=1.2
gnd
gnd
i=0
V3
M2
M3
id=-1.045m
vgs=-500.1m
vds=-595.5m
R0
v=0
i=0
pwr=0
C1
C0
M7
id=4.76m
vgs=604.6m
vds=700.1m
gnd
M1
id=1.043m
vgs=600.3m
vds=600.3m
M0
id=1.045m
vgs=600.3m
vds=604.6m
gnd
gnd
gnd

Frequency compensation

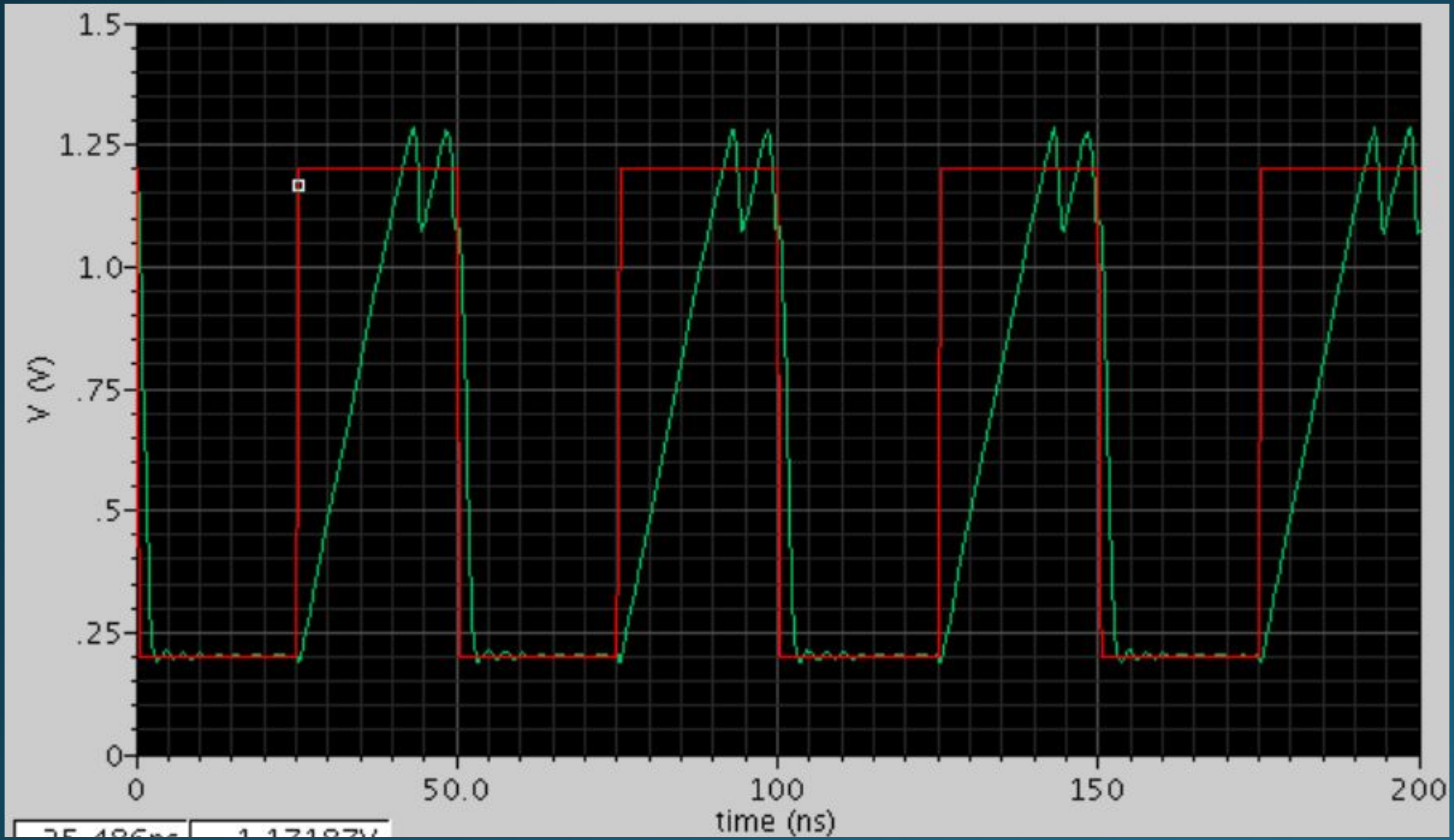
- $w_p = {}^{1}/_{2\pi \times C_L \times R_{out}} = 5.9M < 125.66M$
- Add Cc => $w_p = {}^{1}/_{R1R2gm2Cc} > 125.66M$
  => Choose Cc
- Insert Rz => $w_z = {}^{1}/_{Cc(Rz-1/gm2)} \leq 0$
  => Choose Rz

Gain

- Use vsin => Av = 53.02dB < 60dB => error < 0.3%
- $gm \times r_o = \frac{2id}{Vov} \times \frac{VA}{id}\ \alpha\ VA\ \alpha\ L$

  => choose longer L
- Av = 60.1dB > 60dB

result



- Gain = 60.1dB
- Power = 11.98mV