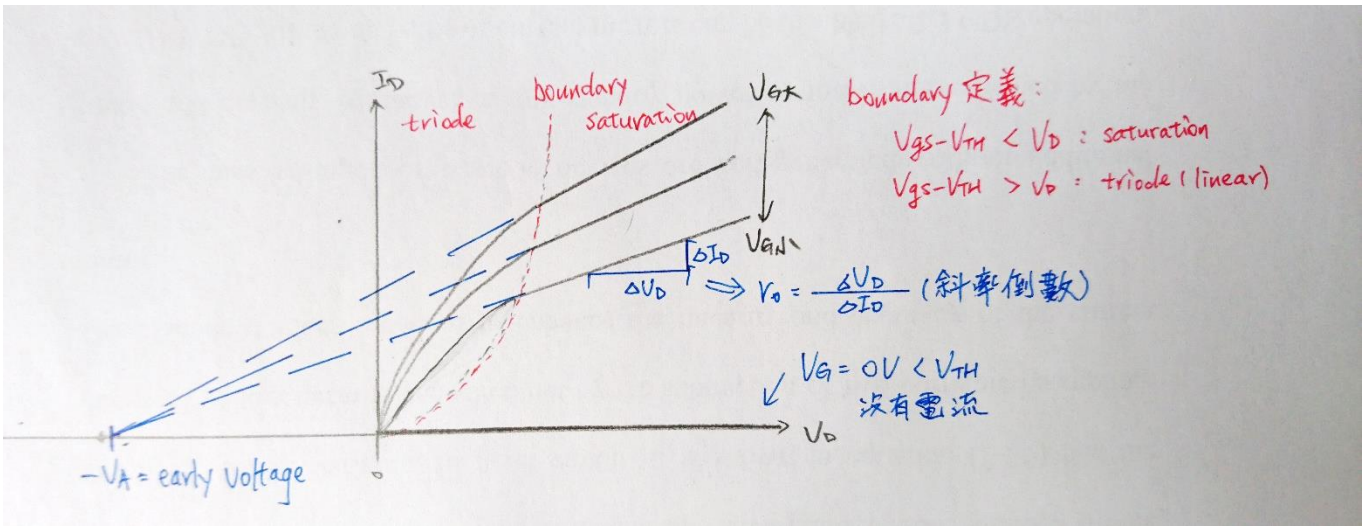
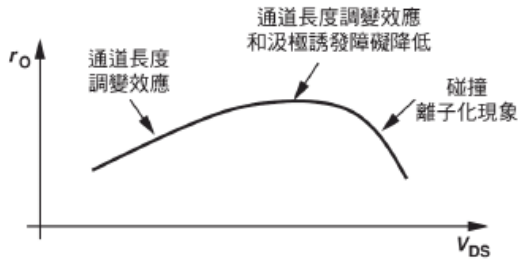
1. Definitions. Please refer the textbook: Design of Analog CMOS Integrated Circuits, Razavi.

(a) **Channel length modulation:** see textbook p.25-27.
(b) **Body effect:** see textbook p.23-25
(c) **Punch through:** In short channel devices, an excessively large drain source voltage widens the depletion region around the drain so much that it touches around the source, creating a very large drain current.
(d) **Velocity saturation:** see textbook p.587-589
(e) **Mobility degradation:** see textbook p.585-587

2. Plot



3.



See textbook p.591

I: Channel-length modulation II: Channel-length modulation + DIBL III: Impact ionization

4.

(a) $I_D = \frac{1}{2}\mu C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$

(b) $I_D = \frac{1}{2}\mu C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$

(c) $g_m = \mu C_{ox}\frac{W}{L}V_{OV}$

(d) $g_m = \sqrt{2\mu C_{ox}\frac{W}{L}I_D}$

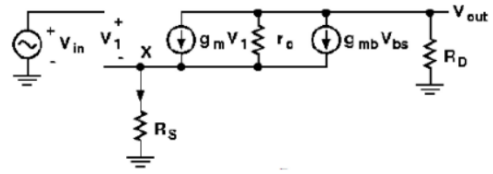
(e) $g_m = \frac{2I_D}{V_{OV}}$

5. text book introdution p69-p78

6. 不考慮 M1，M2 的 body effect $A_v = -g_{m1}(r_{o1}//r_{o2})$

7.

(a)



(b)

$$G_m = \frac{I_{out}}{V_{in}} = \frac{g_m}{1+(g_m+g_{mb})R_S + R_S/r_O}$$

≈8.32e-6(A/V)

(c)

$$\frac{V_{out}}{V_{in}} = -\frac{g_m r_O R_D}{R_D + R_S + r_O + (g_m + g_{mb})R_S r_O}$$
$$= -\frac{g_m r_O}{R_S + r_O + (g_m + g_{mb})R_S r_O} \cdot \frac{R_D[R_S + r_O + (g_m + g_{mb})R_S r_O]}{R_D + R_S + r_O + (g_m + g_{mb})R_S r_O}$$
$$= -G_{meff} R_O = -G_{meff}\{R_D \| [R_S + r_O + (g_m + g_{mb})R_S r_O]\}$$

=0.832(V/V)

8.

(a)

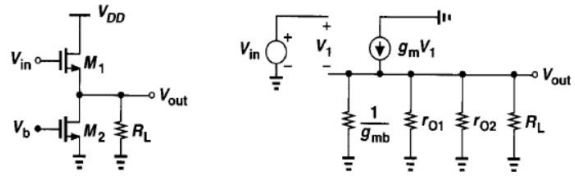
C1=$\frac{2}{3}$WLCox + WCov

C2=WCov

C3=$\frac{1}{2}$WLCox + WCov

(b)
I:Cut off
II:Saturation
III:Triode

9.



Rout=$g_{m1}//g_{mb1}//r_{o1}//r_{o2}) = 166.113\Omega$

(b)

$$A_v = \frac{\frac{1}{g_{mb}} \| r_{O1} \| r_{o2} \| R_L}{\frac{1}{g_{mb}} \| r_{O1} \| r_{o2} \| R_L + \frac{1}{g_m}}.$$

=0.83

10.

(a) $\frac{I_{out}}{I_{ref}} = 4\frac{1+\lambda Vds2}{1+\lambda Vds1}$ => Iout=41.51uA

(b) ro=1/$\lambda Id = 240.9k\Omega$

11.

(a) Vb=0.2+0.5+0.2=0.9V Voutmin=0.2+0.2=0.4V

(b) $(0.7-0.5)^2 \times 1/2 = (0.9-0.5)^2 \times X$ => X=0.25um/2um

12.

(a) Vswing=Vdd-4Vov=2.5V

(b) Av=-gm(gmroro//gmroro)=-125000

13.

(a)Avdm=-gm(Rd//ro)=45.45

(b)Avcm=$\frac{-Rd/2}{\frac{1}{2gm}+Rss} = -50/1001$

(c) V=$\sqrt{2} \times 200mV = 282.84mV$

(d) 0.9V~1.8V

14.

(a) gm

(b) ro//ro=50kΩ

(c) Av=gm(ro//ro)=250

(d) Av=-1/(1+2gmRss)=-1/1001 (or textbook 5.34)

15.

FTTTF FFFTF